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USACE / NAVFAC / AFCEC	**UFGS-23 52 33.03 20 (November 2008)**
	Change 4 - 02/22

Preparing Activity: NAVFAC	**Superseding**
	UFGS-23 52 33.03 20 (July 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025

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SECTION TABLE OF CONTENTS

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

SECTION 23 52 33.03 20

WATER-TUBE BOILERS, OIL/GAS OR OIL

11/08, CHG 4: 02/22

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.3 SYSTEM DESCRIPTION
1.3.1 Design Requirements
1.3.1.1 Boiler Design and Service Conditions
1.3.1.2 Economizer
1.3.1.3 Fans
1.3.1.4 Expansion Joints and Stacks
1.3.1.5 Vertical Fuel Oil Storage Tanks
1.3.1.6 Fuel Oil Pump and Heater Set
1.3.1.7 Deaerating Heater
1.3.2 Detail Drawings
1.3.2.1 Boiler
1.3.2.2 Boiler Room Auxiliary Equipment
1.3.2.3 Burners
1.3.2.4 Dampers, Stacks, and Breechings
1.3.2.5 Fuel Oil Equipment
1.3.2.6 Piping and Specialty Items
1.3.2.7 Ball Joint Installation Details
1.3.2.8 Reproducible Drawings
1.3.3 Design Data
1.3.3.1 Engineering Calculations
1.3.4 Test Reports
1.3.5 Performance Requirements
1.3.5.1 Boiler
1.3.5.2 Economizer
1.3.5.3 Oil Burner/Windbox Package
1.3.5.4 Oil and Gas Burner/Windbox Package
1.4 SUBMITTALS
1.5 QUALITY ASSURANCE
1.5.1 Experience
1.5.1.1 Experience Requirements

1.5.2 Responsibility of the Boiler Manufacturer
1.5.3 Standard Commercial Product
1.5.4 Modification of References
1.5.5 Assembly of Components
1.5.6 Certificates
1.5.6.1 Backflow Preventer
1.5.6.2 Compatibility of Boiler Components and Equipment
1.5.6.3 System and Equipment Installation
1.5.6.4 Tank Calibration
1.5.6.5 Backflow Preventer
1.5.6.6 Identical Equipment
1.5.6.7 Ozone Depleting Substances Technician Certification
1.6 DELIVERY, STORAGE, AND HANDLING
1.7 ENVIRONMENTAL REQUIREMENTS
1.7.1 Burner Emission Requirements
1.7.1.1 NOx Emission Regulations
1.7.1.2 Aquatic Toxicity

PART 2 PRODUCTS

2.1 MATERIALS
2.1.1 Identical Equipment
2.2 BOILERS
2.2.1 Packaged Watertube Boiler
2.2.2 Tubes
2.2.3 Furnace
2.2.4 Transition
2.2.5 Combustion Controls
2.2.6 Access and Observation Doors
2.3 ECONOMIZERS
2.3.1 Construction
2.3.2 Equipment
2.3.3 Insulation
2.4 BURNER AND WINDBOX PACKAGES
2.4.1 Oil Burner/Windbox Package
2.4.1.1 Oil Burner
2.4.1.2 Flame Safeguard Controls
2.4.2 Oil and Gas Burner/Window Package
2.4.2.1 Burner
2.4.2.2 Flame Safeguard Controls
2.5 FANS
2.5.1 Forced Draft Fan
2.5.1.1 Fan Size
2.5.1.2 Fan Construction
2.5.1.3 Electric Motor
2.5.1.4 Noise Level
2.6 COMPRESSED AIR SYSTEM
2.6.1 Plant Compressed Air System
2.6.1.1 Air Filter
2.6.1.2 Oil Filter
2.6.1.3 Air Receiver
2.6.1.4 Electric Motor
2.6.1.5 Controls
2.6.2 Instrument Compressed Air System
2.6.2.1 Air Compressor
2.6.2.2 Air Receiver
2.6.2.3 Aftercooler
2.6.2.4 Electric Motor
2.6.2.5 Controls

2.6.2.6 Accessories
2.6.2.7 Air Dryers
2.6.3 Pressure Reducing Regulator
2.7 BREECHING, EXPANSION JOINTS, STACKS, AND DAMPERS:
2.7.1 Breeching
2.7.1.1 Breeching Connections and Joints
2.7.1.2 Uninsulated Breeching
2.7.1.3 Breeching Access Doors
2.7.1.4 Breeching Cleanout Doors
2.7.1.5 Breeching Structural Materials
2.7.2 Expansion Joints
2.7.2.1 Metallic Breeching Expansion Joints
2.7.2.2 Non-Metallic Expansion Joints
2.7.3 Stacks (For Installation Without Flue Gas Scrubbers)
2.7.3.1 Construction
2.7.3.2 Construction Accessories
2.7.3.3 Finish
2.7.3.4 Stack Sampling Platform
2.7.4 Dampers
2.7.4.1 Multilouver Dampers
2.7.4.2 Guillotine Dampers
2.7.5 Sampling Ports
2.8 FUEL OIL SYSTEM
2.9 MISCELLANEOUS EQUIPMENT
2.9.1 Condensate Receiver
2.9.1.1 Coating
2.9.1.2 Accessories
2.9.2 Deaerating Heater
2.9.2.1 General
2.9.2.2 Heater Capacity
2.9.2.3 Inlet Water Characteristics
2.9.2.4 Storage Tank
2.9.2.5 Vent Condensing Arrangement
2.9.2.6 Materials
2.9.2.7 Accessories
2.9.2.8 Connections
2.9.2.9 Level Control
2.9.2.10 Low Pressure Steam Control
2.9.2.11 Gage Glasses
2.9.2.12 Alarms
2.9.2.13 Multiport Back Pressure Relief Valve
2.9.2.14 Exhaust Head
2.9.3 Boiler Feed Pumps
2.9.3.1 Pump Service Requirements
2.9.3.2 Construction
2.9.3.3 Electric Motors
2.9.3.4 Steam Turbines
2.9.3.5 Minimum Flow Protection for Boiler Feed Water Pumps
2.9.4 Condensate Pumps
2.9.4.1 Condensate Pump Service Requirements
2.9.4.2 Construction
2.9.4.3 Electric Motors
2.9.4.4 Steam Turbines
2.9.5 Variable Speed Motor Controller
2.9.5.1 Housing
2.9.5.2 Variable Frequency Controllers
2.9.5.3 Ratings
2.9.5.4 Minimum Speed
2.9.5.5 Fault Protection

2.9.5.6 Time Delay
2.9.5.7 Acceleration/Deceleration
2.9.5.8 Voltage/Frequency Control
2.9.5.9 Door Interlocks
2.9.5.10 Shutdown Conditions
2.9.5.11 Electrical Bypass
2.9.5.12 Controller Environmental Protection
2.9.5.13 Method of Control
2.9.6 Valve Actuators
2.9.7 Sump Pumps
2.9.8 Water Softening System
2.9.8.1 Raw Water Analysis
2.9.8.2 Softener Effluent Analysis
2.9.8.3 Softener Equipment
2.9.8.4 Brine Storage System
2.9.8.5 Brine Storage System Accessories
2.9.8.6 Storage Tank
2.9.9 Chemical Feed Systems
2.9.9.1 Storage Tank
2.9.9.2 Exterior Gage Glass
2.9.9.3 Low Level Alarm
2.9.9.4 Dissolving Baskets
2.9.9.5 Tank Strainer
2.9.9.6 Supporting Steelwork
2.9.9.7 Agitator
2.9.9.8 Proportioning Pumps
2.9.9.9 Safety Relief Valve
2.9.10 Blowdown Tank
2.9.10.1 Construction
2.9.10.2 Tank Connections
2.9.10.3 Angle Supports and Coating
2.9.10.4 Accessories
2.9.10.5 Controls
2.9.11 Continuous Blowdown System
2.9.11.1 Automatic Blowdown Controller
2.9.11.2 Flow Assembly
2.9.11.3 Controller/Programmer
2.9.11.4 Accessories and Connections
2.9.11.5 Flash Tank
2.9.11.6 Blowdown Inlet
2.9.11.7 Automatic Control System
2.9.11.8 Sample Cooler
2.9.11.9 Heat Exchanger
2.10 PIPING
2.10.1 Piping Materials
2.10.2 Chlorinated Polyvinyl Chloride (CPVC)
2.10.3 Fittings
2.10.3.1 Fittings for Steel Pipe
2.10.3.2 Welded Outlets and Welding Saddles
2.10.3.3 Fittings For Copper Tubing
2.10.3.4 Unions
2.10.4 Flanges
2.10.5 Valves
2.10.5.1 Low Pressure
2.10.5.2 Medium Pressure
2.10.5.3 High Pressure
2.10.5.4 Ball Valves
2.10.5.5 Valve Accessories
2.10.5.6 Steam Pressure Regulating Valves

2.10.5.7 Safety Relief Valves
2.10.6 Bolts and Nuts
2.10.7 Gaskets
2.10.8 Expansion Joints
2.10.8.1 Slip Tube Expansion Joints
2.10.8.2 Flexible Ball Expansion Joints in Piping
2.10.8.3 Bellows Expansion Joints
2.10.9 Pipe Hangers and Supports
2.10.10 Instrumentation
2.10.10.1 Pressure and Vacuum Gages
2.10.10.2 Indicating Thermometers
2.10.11 Miscellaneous Pipeline Components
2.10.11.1 Cold and Hot Water Meters
2.10.11.2 Air Traps
2.10.11.3 Steam Traps
2.10.11.4 Strainers
2.10.12 Backflow Preventers
2.10.13 Insulation Types and Installation Procedures
2.10.14 Pipe Sleeves
2.10.14.1 Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade
2.10.14.2 Partitions
2.10.15 Piping Identification
2.11 FIRE PROTECTION SYSTEM
2.12 MARKING
2.13 TOOLS AND TESTING EQUIPMENT
2.14 WELDING MATERIALS
2.15 MOTORS AND DRIVES
2.16 SOURCE QUALITY CONTROL
2.16.1 Plant Equipment Tests
2.16.1.1 Plant Air Compressors
2.16.1.2 Instrument Air Compressors
2.16.1.3 Variable Speed Motor Controller Factory Test

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Equipment Installation
3.1.1.1 Equipment Foundations
3.1.1.2 Forced Draft Fan
3.1.1.3 Stack
3.1.1.4 Fuel Oil Tanks
3.1.2 Piping
3.1.2.1 Fittings
3.1.2.2 Grading of Pipe Lines
3.1.2.3 Anchoring, Guiding, and Supporting Piping
3.1.2.4 Copper Tubing
3.1.2.5 Sleeves
3.1.2.6 Flashing for Buildings
3.1.2.7 Outlets for Future Connections
3.1.2.8 Screwed Joints in Piping
3.1.2.9 Welds and Welded Joints
3.1.2.10 Cleaning of Piping
3.1.2.11 Reduction in Pipe Size
3.1.2.12 Expansion Control
3.1.2.13 Connection to Equipment
3.1.2.14 Valve Installation
3.1.2.15 Traps and Connections
3.1.2.16 Pressure Gage Installation

3.1.2.17 Thermometer and Sensing Element Installation
3.1.2.18 Strainer Locations
3.1.2.19 Dissimilar Piping Materials
3.1.2.20 Surface Treating, and Pipe Wrapping
3.1.3 Painting
3.1.3.1 Piping, Fittings, and Mechanical and Electrical Equipment
3.1.3.2 Other Items
3.1.3.3 Boilers
3.1.3.4 Vertical Fuel Oil Tank
3.1.3.5 Surfaces Not to be Painted
3.1.4 Insulation
3.2 FIELD QUALITY CONTROL
3.2.1 Tests and Inspections (Piping)
3.2.1.1 General Requirements
3.2.1.2 Hydrostatic and Leak Tightness Tests
3.2.2 Preliminary Operation
3.2.3 General Startup Requirements
3.2.4 Fuel Oil Tanks
3.2.4.1 Blowdown Valves and Try Cocks
3.2.4.2 Fans, Heaters, Pumps, and Motors
3.2.5 Boilers and Auxiliaries Tests and Inspections
3.2.5.1 Strength and Leak Tightness Tests
3.2.5.2 Boiler Inspection
3.2.5.3 Boiler Cleaning and Startup
3.2.5.4 Boiler Preliminary Operational Tests
3.2.5.5 General Controls Operational Tests
3.2.5.6 Steady State Combustion Tests
3.2.5.7 Varying Load Combustion Tests
3.2.5.8 Auxiliary Equipment and Accessory Tests
3.2.5.9 Feedwater Equipment Tests
3.2.5.10 Capacity and Efficiency Tests
3.2.5.11 Test Runs
3.2.5.12 Fuel Analysis
3.2.5.13 Temporary Waste Steam Connection
3.2.5.14 Fire Safety for Oil-fired Boilers
3.2.5.15 Plant Acceptance Operation
3.2.6 Manufacturer's Field Services
3.2.6.1 Erection/Installation Supervisors and Service Engineers
3.2.6.2 Boiler and System Representatives
3.2.6.3 Instruction to Government Personnel
3.3 SCHEDULE

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC	**UFGS-23 52 33.03 20 (November 2008)** **Change 4 - 02/22**
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SECTION 23 52 33.03 20

WATER-TUBE BOILERS, OIL/GAS OR OIL
11/08, CHG 4: 02/22

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NOTE: This guide specification covers the requirements for steam heating plants from 2 1/2 to 47 1/4 kg/sec 20,000 to 375,000 lbs/hr of steam capacity using packaged watertube boilers which burn either oil or gas or both fuels combined.

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

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

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

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NOTE: This specification is intended to be used in the procurement and installation of heating plant equipment. Requirements for materials and procedures for special or unusual design shall be added to and modifications made to this specification as necessary to fit specific projects. This guide specification shall be used in conjunction with the following NAVFAC definitive drawings and UFC 3-410-06N, "Central Heating Plants Operation and Maintenance".

NAVFAC NO. DRAWING TITLE

1429301 - STEAM HEATING PLANT NO.2 2 1/2 - 47 1/4 kg

PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL FLOOR PLANS

1429302 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL LONGITUDINAL SECTION

1429303 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL PIPING SCHEMATIC

1429304 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL DETAILS

1429305 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL FUEL OIL UNLOADING

1429306 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL FUEL OIL STORAGE

1429307 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL FLOOR PLAN - ELECTRICAL

1429308 - STEAM HEATING PLANT NO. 2 2 1/2 - 47 1/4 kg PER HOUR 20,000 - 375,000 POUNDS PER HOUR WATERTUBE (PACKAGED) OIL/GAS OR OIL ONE LINE DIAGRAM - ELECTRICAL

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NOTE: Information describing any and all specific project and site conditions which the Contractor would need to know in order to submit a firm price shall be specified in Division 1 of the project specifications. Such conditions include:

1. Allocated space for storage of materials.

2. Railway spurs and sidings available to the Contractor for delivery of materials.

3. Any restrictions on daily working hours.

4. Procedure for scheduling outages and tests.

5. Any noise or traffic restrictions.

6. Availability of utilities required for construction.

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PART 1 GENERAL

1.1 REFERENCES

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

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

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

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 118	(1979) Coal-Tar Bitumen Used in Roofing, Damp-Proofing, and Waterproofing

AMERICAN BOILER MANUFACTURERS ASSOCIATION (ABMA/BOIL)

ABMA Boiler 103	(2001) Selected Codes and Standards of the Boiler Industry

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN LADDER INSTITUTE (ALI)

ALI A14.3	(2008; R 2018) Ladders - Fixed - Safety Requirements

AMERICAN PETROLEUM INSTITUTE (API)

API Std 607	(2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats
API Std 650	(2013; Errata 1 2013; Addendum 1 2014; Errata 2 2014; Addendum 2 2016; Addendum 3 2018) Welded Tanks for Oil Storage

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2023) Scheme for the Identification of Piping Systems
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2024) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
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	(2024) Power Piping
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC II-C	(2017) BPVC Section II-Materials Part C-Specifications for Welding Rods Electrodes and Filler Metals
ASME BPVC SEC VII	(2017) BPVC Section VII-Recommended Guidelines for the Care of Power Boilers
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 4	(2013; R 2023) Fired Steam Generators

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C511	(2017; R 2021) Reduced-Pressure Principle

	Backflow Prevention Assembly
AWWA C651	(2023) Standard for Disinfecting Water Mains

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2022) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2024) 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 A193/A193M	(2024a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2024) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A242/A242M	(2024) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B111/B111M	(2024) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM D396	(2021) Standard Specification for Fuel Oils
ASTM D1047	(2016) Poly(Vinyl Chloride) Jacket for Wire and Cable
ASTM D1220	(1965; R 1990) Measurement and Calibration

	of Upright Cylindrical Tanks
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM D6081	(1998; R 2014) Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation
ASTM F1007	(2018; R 2022) Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F1120	(1987; R 2024) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASTM F1508	(1996; R 2021) Standard Specification for Angle Style, Pressure Relief Valves for Steam, Gas, and Liquid Services

FM GLOBAL (FM)

FM DS 12-17	(2001) Watertube Boilers

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-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBI)

NBBI NB-27	(1991) National Board Rules and Recommendations for the Design and Construction of Boiler Blowoff Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2024) National Fuel Gas Code
NFPA 85	(2023) Boiler and Combustion Systems Hazards Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1424	(2016) Engineering and Design -- Lubricants and Hydraulic Fluids

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
MIL-T-19646	(1990; Rev A; Notice 1 2021) Thermometer, Gas Actuated, Remote Reading

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50494	(Basic; Notice 1) Exhaust Head, Steam
CID A-A-50555	(Basic) Pumping Units, Sewage, Duplex, Centrifugal, Automatic Wet-Pit Type
CID A-A-50558	(Basic; Notice 1) Valves, Pressure Regulating, Steam
CID A-A-50562	(Basic) Pump Units, Centrifugal, Water, Horizontal; General Service and Boiler-Feed: Electric-Motor or Steam-Turbine-Driven
CID A-A-59222	(Basic; Notice 1; CANC Notice 1 2021) Fans, Centrifugal, Draft, Forced and Induced
CID A-A-59224	(Basic; Notice 2) Meters, Fluid Quantity Volumetric
CID A-A-60001	(Rev A) Traps, Steam
FS F-B-2902	(Basic; Notice 1) Boilers, Steam Watertube (Bent Tube, Multi-Drum and Cross Drum) Packaged Type (10,000,000 to 125,000,000 BTU/HR Thermal Output Capacity)
FS F-B-2910	(Basic) Burners, Single Oil, Gas, and Gas-Oil Combination for Packaged Boilers (320,001 to 125,000,000 BTU/HR Thermal Output Capacity)
FS F-F-351	(2019; Rev G; Notice 1) Filters and Filter Elements, Fluid Pressure: Lubricating Oil, Bypass and Full Flow
FS W-H-2904	(Basic; Notice 1) Heaters, Fluid, Deaerating (For Water Only) 1,000 to 1,600,000 Pounds Per Hour Capacity

FS WW-S-2739	(Basic; Notice 1; Notice 2) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam
FS XX-C-2816	(Rev A) Compressor, Air, Reciprocating or Rotary, Electric Motor Driven, Stationary, 10 HP and Larger

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

29 CFR 1910-SUBPART D	Walking - Working Surfaces
29 CFR 1910-SUBPART Q	Welding, Cutting, and Brazing
40 CFR 82	Protection of Stratospheric Ozone

U.S. NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND (NAVFAC)

NAVFAC MO 324	(1992) Inspection and Certification of Boilers and Unfired Pressure Vessels

UL SOLUTIONS (UL)

UL 296	(2017; Reprint Nov 2022) UL Standard for Safety Oil Burners
UL 726	(1995; Reprint Sep 2024) UL Standard for Safety Oil-Fired Boiler Assemblies
UL 795	(2016; Reprint May 2022) UL Standard for Safety Commercial-Industrial Gas Heating Equipment

WATER QUALITY ASSOCIATION (WQA)

WQA S-100	(2000) Household, Commercial, and Portable Exchange Cation Exchange Water Softeners

1.2 RELATED REQUIREMENTS

The following UFGS sections apply to this section, with the additions and modifications specified herein:

a. 01 78 23 OPERATION AND MAINTENANCE DATA

b. 03 30 00 CAST-IN-PLACE CONCRETE

c. 09 90 00 PAINTS AND COATINGS

d. 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS

e. 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS

f. 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS

g. 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION

h. 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS

i. 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS

j. 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS

k. 33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION)

l. 40 17 26.00 20 WELDING PRESSURE PIPING

m. 22 00 00 PLUMBING, GENERAL PURPOSE

n. 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS

1.3 SYSTEM DESCRIPTION

1.3.1 Design Requirements

****
NOTE: The Energy Policy Act of 2005 and UFC 1-200-02 require new buildings to use 30 percent less energy than the ASHRAE 90.1 - SI ASHRAE 90.1 - IP baseline.
****

1.3.1.1 Boiler Design and Service Conditions

a. Design pressure: [_____] kPa (gage) psig

b. Operating pressure: [_____] kPa (gage) psig

c. Steam temperature: [_____] degrees C F

d. Feedwater temperature: [_____] degrees C F

e. Site elevation: [_____] meters feet

f. Ambient air temperature:

Minimum: [_____] degrees C F

Maximum: [_____] degrees C F

g. Maximum continuous output (steam): [_____] kg/sec lb/hr

h. Excess air leaving the boiler: [_____] percent

i. Gas temperature leaving boiler: [_____] degrees C F

j. Total forced draft fan static pressure: [_____] Pa inches WC

k. Gas draft at boiler outlet: [_____] Pa inches WC

l. Oxygen (O2) concentration in flue gas: [_____] percent

m. Carbon monoxide (CO) flue gas concentration: [_____] ppm

n. Nitrogen oxide (NOx) conc. in flue gas: [_____] ppm

****

NOTE: Due to limited manufacturer and boiler size options for FEMP stated efficiency requirements, this document includes boiler efficiency requirements in conformance with ASHRAE 90.1. ASHRAE 90.1 requires that low and medium pressure boilers used primarily in commercial space heating applications meet the following thermal (Et) or combustion (Ec) efficiencies.

Natural Gas-fired Steam (excluding natural draft) rated at 88 kW 300,000 Btuh capacity and larger, Et = 79 percent.

Natural Gas-fired - Natural Draft Steam rated at 88 kW 300,000 Btuh capacity and larger, Et = 77 percent.

#2 Oil-fired Steam rated at 88 kW 300,000 Btuh capacity and larger, Et = 81 percent.

Include all equipment efficiencies on the equipment schedules on the drawings.

****

o. Boiler thermal efficiency: [_____][_____] percent

1.3.1.2 Economizer

a. Design pressure: [_____] kPa (gage) psig

b. Operating pressure: [_____] kPa (gage) psig

c. Fuel [Natural Gas] [No.: [_____] Fuel Oil]

d. Specific heat of the flue gas: [_____] kJ/kg. C Btu/lb-degree F

e. Feedwater flow: [_____] L/s gpm

f. Flue gas temperature entering economizer: [_____] degrees C F

g. Flue gas temperature leaving economizer: [_____] degrees C F

h. Feedwater temperature entering economizer: [_____] degrees C F

i. Feedwater temperature leaving economizer: [_____] degrees C F

****

NOTE: Unless fuel oil to be burned has an uncommon tendency to foul tubes, finned tube economizers should be suitable for gas and oil. Feedwater temperatures should be 110 degrees C 230 degrees F when sulphur (S) content of oil is 0.5 percent to 1.5 percent; 116 degrees C 240 degrees F, S=1.5 percent to 2 percent; 121 degrees C 250 degrees F, S=2.0 percent to 2.7 percent.

****

j. Maximum pressure drop, economizer gas side: [_____] Pa in. WC

k. Maximum pressure drop, economizer water side: [_____] kPa psi

l. Fouling factor on feedwater side: [_____]

m. Fouling factor on gas side: [_____].

1.3.1.3 Fans

Design fan to handle air at temperatures from [_____] to [_____] degrees C F. Fan shall be [single] [double] width inlet, [single] [double] width outlet, with [clockwise] [counter clockwise] rotation when viewed from the motor end.

1.3.1.4 Expansion Joints and Stacks

a. Temperature:

(1) Maximum ambient: [_____] degrees C F

(2) Minimum ambient: [_____] degrees C F

(3) Inlet gas at maximum gas flow (gas): [_____] degrees C F

(4) Inlet gas at maximum gas flow (oil): [_____] degrees C F

(5) Inlet gas at minimum gas flow (gas): [_____] degrees C F

(6) Inlet gas at minimum gas flow (oil): [_____] degrees C F.

b. Gas Flow at Inlet

(1) Maximum: [_____] kg/s lb/hr

(2) Minimum: [_____] kg/s lb/hr

c. Required Net Available Draft at Stack Inlet At maximum gas flow: [_____] Pa inches water

d. Gas Exit Velocity (Cone Exit) Maximum at maximum conditions: [_____] m/s ft/sec

e. Flue Gas Acid Dew Point Fuel oil: [_____] degrees C F

f. Test Pressures Shop Test: [_____] Pa inches water

g. Thermal Efficiency of Stack: 96 to 98 percent

h. Stack Friction Maximum at design conditions: [_____] Pa inches water

i. Stack Height

(1) Ground elevation: [_____] m ft

(2) Roof elevation: [_____] m ft

(3) Stack height: [_____] m ft

(4) Foundation or footing elevation: [_____] m ft

j. Wind pressure: [_____] Pa psf

k. Wind velocity, gusting: [_____] km/h mph

l. Stack Diameter Minimum (below exit cone): [_____] mm inches

m. Stack deflection Maximum (from vertical center line): [_____] mm inches

n. Soil bearing stress, maximum: [_____] kg/m2 psf

o. Seismic zone: [_____].

1.3.1.5 Vertical Fuel Oil Storage Tanks

Design the tank to resist the following loads and forces:

Wind: [_____] Pa pounds per square foot

Seismic zone: [_____]

Roof live load: [_____] kg/m2 pounds per square foot

Density of liquid: [_____] kg/m3 pounds per cubic foot.

Allow the following combinations of loads, with corresponding percentages of basic stresses to be used in design:

Load Combination	Percent of Basic Stress
Dead load plus live load	100
Dead load plus live load plus wind load	133
Dead load plus live load plus seismic load	133

1.3.1.6 Fuel Oil Pump and Heater Set

****

NOTE: Tabulated pump data is included in the specifications but it is preferred that such information be shown on the drawings instead.

****

a. Pump/Heater Set

(1) Capacity each pump and each steam heater: [_____] L/s gpm

(2) Suction lift: [_____] kPa ft of water

(3) Discharge pressure at outlet of heater: [_____] kPa (gage) psig

(4) Maximum pump speed: 1750 rpm

(5) Specific gravity range: [.92 to .99] [_____to_____]

(6) Viscosity at BHP selection point: 5000 ssu

(7) Viscosity range: [500 to 5000] ssu [_____to_____] ssu

(8) Oil temperature at inlet of heater: [_____] degrees C F

(9) Oil temperature at outlet of heater: [_____] degrees C F

(10) Maximum oil pressure drop through heater: [_____] kPa psi

(11) Heating medium: Steam

(12) Steam pressure available: [_____] kPa (gage) psig

(13) Steam temperature: [_____] degrees C F

(14) Heater type: [Bare Tube] [Extended Surface]

b. Fuel Oil Heater Set With Electric Startup Heater

(1) Oil temperature at inlet of heater: [_____] degrees C F

(2) Oil temperature at outlet of heater: [_____] degrees C F

(3) Maximum oil pressure drop through heater: [_____] kpa psi

(4) Capacity of heater: [_____] L/s gpm

(5) Heating power supply at three phase, 60 Hz: [_____] volts

(6) Control power supply 120 volts, single phase, 60 Hz.

1.3.1.7 Deaerating Heater

a. Design pressure: 207 kpa (gage) 30 psig

b. Normal steam operating pressure: [_____] kPa (gage) psig

c. Maximum steam operating pressure: [_____] kPa (gage) psig

d. Capacity (minimum): [_____] kg/sec lb/hr of feedwater

e. Inlet Conditions at Heater:

	Pressure kPa(gage)	Temperature Range Degrees C	Maximum Flow Rate kg/sec
(1) Condensate return	[_____]	[_____] to [_____]	[_____]
(2) High pressure trap returns	[_____]	[_____] to [_____]	[_____]
(3) Makeup water (softened)	[_____]	[_____] to [_____]	[_____]

	Pressure psig	Temperature Range Degrees F	Maximum Flow Rate lb/hr
(1) Condensate return	[_____]	[_____] to [_____]	[_____]
(2) High pressure trap returns	[_____]	[_____] to [_____]	[_____]
(3) Makeup water (softened)	[_____]	[_____] to [_____]	[_____]

f. Outlet temperature of feedwater from heater at design capacity: [_____] degrees C F

g. Heating steam pressure: [_____] kPa (gage) psig

h. Heating steam enthalpy: [_____] kJ/kg Btu/lb

i. Storage capacity to overflow of tank: [_____] liters gallons storage.

1.3.2 Detail Drawings

1.3.2.1 Boiler

Show arrangement and details of foundations, plans, elevations, wall sections, insulation, tubing details, expansion joints, external piping details and schematics, wiring schematics, [economizer and economizer structural details]. Submit descriptive information with the drawings on each item of the drawings.

1.3.2.2 Boiler Room Auxiliary Equipment

Drawings shall show equipment arrangements, wiring and piping diagrams. Include descriptive information for each item shown. Submit drawings showing the following:

a. Water softening equipment

b. Brine storage tank

c. Condensate receiver

d. Condensate transfer pumps including certified performance curves

e. Deaerator

f. Boiler feed pumps including certified performance curves

g. Steam turbines

h. Continuous blowdown system

i. Chemical feed units

j. Air compressors

k. Air dryers

l. Cranes and hoists

m. Plant heating and ventilating equipment and related ductwork

1.3.2.3 Burners

Submit drawings showing the following:

a. General arrangement

b. Piping details

c. Burner control schematics

d. Flame safety schematics

e. Component details

f. Throat tile details

1.3.2.4 Dampers, Stacks, and Breechings

Submit drawings showing the following:

a. General arrangement

b. Breeching and reinforcing details

c. Breeching hangers and support details

d. Dampers and operators

e. Access doors and frames

f. Expansion joints

g. Stack details

For stack details, include anchor bolt and foundation details, stack sampling ports, platforms, and accessories.

1.3.2.5 Fuel Oil Equipment

Drawings may be manufacturer's standard size for pumps, pump curves, valves, strainers manufacturer's standard size for pumps, pump curves, valves, strainers and pump wiring. Submit drawings showing the following:

a. Certified outline and general arrangement

b. Certified pump curves

c. Equipment detail sheets including viscosity controller, heater, valves

d. Electrical wiring diagrams

e. Oil tanks, foundations, tank heaters, appurtenances, water drawoff,

level indication

1.3.2.6 Piping and Specialty Items

Drawings may be manufacturer's standard size. Submit drawings showing the following:

a. Details of special valves and fittings

b. Feedwater regulator details and schematics

c. Details and schematics of feedwater automatic recirculation

1.3.2.7 Ball Joint Installation Details

Include allowable angular flex and minimum offset dimensions for approval.

1.3.2.8 Reproducible Drawings

Submit one reproducible mylar shop drawing of each approved drawing sheet to the Contracting Officer for the following items:

a. Boiler layout, construction and details

b. Breeching layout and details

c. Burner control schematics and burner details

d. Wiring diagrams

e. Fuel oil tanks, foundations and appurtenances

f. Automatic feedwater recirculation system

g. Piping schematics

1.3.3 Design Data

1.3.3.1 Engineering Calculations

Furnish the following calculations from the manufacturer:

a. Foundation (including bearing and moment forces) and anchor bolts.

b. Stack

(1) Stresses due to various loading conditions including wind and seismic loads.

(2) Vibration and damping.

(3) Heat transfer at various design and ambient conditions.

(4) Expansion profiles.

(5) Shipping and erection stress analysis.

1.3.4 Test Reports

Submit the predicted economizer performance along with and as part of the boiler predicted performance report.

1.3.5 Performance Requirements

1.3.5.1 Boiler

****

NOTE: When analyses of the specific fuels to be burned are known, insert the proper values in this paragraph. When unknown and the analyses given in FS F-B-2902 are sufficient, omit this paragraph.

****

Base performance requirements, including furnace heat release rates, on the following ultimate analysis and high heating values.

a. Fuel Oil Analysis

(1) Grade of fuel oil: [_____]

(2) Ultimate analysis (percent by weight, as fired)

Carbon	[_____]
Hydrogen	[_____]
Nitrogen	[_____]
Sulfur	[_____]
Oxygen (O2)	[_____]
TOTAL	[_____]

(3) Heating valve: [_____] kJ/kg Btu/lb

(4) Specific gravity: [_____] degrees API

(5) Viscosity at burner: [_____] SSF at 50 degrees C 122 degrees F

(6) Water and sediment: [_____] percent by volume

(7) Flash point: [_____] degrees C F.

b. Natural gas analysis

(1) Proximate Analysis (percent by volume, as fired)

Methane:	[_____] percent
Ethane:	[_____] percent

Propane:	[_____] percent
Butane:	[_____] percent
Carbon Dioxide:	[_____] percent
Nitrogen:	[_____] percent
Miscellaneous:	[_____] percent
TOTAL	[_____] percent

(2) Ultimate analysis (percent by weight, as fired)

Hydrogen:	[_____] percent
Carbon:	[_____] percent
Nitrogen:	[_____] percent
Oxygen:	[_____] percent
Miscellaneous:	[_____] percent
TOTAL	[_____] percent

(3) Heating value: [_____] kJ/m3 Btu/cu ft

(4) Heating value: [_____] kJ/kg Btu/lb

(5) Density: [_____] kg/m3 lb/cu ft

(6) Specific gravity: [_____].

1.3.5.2 Economizer

The increase in efficiency due to the economizer shall be not less than [_____] percent at full load. Fully coordinate the economizer with the boiler to which it is to be applied.

1.3.5.3 Oil Burner/Windbox Package

Burner turndown ratio on specified fuel oil shall be not less than eight to one, with excess air not over 15 percent at full steam load, and excess air not over 22 percent at 20 percent steam load. [Air flow shall be modulated through a single set of register louvers.]

1.3.5.4 Oil and Gas Burner/Windbox Package

Burner turndown ratio shall not be less than eight to one, when firing fuel oil only and ten to one when firing natural gas only with excess air not over 15 percent at full steam load, and excess air not over 22 percent at 20 percent steam load. [Air flow shall be modulated through a single set of register louvers.]

1.4 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 and Air Force 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.

****

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. Submittals not having a "G" or "S" classification are 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:

Submittals required by this section require the approval of the Contracting Officer. Within [60] [75] [90] days after award of the contract, shop drawings accompanied with complete manufacturer's descriptive information shall be submitted for approval as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS. Drawing size shall be 841 by 594 mm 34 by 22 inches.

SD-02 Shop Drawings

Boiler; G, [_____]

Boiler Room Auxiliary Equipment; G, [_____]

Burners; G, [_____]

Dampers, Stacks, and Breechings; G, [_____]

Fuel Oil Equipment; G, [_____]

Piping and Specialty Items; G, [_____]

Ball Joint Installation Details; G, [_____]

Reproducible Drawings; G, [_____]

SD-03 Product Data

Insulation Types and Installation Procedures; G, [_____]

Boiler

****
NOTE: Include refrigerant submittal when a compressed air refrigerated air dryer is included.
****

[Refrigerant (compressed air refrigerated air dryers) - Provide SDS sheets for all refrigerants

] SD-05 Design Data

Engineering Calculations; G, [_____]

SD-06 Test Reports

Boiler Predicted Performance

Economizer Performance

Variable Speed Motor Controller; G, [_____]

Submit certified copies of design, production and conformance tests for approval before delivery of the equipment.

Hydrostatic and Leak Tightness Tests; G, [_____]

Preliminary Operation; G, [_____]

General Startup Requirements; G, [_____]

Fuel Oil Tanks; G, [_____]

Boilers and Auxiliaries Tests and Inspections; G, [_____]

Submit for tests and inspections as specified in the paragraph FIELD QUALITY CONTROL. Submit a detailed written record of test conditions, test procedures, field data, and startup and operational performance of entire heating plant to the Contracting Officer before the Contractor's operational and test personnel leave the site.

Aquatic Toxicity

SD-07 Certificates

Compatibility of Boiler Components and Equipment; G, [_____]

System and Equipment Installation; G, [_____]

Tank Calibration; G, [_____]

Backflow Preventer; G, [_____]

Submit the required information and experience certificates as specified under the paragraph EXPERIENCE REQUIREMENTS, within 30 days after award and prior to commencing work on the site.

Identical Equipment; G, [_____]

Ozone Depleting Substances Technician Certification

SD-10 Operation and Maintenance Data

Boiler, Data Package 3; G, [_____]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include the following supplemental information in addition to the requirements of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS.

a. Illustrations, catalog information, shop drawings, and certified drawings of each item of equipment and control components

b. Tests and Test Results

c. Adjustments

d. Fan and Blower Characteristics Curves

e. Pump Characteristic Curves

f. Boiler Predicted Performance Data

g. List of Special Tools Required

h. Posted Operating Instructions

i. Controls Drawings, Setup and Calibration Data

1.5 QUALITY ASSURANCE

1.5.1 Experience

1.5.1.1 Experience Requirements

****
NOTE: Verify number of manufacturers' installations operating and years of operation for boiler, forced draft fan, burner/windbox package and control systems to avoid an unnecessarily restrictive experience requirement.
****

The boiler(s), with auxiliary equipment installed, within, or as a part of

the heating plant, shall be of a proven design; the manufacturer shall be regularly employed in designing, fabricating, erecting, testing and startup of the equipment.

1.5.2 Responsibility of the Boiler Manufacturer

Contractor shall ensure that the manufacturers of boiler components and auxiliaries provide equipment compatible with the boiler. Equipment includes but is not limited to the following: Blowdown valves, burner/windbox package, combustion control system, emission control components, fans, economizer, refractories, insulation, sootblowers, steam separator, scanner, [air preheater,] dust collector, breeching between boiler outlet and stack inlet, boiler trim, safety valves and drains.

1.5.3 Standard Commercial Product

Boilers and equipment shall be manufactured in accordance with the requirements of this specification and shall be the manufacturer's standard commercial product. Additional or higher quality features which are not specifically prohibited by this specification, but which are a part of the manufacturers' standard commercial product, shall be included in the boilers and equipment being provided. A standard commercial product is a product which has been sold or is being currently offered for sale on the commercial market through advertisements or manufacturer's catalogs, or brochures, and represents the latest production model.

1.5.4 Modification of References

In API Std 650, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" and "suggested" wherever they appear.

1.5.5 Assembly of Components

The equipment shall be factory assembled except for steam generators which may utilize factory assembled components to the maximum extent to facilitate erection and minimize field labor.

1.5.6 Certificates

1.5.6.1 Backflow Preventer

Certificates of Approval for each backflow preventer from the Foundation for Cross-Connection Control Research, University of Southern California, and shall attest that this design, size, and make of backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. A Certificate of Provisional Approval will not be acceptable in lieu of the above.

1.5.6.2 Compatibility of Boiler Components and Equipment

Contractor shall submit certifications from the boiler manufacturer stating that boiler components, including auxiliary equipment, are compatible with the boiler. Certificates of compatibility for boiler components and auxiliary equipment not directly produced by the boiler manufacturer may be submitted through the boiler manufacturer.

1.5.6.3 System and Equipment Installation

Contractor shall submit written certification from each system supplier and each manufacturer of the equipment that the system and equipment installation is in accordance with the system supplier's and equipment manufacturer's instructions and recommendations, that the unit or system has been run, rotating parts have been dynamically balanced, fluid (including air) flows have been balanced, instrumentation and controls are properly functioning, adjusted and have been calibrated, and the equipment or system is ready for final testing. Certificates shall be submitted before the entire boiler plant may be given an acceptance test.

1.5.6.4 Tank Calibration

Submit four copies of a certified record of the vertical fuel oil tank calibration.

1.5.6.5 Backflow Preventer

Submit a Certificate of Full Approval or a current Certificate of Approval for each design, size, and make of backflow preventer being provided for the project.

1.5.6.6 Identical Equipment

Contractor shall submit evidence from the equipment manufacturer to show that substantially identical equipment produced by the manufacturer and of comparable operating parameters (within plus or minus 20 percent) has been successfully installed and operated in not less than [one] [two] [three] installations under comparable operating conditions for a period of not less than two years.

1.5.6.7 Ozone Depleting Substances Technician Certification

****

NOTE: The following paragraph requires a certification for technicians who work on equipment that could release ozone depleting refrigerants into the atmosphere. This is required as of January 1, 2018 to meet the requirements of 40 CFR 82, Subpart F.

****

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.6 DELIVERY, STORAGE, AND HANDLING

Each assembly of components packaged as a unit shall be of a size that can be transported by common carrier without disassembly insofar as shipping clearances are concerned.

1.7 ENVIRONMENTAL REQUIREMENTS

1.7.1 Burner Emission Requirements

The emission requirements shall be met at the maximum required continuous output. The burner shall meet environmental rules and regulations. Emission requirements to be considered are oxides of nitrogen (NOx), opacity, particulate, sulfur dioxide, and carbon monoxide. Other emission requirements may be imposed.

1.7.1.1 NOx Emission Regulations

Compliance shall be met using [one] [a combination] of the following:

a. Low NOx burners

b. Flue gas recirculation equipment which conforms to UL 795

c. Other NOx reduction techniques. See Nitrogen oxide control for stationary combustion sources.

1.7.1.2 Aquatic Toxicity

Assess potential effects of all lubricants on aquatic organisms in accordance with ASTM D6081 and submit aquatic toxicity reports. Assess biodegradation in accordance with ASTM D5864. In accordance with EM 1110-2-1424 Chapter 8, aquatic toxicity shall exceed 1,000 ppm at LL50 and biodegradation shall exceed 60 percent conversion of carbon to carbon dioxide in 28 days.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials free of defects which could adversely affect the performance or maintainability of individual components or of the overall assembly. Materials not specified herein shall be of the same quality used for the intended purpose in commercial practice. Unless specified otherwise herein, equipment, material, and articles incorporated in the work covered by this specification shall be new.

2.1.1 Identical Equipment

Provide physically and mechanically identical boilers and equipment of the same classification size or capacity to permit the interchangeability of replacement parts. This requirement includes parts, assemblies, components, and accessories. Parts provided on the same type unit regardless of unit size and identifiable by identical part number shall be functionally and dimensionally interchangeable. No deviation is acceptable without prior written approval of the Contracting Officer.

2.2 BOILERS

2.2.1 Packaged Watertube Boiler

FS F-B-2902, Type [_____] except as modified below. Provide lifting attachments.

2.2.2 Tubes

****
NOTE: Use this paragraph when tube diameters larger than specified in FS F-B-2902 are desired and insert minimum acceptable diameter.
****

Boiler and furnace tubes shall be at least [_____] mm inches in outside diameter.

2.2.3 Furnace

****
NOTE: When a D-type boiler is acceptable, use this paragraph and insert desired hand.
****

Furnaces for D-type boilers shall be on the [_____] hand side of the drums when viewed from the front of the boiler.

2.2.4 Transition

****
NOTE: This paragraph should be used when a breeching transition piece is desired to be provided with the boiler.
****

Provide a transition piece to permit adapting the [boiler] [economizer] outlet to the [stack] [breeching]. Design transition pieces for [vertical] [horizontal] discharge.

2.2.5 Combustion Controls

As specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

2.2.6 Access and Observation Doors

Provide boiler with sufficient number of access doors and observation doors, to give free and easy access and observation to all parts of the interior of the boiler.

2.3 ECONOMIZERS

****
NOTE: Economizers shall be specified for all boilers with operating pressure greater than 345 kPa (gage) 50 psig and a capacity of 2 1/4 kg per second 18,000 pounds per hour and larger. For boilers from 1/2 to 2 1/4 kg per second 4,000 to 18,000 pounds per hour the designer shall make the decision based upon a specific economic analysis. This paragraph shall be included as applicable.
****

****
NOTE: Unless fuel oil to be burned has an uncommon tendency to foul tubes, finned tube economizers

should be suitable for gas and oil. Feedwater temperatures should be 110 degrees C 230 degrees F when sulphur (S) content of oil is 0.5 percent to 1.5 percent; 116 degrees C 240 degrees F, S=1.5 percent to 2 percent; 121 degrees C 250 degrees F, S=2.0 percent to 2.7 percent.

****

Provide a modular unit constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section 1, of one of the following types:

a. Internal Tubular Type: Boiler feedwater flows through the outer shell and flue gases circulate up through internal tubes provided with removable flue gas spinners.

b. Finned or Spiral Wound Tube Type: Feedwater circulates through finned tubes and flue gas flows through outer shell.

2.3.1 Construction

Provide manufacturer's standard economizer design for the operating conditions and the fuel(s) specified. Coordinate the amount of heating surface with the flue gas conditions exiting the boiler or boilers on which the economizer is to be applied to preclude reaching the "acid dew point" for the fuels specified. When necessary (if there is sulfur in the specified fuel, and the designed inlet temperature could fall below the acid dew point), provide a feedwater temperature control system to maintain temperatures above the acid dew point. Provide casing of not less than 12 gage steel plate reinforced as required with support lugs and breeching flanges. Provide building framing steel to support the economizer. [Provide built-in soot blower for each economizer to thoroughly clean the surfaces exposed to the flue gas.] Design the economizer so that internal construction can be easily cleaned and inspected.

2.3.2 Equipment

Provide the following equipment for each unit:

a. Relief valve.

b. Shutoff gate valve on feedwater outlet and shutoff globe valve on inlet with globe valve bypass. Size valves as shown in economizer piping detail.

c. Temperature indicator on feedwater outlet.

d. Temperature indicator on feedwater inlet.

e. Temperature indicator on flue gas outlet.

f. Temperature indicator on flue gas inlet.

g. Temperature alarm switches for high and low flue gas temperatures.

h. Alarm with trouble light and silencing switch.

i. Panel with annunciator and temperature indicators for feedwater inlet, feedwater outlet, flue gas inlet and flue gas outlet for each

economizer.

j. A drain valve downstream of the economizer before the shutoff valve.

k. A stack flue gas temperature control system to control and limit flue gas temperature to not less than 149 degrees C 300 degrees F by modulating motorized feedwater control valves in a bypass around the economizer. Provide shutoff valve on each side of the control valves with a strainer upstream of each valve. Provide this system in parallel to the manual shutoff and bypass described above.

l. Differential pressure indicator on water side.

m. Differential pressure indicator on gas side.

n. Pressure gages on feedwater inlet and outlet.

2.3.3 Insulation

Insulate the economizer with not less than the equivalent of 50 mm 2 inches of mineral wool insulation and lag with not less than 27 gage galvanized, weatherproof lagging.

2.4 BURNER AND WINDBOX PACKAGES

2.4.1 Oil Burner/Windbox Package

****
NOTE: The designer shall fill in the appropriate information as defined in FS F-B-2910.
****

Provide a fully modulating, oil burner conforming to FS F-B-2910, Size [_____], Class [_____], Control sequence [_____], Combustion control system [_____] except as modified below. Provide burner with windbox, [forced draft fan,] dampers, fuel train and associated controls to comprise a complete factory assembled package. Total heat input to the boiler furnace shall be provided by [_____] burners. The burner package shall be considered an integral part of the steam generator and shall be subject to applicable provisions of the boiler design and service together with requirement of tests, performance guarantees and other warranties specified for the boiler.

2.4.1.1 Oil Burner

****
NOTE: At the text below, for boilers below 3.15 kg/sec 25,000 pounds per hour the designer shall select either compressed air or steam atomization after performing an economic analysis. For 3.15 kg/sec 25,000 pounds per hour and above, atomization shall be by compressed air unless steam pressure is required for greater turndown.
****

a. Oil Burner Characteristics: The burner shall be quiet in operation and shall operate with a balanced clean stable flame so as not to localize heat in any part of the combustion chamber. The burner shall be capable of completely atomizing and effectively mixing the oil with

air so as to insure complete combustion. The air admitted shall be of sufficient quantity for complete combustion, but not of such quantity as to produce an undue percentage of excess air with attendant high stack loss. The burner shall operate without clogging or failure, and shall have sufficient capacity to develop not less than the specified capacity. The burner unit shall be easily removed from firing position and readily accessible for inspection, cleaning, and other purposes. Provide observation ports to view operation of burner. There shall be no flame impingement on the sidewalls, top, bottom or rear walls of the furnace. Burner manufacturer shall furnish, and Contractor shall install refractory throat tiles or other items required for proper installation of burner.

b. Atomization: Burner shall be [steam atomizing; steam pressure at header is [_____] kPa (gage) psig; steam temperature at header is [_____] degree C F] [air atomizing; filtered compressed air shall be available for burner atomization and the maximum requirement for each burner shall not exceed [_____] standard L/s scfm of air at [_____] kPa (gage) psig]. Provide pressure reducing valve and controls as required.

c. Electric Ignition System: Burner shall be equipped with an electric ignition system. System shall be either the high energy ignition or glow rod type. Gas ignition system is not acceptable. The high energy ignition system shall use stored energy to develop 2000 Vdc pulses. The glow rod system shall use a low voltage, carbon rod electrode which develops a tip temperature of 1427 degrees C 2600 degrees F. Provide ignition system complete in all respects.

d. Windbox: Construct of carbon steel plate not less than 10 gage thickness with 6 mm 1/4 inch thick front plate. Design windbox to provide even and uniform air entrance into the burner register and seal weld to the boiler front wall. Provide windbox with support legs.

e. Purge Connection: Provide [steam] [air] purge connection, properly valved, for purging oil from gun prior to removal from burner.

****
NOTE: At the text below, provide aspirating system only for boilers in which the expected furnace pressure exceeds 1245 Pa 5 inches water.
****

[f. Aspirating System: Provide an air aspirating system for the fuel oil atomizer guide pipes to prevent blowback of hot furnace gases. Aspirating system shall use approximately [_____] L/s scfmof [_____] kPa (gage) psig compressed air.

] g. Piping: Provide piping and flexible hoses for the guide pipe purge [and aspirating] system[s]. Air from the forced draft fan shall be used for guide pipe purging during normal operation.

h. Material: All metal parts exposed to radiant heat, including the atomizer shield, shall be of stainless steel or other approved alloy.

i. Fuel Oil Control Valve: Fuel oil will be supplied at [_____] kPa (gage) psig and [_____] degrees C F at the inlet of the fuel piping train. Size fuel oil automatic control valve for 103 kPa 15 psi differential pressure as specified in Section 23 09 53.00 20 SPACE

TEMPERATURE CONTROL SYSTEMS.

(1) j. Fuel: ASTM D396, Grade no. [_____].

****
NOTE: At the text below, the designer shall make a technical evaluation to determine if the forced draft fan should be integrated with or mounted separately from the windbox on the floor next to the boiler. If the forced draft fan is to be mounted separately, delete this paragraph and specify the fan in the paragraph FANS.
****

[j. Forced Draft Fan: Fan shall be fully integrated with and mounted on the windbox. Provide an inlet silencer, if required, to insure operation at noise level below 85 dBA.

k. Electric Motor: Motor shall be [variable speed], [_____] volt, [_____] phase, 60 Hz, [totally enclosed, non-ventilated] [totally enclosed, fan cooled], not less than [_____] hp as specified under MOTORS AND DRIVES in this section.

]2.4.1.2 Flame Safeguard Controls

a. General: Provide a complete system of valves, interlocks and controls in accordance with NFPA 85 and FM DS 12-17.

b. Fuel Oil Train: Provide fuel oil train consisting of [steam] [air] atomizing oil gun, auxiliary [steam] [air] atomizing oil gun for changing guns without a shutdown, fuel oil control valve, two safety shutoff valves, recirculation valve, strainer, and flexible hose connections to oil burner. Provide low oil pressure and low atomizing air pressure switches, and other safety interlocks and devices as required. Provide in panel mounted on burner package the following gages. Gages shall be 150 mm 6 inch diameter with white coated dials and black lettering:

(1) Fuel oil supply pressure (0 to 1034 kPa (gage) 150 psig)

(2) Fuel oil pressure at burner (0 to 1034 kPa (gage) 150 psig)

[(3) Atomizing air pressure at burner (0 to 1034 kPa (gage) 150 psig)

][(4) Atomizing steam pressure at burner (0 to 1034 kPa (gage) 150 psig)

] c. Control Sequencing: Flame safeguard system shall be designed to insure safe purge, light-off and shutdown procedures, and to monitor light-off, main flame and boiler operating conditions.

[(1) Control Type: Flame safeguard system shall be of the automatically sequenced type with programming timed and sequenced by a heavy duty, industrial type timer. This timer shall be tamper-proof and shall be designed so that advancement of the timer to shorten purge will shut down the unit.

] (2) Scanner and Relay: Provide system with [ultraviolet] [infrared] scanner and electronic relay located in the front wall which will shut down the fuel within 2 to 4 seconds of loss of flame.

(3) Output Meter: Provide scanner output meter in panel for indication of scanner signal strength.

(4) Limit Devices: Safety system shall include the following limit devices incorporated into a limit circuit:

(a) Flame failure

(b) High boiler outlet pressure

(c) Low fuel oil pressure

(d) Low water level cutout

(e) Low combustion air flow

(f) Low atomizing [air] [steam] pressure

(g) Any additional as required by FM DS 12-17 or NFPA 85

[(h) Low fuel oil temperature

] (5) Annunciator: Safety system limits specified above shall be displayed on a first out annunciator mounted in the burner panel. [Provide a common alarm contact to be wired to the operator control console, specified under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.]

d. Light Off: Failure shall require a manual restart of the programmer. Safety system shall provide a mandatory purge with the forced draft fan vanes proven open, and a return to proven low fire position before light off. Main fuel valve shall open for a timed period of 10 seconds during trial for ignition.

e. Circuit Analyzer: Provide a circuit analyzer system, which, by means of 12 or more lights, will indicate which circuits are energized at any specific time, and will thereby indicate improperly operating circuit.

f. Control Panel: Programmer, limit control, relays, annunciator, shall be mounted in a [NEMA 1 control panel, modified with fully gasketed doors and panels mounted on burner package] [control panel as specified under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.]

2.4.2 Oil and Gas Burner/Window Package

****
NOTE: Choose this paragraph and subparagraphs or the paragraph and subparagraphs above, OIL BURNER/WINDBOX PACKAGE.
****

Provide, fully modulating, dual fuel burner conforming to FS F-B-2910, Class [_____], Combustion control system [_____] except as modified below. Provide burner with windbox, [forced draft fan,] dampers, fuel train and associated controls to comprise a complete factory assembled package. Total heat input to the boiler furnace shall be provided by

[_____] burners. Burner package shall be considered an integral part of the steam generator and shall be subject to applicable provisions of the boiler design and service together with requirement of tests, performance guarantees and other warranties specified for the boiler.

2.4.2.1 Burner

a. Burner Characteristics: The burner shall be quiet in operation and shall operate with a balanced clean stable flame so as not to localize heat in any part of the combustion chamber. The burner shall be capable of completely atomizing and effectively mixing the oil with air so as to insure complete combustion. The air admitted shall be of sufficient quantity for complete combustion, but not of such quantity as to produce an undue percentage of excess air with attendant high stack loss. The oil burner shall operate without clogging or failure, and shall have sufficient capacity to develop not less than the specified capacity. The burner unit shall be easily removed from firing position and readily accessible for inspection, cleaning, and other purposes. Provide adequate observation ports on burner. There shall be no flame impingement on the sidewalls, top, bottom or rear walls of the furnace. Contractor shall install refractory throat tiles or other items provided by the burner manufacturer which may be required for proper installation of the burner.

b. Atomization: Burner shall be [steam atomizing; steam pressure at header is [_____] kPa (gage) psig; steam temperature at header is [_____] degree C F] [air atomizing; filtered compressed air shall be available for burner atomization and the maximum requirement for each burner shall not exceed [_____] L/s scfm of air at [_____] kPa (gage) psig]. Provide pressure reducing valve and controls as required.

[c. Electric Ignition System: Burner shall be equipped with an electric ignition system. System shall be either the high energy ignition or glow rod type. Gas ignition system is not acceptable. High energy ignition system shall provide stored energy to develop 2000 volt DC pulses. Glow rod system shall provide a low voltage, carbon rod electrode which develops a tip temperature of 1427 degrees C 2600 degrees F. Provide ignition system complete in all respects.
]

****
NOTE: At the text below, a gas pilot ignition system is optional for a combination oil/gas burner.
****

[d. Natural Gas Pilot Ignition System: Provide a complete interrupted type natural gas-fired, spark ignited pilot system for the burner assembly. Combustion air supply shall be from the burner windbox. Lighting system shall have capacity to stabilize the firing during startup periods. Lighter shall be arranged for easy removal and servicing while the boiler is in operation. Furnish igniter complete with a spark rod and a power pack. Power pack shall operate on 120 volt, 60 cycle, single phase power. Provide gas piping, to one point of supply, including necessary gas pressure regulators. Igniter system shall include controls, gages, flame safety systems, interlocks and accessories to comply with Industrial Risk Insures' (I.R.I) (formerly F.I.A.) requirements and applicable codes and regulations.

] e. Windbox: Construct of carbon steel plate not less than 10 gage thickness with 6 mm 1/4 inch thick front plate. Design windbox to

provide even and uniform air entrance into the burner register and seal weld to the boiler front wall. Provide windbox with support legs.

f. Purge Connection: Provide [steam] [air] purge connection, properly valved, for purging oil from gun prior to removal from burner.

[g. Aspirating System: Provide an air aspirating system for the fuel oil atomizer guide pipes to prevent blowback of hot furnace gases. Aspirating system shall use approximately [_____] L/s scfm of [_____] kPa (gage) psig compressed air.

] h. Guide Pipe Purging: Provide piping and flexible hoses for the guide pipe purge [and aspirating] system[s]. Air from the forced draft fan shall be provided for guide pipe purging during normal operation.

i. Materials: Metal parts exposed to radiant heat, including the atomizer shield, shall be of stainless steel or other approved alloy.

j. Natural Gas Control Valve: Natural gas shall be supplied at [_____] kPa (gage) psig and [_____] degrees C F at the inlet of the fuel piping train. Size the natural gas automatic control valve for [_____] kPa psi differential pressure as specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

k. Fuel Oil Control Valve: Fuel oil will be supplied at [_____] kPa (gage) psig and [_____] degrees C F at the inlet of the fuel piping train. Size fuel oil automatic control valve for 103 kPa 15 psi differential pressure as specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

l. Fuel: ASTM D396, Grade no. [_____] and natural gas.

[m. Forced Draft Fan: Fan shall be fully integrated with and mounted on the windbox. Provide an inlet silencer, when required, to insure operation at noise level below 85 dBA. The F. D. Fan Electric Motor shall be [variable speed], [_____] volt, [_____] phase, 60 Hz, [totally enclosed, non-ventilated] [totally enclosed, fan cooled], not less than [_____] kW hp as specified under MOTORS AND DRIVES in this section.

]2.4.2.2 Flame Safeguard Controls

Provide a complete system of valves, interlocks and controls in accordance with NFPA 85 and as approved by Factory Mutual Engineering and Research.

a. Natural Gas Train: Provide natural gas train consisting of gas ring, gas control valve, two safety shutoff valves, high gas valve, and manual shutoff cock. Provide low gas pressure switch, high gas pressure switch, and other safety interlocks and devices as required. Provide in panel mounted on burner package the following gages. Gages shall be 150 mm 6 inch with white coated dial and black figures.

(1) Natural gas supply (0 to 172 kPa (gage) 25 psig)

(2) Burner gas supply pressure (0 to 172 kPa (gage) 25 psig)

b. Fuel Oil Train: Provide fuel oil train consisting of [steam] [air] atomizing oil gun, auxiliary [steam] [air] atomizing oil gun for changing guns without a shutdown, fuel oil control valve, two safety

shutoff valves, recirculation valve, strainer, and flexible hose connection(s) to oil burner. Provide low oil pressure and low atomizing air pressure switches, and other safety interlocks and devices as required. Provide in panel mounted on burner package the following gages. Gages shall be 150 mm 6 inch with white coated dials and black figures:

(1) Fuel oil supply pressure (0 to 1034 kpa (gage) 150 psig)

(2) Fuel oil pressure at burner (0 to 1034 kPa (gage) 150 psig)

[(3) Atomizing air pressure at burner (0 to 1034 kPa (gage) 150 psig)

][(4) Atomizing steam pressure at burner (0 to 1034 kPa (gage) 150 psig)

] c. Control Sequencing: Flame safeguard system shall be designed to ensure safe purge, light-off and shutdown procedures, and to monitor light-off, main flame and boiler operating conditions.

[(1) Control Type: The flame safeguard system shall be of the automatically sequenced type with complete programming timed and sequenced by a heavy duty, industrial type timer. This timer shall be tamper-proof and shall be designed so that advancement of the timer to shorten purge will shut down the unit.

] (2) Scanner and Relay: Provide system with ultraviolet [and infrared] scanner[s] and electronic relay located in the front wall which will shut down the fuel within 2 to 4 seconds of loss of flame.

(3) Output Meter: Provide scanner output meter in panel for indication of scanner signal strength.

(4) Limit Devices: The safety system shall include the following limit devices incorporated into a limit circuit:

(a) Flame failure

(b) High boiler outlet pressure

(c) Low fuel oil pressure

(d) Low natural gas pressure

(e) High natural gas pressure

(f) Low water level cutout

(g) Low combustion air flow

(h) Low atomizing [air] [steam] pressure

(i) Any additional as required by FM DS 12-17 or NFPA 85

(5) Annunciator: Safety system limits specified above shall be displayed on a first out annunciator mounted in the burner panel. [Provide a common alarm contact to be wired to the operator control console, specified under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.]

d. Light Off: Failure shall require a manual restart of the programmer. Safety system shall provide a mandatory purge with the forced draft fan vanes proven open, and a return to proven low fire position before light off. Main fuel valve shall open for a timed period of 10 seconds during trial for ignition.

e. Circuit Analyzer: Provide a circuit analyzer system, which, by means of 12 or more lights, will indicate which circuits are energized at any specific time, and will thereby indicate improperly operating circuit.

f. Control Panel: Programmer, limit control, relays and annunciator, shall be mounted in a [NEMA 1 control panel, modified with fully gasketed doors and panels mounted on burner package] [control panel as specified under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.]

2.5 FANS

****
NOTE: The designer shall make a technical evaluation to determine if the forced draft fan should be integrated with or mounted separately from the windbox on the floor next to the boiler. If the forced draft fan is to be mounted separately, delete this paragraph and specify the fan in the paragraph FANS.
****

2.5.1 Forced Draft Fan

CID A-A-59222, Type [_____], Class 1, except as specified otherwise.

2.5.1.1 Fan Size

Size fans for complete combustion of fuel at maximum firing rate taking into account design allowances, corrections for burner pressure drop, furnace pressure, combustion air temperature, plant elevation, and other design factors [including allowance for economizer]. After fans have been sized in accordance with the above, add the following allowances for momentary overloads and normal deterioration of fans, firing equipment and boilers:

a. Excess volume: 10 percent

b. Excess pressure: 20 percent

2.5.1.2 Fan Construction

Construct fan wheel of steel. Direction of fan discharge shall be easily changed at angles of 45 degrees. Provide fan with roller bearings mounted in pillow blocks.

2.5.1.3 Electric Motor

****
NOTE: The designer shall perform an economic analysis and make a technical evaluation to

determine if the forced draft fan motor shall be provided with variable speed control. Generally, variable speed drives for forced draft fans over 7 1/2 kW 10 HP will be cost effective.

****

Motor for driving the forced draft fan shall be [variable speed], [two speed], [_____] volt, three phase, 60 Hz, [open drip-proof] [totally enclosed, fan cooled] not less than [_____] kW hp, as specified under MOTORS AND DRIVES in this section, and shall not overload at the specified capacity with unheated cold air. [Provide [_____] mm inch thick steel soleplate for motor. Soleplate must be common for all four motor mounting bolts. Separate parallel soleplate bars are not acceptable.]

2.5.1.4 Noise Level

Noise level shall not exceed 85 dBA sound pressure level at 1 1/2 meters 5 feet above the floor and 1 1/2 meters 5 feet from the fan in any direction. [Provide heavy duty sound attenuator with screen on fan inlet, if required, to meet the sound pressure level requirements.]

2.6 COMPRESSED AIR SYSTEM

****

NOTE: Refer to utilities schedule on definitive drawings for suggested plant air requirements.

****

2.6.1 Plant Compressed Air System

Provide [two] packaged units conforming to FS XX-C-2816 Type [_____], and ASME BPVC SEC VIII D1, except as modified below. Each compressor capacity shall be not less than [_____] L/s scfm of air, at 20 degrees C 68 degrees F and [_____] kPa (gage) psig (equivalent to pressure at an elevation of [_____] meters feet), compressed to 1379 kPa (gage) 200 psig at the discharge. Compressor speed shall not exceed [_____] rpm. Number of stages shall be [_____]. [Compressor shall have water cooled cylinders and heads.] [Oil free delivery is required.] Provide a safety valve between each compressor discharge and its shutoff valve. Provide a shutoff valve on the discharge piping of each compressor. Provide an electric thermostatically controlled immersion heater. Provide compressor with [air cooled] [water cooled] [intercooler and] aftercooler. [Compressor and motor shall be tank mounted.] Provide lifting lugs and tie down attachments.

2.6.1.1 Air Filter

Air filter on inlet shall act as a muffler. Provide filter of the [oil wetted type] [dry type] readily removable for cleaning.

2.6.1.2 Oil Filter

Provide full flow type filter for positive forced feed lubrication conforming to FS F-F-351.

2.6.1.3 Air Receiver

Receiver shall be [_____] cubic meters feet minimum volume designed in conformance with FS XX-C-2816 and ASME BPVC SEC VIII D1, except that

working pressure shall be 1724 kPa (gage) 250 psig. Provide the receiver, with a safety valve set at a pressure not to exceed the maximum allowable working pressure of the receiver, a drain valve and an air trap with shutoff valve. [Provide a stand for mounting the receiver.] Provide a dial gage, not less than 114 mm 4 1/2 inches diameter, range zero to 2068 kPa (gage) 300 psig, on the receiver.

2.6.1.4 Electric Motor

Motor shall be [_____] volt, [_____] phase, 60 Hz, totally enclosed, fan cooled not less than [_____] kW hp, as specified under MOTORS AND DRIVES in this section. Control circuits for motors shall be nominal 120 volts.

2.6.1.5 Controls

Provide [constant speed] [dual control] regulation and the "optional safety controls" as specified in Table I of FS XX-C-2816 for the compressor system. In addition, provide a lead-lag control system with alternating lead-lag cycles.

2.6.2 Instrument Compressed Air System

Provide air compressor package with two compressors, two electric motors, one horizontal receiver, and control panel, [all mounted on one supporting steel base with skids] [mounted separately].

2.6.2.1 Air Compressor

Each air compressor shall be a single stage, cross head type, vertical, double acting, water cooled, nonlubricated head type. Compressor shall be specially designed for non-lubricated service, with a honed cylinder, piston rod packing, piston rings and piston wear rings. Valve guide inserts and wear rings shall be TFE. Valves shall be reversible and hardened, with stainless steel seat plates for nonlubricated service. Provide necessary sleeves, baffles, and collars to prevent oil carryover. Provide air operated, piston type, free air unloaders for capacity reduction and starting. Mount filter-silencer directly on the air inlet to the cylinder.

Design and Performance: Each compressor shall deliver not less than [_____] L/s scfm of free air at a discharge pressure of 690 kPa(gage) 100 psig.

2.6.2.2 Air Receiver

Air receiver shall be a horizontal tank with a volume not less than [_____] cubic meters feet. Design unit for 1034 kPa (gage) 150 psig working pressure in accordance with ASME BPVC SEC VIII D1. A receiver bearing the ASME Code Symbol stamp will be accepted as meeting these requirements. Provide an automatic condensate trap, safety valve, and outlet connection.

2.6.2.3 Aftercooler

Aftercoolers shall be water cooled, with counter current flow, and shall be installed directly between each compressor cylinder and the air receiver. Design cooler to cool the total output air flow of the compressor to within minus 9 degrees C 15 degrees F of the inlet cooling water temperature. The tube bundle shall be removable for cleaning and

inspection.

2.6.2.4 Electric Motor

Each compressor shall be V-belt driven by a [_____] volt, [_____] phase, 60 Hz motor not less than [_____] kW hp as specified under MOTORS AND DRIVES in this section. Provide a removable, totally enclosed belt guard.

2.6.2.5 Controls

Provide controls and shutdowns for automatic operation of the compressor package. House controls in NEMA 12 control cabinet. Controls shall include two, full voltage, automatic across-the-line starters; alternator to switch compressors from lead to lag and to run both compressors when required; 120 volt control transformer; air discharge pressure gage; selection switches for constant speed for automatic dual control, along with necessary time delay and control relays. Provide automatic solenoid operated cooling water valve in the cooling water line to the compressors and aftercoolers. Factory wire control cabinet and mount as a part of the package.

2.6.2.6 Accessories

Factory assemble compressors, electric motors, controls, air receiver, aftercoolers, and miscellaneous hardware and mount on steel supporting base. Provide lifting lugs and tiedown attachments. Provide air, water, and condensate piping and terminate them at the edge of the supporting base. Lubricate inspection ports so that they can easily be removed for visual inspections.

2.6.2.7 Air Dryers

****
NOTE: Choose this item or item (b) below REFRIGERATED AIR DRYER.
****

[a. Desiccant Air Dryer: Provide for systems exposed to freezing temperatures a compressed air desiccant dryer with noncorrosive desiccant housed in twin pressure vessels, capable of drying [_____] L/s scfm of air to [_____] degrees C Fpressure dewpoint. Unit shall be field adjustable to maintain the pressure dewpoint of the dried air at any preselected value below operating temperature, to minus 40 degrees C F. As an integral part of the unit provide an indicator showing the water content of the dry air and a calibrated adjustment control to change the water content to any preselected level.

(1) Design: Design unit for maximum temperature of not less than 49 degrees C 120 degrees F and maximum operating pressure of not less than 1034 kPa (gage) 150 psig. Pressure drop through the unit operating at full rated flow shall not exceed 28 kPa 4 psi.

(2) Controls: Provide continuous supply of dry air by automatically cycling operation of the desiccant beds. Dryer shall be complete with panel mounted gages showing pressure in each drying tower and spark suppressor to protect microswitch in timer circuit. Total electrical power requirements shall not exceed 75 watts at 110 Vac.

(3) Filters: Provide prefilter upstream of dryer to remove oil vapor, liquid water, and solid particles. It shall have greater than 99 percent efficiency in removing both 0.5 micron diameter solid particles and 0.5 micron diameter oil aerosol. Filter shall have replaceable oil absorbing filter element which turns red to indicate saturation with oil and which shall be mounted in a transparent cast methyl methacrylate tube for visibility and inspection while on stream. Protect transparent acrylic tube by a safety shield. Provide afterfilter for removal of solid particles down to 5 microns size.

]

****

NOTE: Choose this item or item (a) above DESICCANT AIR DRYER.

****

[b. Refrigerated Air Dryer: Provide for systems not exposed to freezing temperatures a compressed air dryer of self-contained refrigerated type complete with heat exchanger, a commercial quality refrigerated system, a moisture separator and condensate trap, and internal wiring and piping. Install dryer between the receiver and distribution line.

(1) Heat Exchanger: Provide air and refrigerant coils surrounded by aluminum granules of sufficient mass to insure adequate cooling capacity for varying air flow loads without causing excessive refrigeration cycling. Provide an automatic control system, for the heat exchanger with a sensing element located in the aluminum granules, to shut down the refrigeration system on low or no-load conditions. Provide means to determine exchanger temperature.

(2) Moisture Separator: Provide centrifuge type located within the heat exchanger to provide for moisture separation at point of minimum air temperature.

(3) Refrigeration Unit: Provide hermetically sealed type which operates intermittently at all but maximum load conditions. The unit shall be capable of drying [_____] L/s scfm of air to an atmospheric dew point of not less than minus 23 degrees C 10 degrees F with entering air at 38 degrees C 100 degrees F, saturated. The maximum operating pressure of the dryer shall be [_____] kPa (gage) psig. House the entire unit in a steel cabinet. Provide cabinet with access door and panel for easy access to parts for maintenance and inspection.

(4) Refrigerant: CFC-based refrigerants are prohibited. Refrigerant must have an Ozone Depletion Potential (ODP) no greater than 0.0, with exception to R-123.

]2.6.3 Pressure Reducing Regulator

Provide self-operating type designed for not less than a 1724 kPa (gage) 250 psig operating pressure, and a normal operating temperature range of minus 29 degrees to plus 66 degrees C minus 20 degrees F to plus 150 degrees F. Regulator shall have an adjustable outlet pressure range not less than 34 to 690 kPa (gage) 5 to 100 psig with not less than four ranges. Provide external adjusting screw for adjustment throughout each spring range. Provide internal pressure tap for outlet pressure regulation.

2.7 BREECHING, EXPANSION JOINTS, STACKS, AND DAMPERS:

2.7.1 Breeching

Provide with rectangular cross section and fabricate of not less than 5 mm 3/16 inch thick black steel plate unless otherwise noted. Stiffeners shall be not less than 65 by 50 by 6 mm 2 1/2 by 2 by 1/4 inch steel angles welded to exterior with 50 mm 2 inch leg outstanding. Stiffeners shall not exceed one meter 3 feet on centers. Breeching shall connect to [each boiler flue gas outlet,] [intermediate heat recovery equipment,] [air pollution control equipment,] [and to stack as required].

2.7.1.1 Breeching Connections and Joints

Weld or bolt breeching joints unless indicated otherwise. Welding shall conform to AWS D1.1/D1.1M and AWS D1.3/D1.3M. Bolts for bolted connections shall be not less than 15 mm 1/2 inch diameter and spaced not more than 80 mm 3 inches apart, with bolts, lockwashers and nuts being hot-dipped galvanized. Provide bolted joints with a minimum of 3 mm 1/8 inch thick gaskets. Bolt breeching connections to boilers, equipment items, dampers, expansion joints, and breeching accessories. Flanged breeching connections to equipment shall be drilled to match flanges on equipment. Flanged joints shall be seal welded to make connection gas-tight.

2.7.1.2 Uninsulated Breeching

Thoroughly wire brush breeching which is not to be insulated and clean by degreasing with nonflammable solvent such as trichloroethylene prior to painting.

2.7.1.3 Breeching Access Doors

Provide breeching access doors where indicated. Construct access doors with frame and hinged door of cast iron or reinforced steel plate. Frame shall be not less than 635 by 940 mm 25 by 37 inches with access opening of 457 by 762 mm 18 by 30 inches. Connection to breeching shall be gasketed and made with minimum 15 mm 1/2 inch diameter hot-dipped galvanized bolts, lockwashers, and nuts spaced not less than 127 mm 5 inches on center. Each side of the access door shall have not less than two quick-clamp positive closing latches, with the long side opposite the hinges containing three clamps to give a gastight seal. Side of access door opposite hinges shall contain a minimum 80 by 125 mm 3 by 5 inch size handle. Provide a gasket consisting of 10 mm 3/8 inch diameter fire resistant resilient rope seal and mastic compound between the access door and the access door frame.

2.7.1.4 Breeching Cleanout Doors

Provide breeching cleanout doors where indicated. Construct cleanout doors of not less than 5 mm 3/16 inch thick steel plate. Secure cleanout doors to a 32 by 32 by 5 mm 1 1/4 by 1 1/4 by 3/16 inch thick angle frame with 10 mm 3/8 inch hot-dipped galvanized mounting bolts welded to the angle frame and spaced not more than 150 mm 6 incheso.c. Weld frame to breeching and provide a 1.50 mm 1/16 inchgasket between frame and cleanout door. Cleanout doors shall be not less than 610 mm 24 inches square except where breeching dimensions are smaller, in which case the cleanout door shall be full height of the breeching and not less than 305 mm 12 inches in length.

2.7.1.5 Breeching Structural Materials

****

NOTE: The designer shall detail breeching supports and breeching stiffening. Breeching hangers shall be designed to carry not less than 5 times the breeching weight, or the breeching weight plus 136 kg 300 pounds whichever is greater. Hangers for rectangular breeching shall be of the trapeze type with angle or channel support members and hanger rods. Breeching shall be stiffened with angle or channel members as required to withstand internal breeching static pressure.

****

Structural and support materials shall be steel and shall comply with the applicable sections of AISC 360. [Support and stiffen breeching as indicated.]

2.7.2 Expansion Joints

2.7.2.1 Metallic Breeching Expansion Joints

Provide factory fabricated metallic breeching expansion joints [where indicated]. Expansion joints shall be guided metal bellows type capable of a minimum of [_____] mm inches of axial travel. Form metal bellows from not less than 1.50 mm 1/16 inch thick type 321 stainless steel plate. Cover plates shall be not less than 3 mm 1/8 inch thick steel plate.

2.7.2.2 Non-Metallic Expansion Joints

Provide factory fabricated non-metallic breeching expansion joints 3 mm 1/8 inch minimum thickness [where indicated]. Expansion joints shall be constructed of fluoroelastomer vulcanized to two plies of knitted wire mesh capable of a minimum of [_____] mm inches of axial compression, [_____] mm inches of axial extension and [_____] mm inches of lateral offset [unless indicated otherwise]. Joints shall have a continuous operating temperature rating of 204 degrees C 400 degrees F, with excursion design standards up to 400 degrees C 750 degrees F. Operating pressure range shall be minus 34 kPa (gage) to plus 34 kPa (gage) minus 5 psig to plus 5 psig. Expansion joints shall be preformed with integrally molded corners, suitable for mounting against a 150 mm 6 inch flange. Provide carbon steel backup bars with slotted holes, bolts, and nuts.

2.7.3 Stacks (For Installation Without Flue Gas Scrubbers)

Stacks shall be free standing, dual wall with insulated annular space, self supporting, steel construction. Contractor shall assure that the design of the stack and supporting steel or concrete foundations meets or exceeds the design conditions listed below. Provide each stack complete with accessories and appurtenances, including test ports, sampling platforms, caged safety ladders, anchors, sleeves, insulation, base and chair rings, and cleanout door.

2.7.3.1 Construction

a. Air Space: Provide in the annular air space between the two steel

shells insulation with sealing means to accommodate thermal expansion differentials and lateral deflections or sway of the inner and outer shells.

b. Opening Reinforcement: Provide openings with adequate reinforcement to minimize stress concentrations.

c. Inner Shell: Design wall thickness of the inner shell to be 1.50 mm 1/16 inch thicker than that required by dynamic and static structural design but not less than 5 mm 3/16 inch.

d. Outer Shell: Construct of ASTM A242/A242M steel with a plate thickness not less than [_____] mm inch.

e. Expansion Devices: Construct of corrosion resistant stainless steel suitable for the temperatures and flue gas combinations to be experienced by the stacks.

f. Base construction of the stack shall transmit forces and moments in the shell to the [foundation] [supporting steel] without local stresses of appreciable magnitude being induced in the shell or exceeding the allowable stresses of the supporting [concrete] [steel].

g. Provide openings in breeching and stack for test equipment for sampling flue gas and for metering devices. Openings shall be properly reinforced and designed for differential expansion. Breeching opening shall be of double wall construction. All penetrations through inside shell of stack shall be completely welded to provide proper sealing between the stack and the opening.

h. Provide top 1.22 meters 4 feet cone section of the stack of corrosion resistant steel.

i. Anchor Bolts: provide suitable anchor bolts.

2.7.3.2 Construction Accessories

Accessories to be provided:

a. Cleanout Door: Provide double wall insulated steel plate door complete with 25 mm one inch round hinge pin, gasket and not less than 18 swing bolts.

b. Inspection Trolley: Provide a ring of Type 304 Corrosion Resistant Steel (CRES) to support an inspection or painter's trolley. Weld ring and support from the stack plates with not less that three brackets 10 by 65 by 381 mm 3/8 by 2 1/2 by 15 inches. Space brackets at not more than 610 mm 2 feet on centers around the circumference of the stack.

c. Provide a three wheel CRES flat rail trolley of 227 kg 500 pound capacity. The trolley shall have guides to prevent it from leaving the track and a hole shall be provided in the hinge plate for the attachment of [_____] meters feet of 6 mm 1/4 inch CRES plow steel cable.

d. Ladder: Provide each stack with an external ladder with cage for the full height of the stack. Construct ladder and cage of corrosion resistant steel in accordance with ALI A14.3.

e. Thermocouples: Provide a flue gas sensing thermocouple well with thermocouple one meter 3 feet above the breeching opening and 1 1/2 meters 5 feet below the top of the stack. The wells shall be CRES and shall extend about halfway into the stack.

2.7.3.3 Finish

Stacks shall be shop coated prior to shipping from the factory.

2.7.3.4 Stack Sampling Platform

****

NOTE: Designer shall detail a stack sampling platform if required. If not required delete this paragraph. If required the platform will have to be located at a point as approved by air pollution control agency having jurisdiction. Many local and state codes incorporate Title 40 Code of Federal Regulations, Part 60. Depending upon final air pollution control equipment arrangement this location may be on the stack or possibly on a long length of horizontal breeching. Stack sampling platform should have the following features:

1. Location of sampling ports would be according to 40 CFR 60 Appendix A, Method.

2. Platform should be one meter 36 inches wide but at ports location it should project away from breeching or stack a minimum of 600 mm 2 feet plus the diameter of the breeching or stack for up to 3 meters 10 feet in diameter stack.

3. If any type of continuous air pollution monitoring devices are located at stack sampling point or anywhere else on breeching, a non-vertical access (stairs or catwalk) is required. For stack sampling purposes a non-vertical ladder is preferred but is not required. Platform with grating shall be designed for a live loading of 1464 kg/m2 300 lbs/sq. ft; platform should have railing with two intermediate railings and 100 mm 4 inch toeplate. Four 30 amp weatherproof receptacles and adequate lighting including lights over the test ports should be provided.

****

Provide stack sampling platform conforming to the requirements of 29 CFR 1910-SUBPART D.

2.7.4 Dampers

2.7.4.1 Multilouver Dampers

****

NOTE: Opposed blade dampers shall be used for throttling service and parallel blade dampers shall be used for two-position service.

****

Provide factory fabricated multilouver dampers with [parallel] [or] [opposed] blade type operation. Construct damper frame of distortion resistant welded steel channels with raised seat to ensure free nonbinding operation of blades and to keep blades square in the frame. Construct blades of 6 mm 1/4 inch thick steel plate in a stressed skin airfoil-shape with fully welded seams containing no external ribs. Blade shafts shall be stainless steel. Blades shall be pinned to blade shafts. Louver shaft bearings shall be outboard type and shall be self-lubricating and self-cleaning. Bearing seals shall be gas-tight.

a. Multilouver Damper Linkage: Damper linkage shall be adjustable and of pinned construction for easy removal and shall be designed to handle full operation torque. Linkage on dampers in clean flue gas areas shall operate from a single connection point. Design linkage on dampers in dirty flue gas areas, between boiler outlet and inlet to air pollution equipment, so that the bottom blade linkage arm is not connected to the above linkage, to allow this blade to operate separately. The remaining linkage for this damper shall be constructed to operate from a single operating point.

b. Control Damper Operators: Provide control damper operators as noted. Operators may be either electrically or pneumatically operated with positive positioning, manual override, and hydraulic or oil immersed gear trains. Each operator shall be full-proportioning type, with spring return to position indicated in case of loss of power. Damper operating speeds shall be selected or adjusted so that the operators will remain in step with the controller. Operators acting in sequence with other operators shall have adjustment of control sequence as required by the operating characteristics of the system.

c. Two-Position Damper Operators shall be pneumatically operated with air cylinder, four way valve, and solenoid valve arrangement.

2.7.4.2 Guillotine Dampers

****
NOTE: Guillotine dampers shall be used for open-shut service where tight shutoff is required; for example, for air pollution control equipment bypass dampers.
****

Provide factory fabricated guillotine dampers with heavy structural frame rigid enough to support the extended blade and external loads through the breeching flange. Damper shall be capable of operating without precleaning or manual assistance under normal operating conditions. Enclosed bonnets will only be required where indicated. Provide three inch diameter cleanout ports on both sides for cleaning bottom sections.

a. Guillotine Damper Blades: Provide stress-relieved flat plate guillotine damper blades. Damper blade shall be nonwarping. Intermediate blade supports are acceptable to limit blade deflection. The leading edge of the damper blade shall be beveled and capable of guiding damper blade into frame seat. Blade guides shall be continuous and self cleaning and capable of preventing binding from deposits and damage from misalignment. Bonnet guides shall be removable. Design damper so that a damper blade can be replaced without opening the frame.

b. Guillotine Damper Bonnet Seal: Provide bonnet seal to effectively seal against atmospheric leakage under normal operating conditions.

c. Guillotine damper drive shall be a positive dual endless chain drive capable of driving damper in both directions. Chain drive headshaft shall have sufficient torsional rigidity to prevent binding of blade if the blade is stalled. Damper shall be motor operated with manual override. Design drive mechanism to prevent back driving of motor. Entire drive mechanism shall be of a simple design and require no routine maintenance other than inspection. Chain shall be capable of operating up to the stall torque of the damper drive motor.

d. Electric Motor: Shall be [_____] volt, [_____] phase, 60 Hz, [totally enclosed, fan cooled] [open drip-proof], not less than [_____] kW hp, as specified under MOTORS AND DRIVES in this section. Provide removable, totally enclosed chain guard.

2.7.5 Sampling Ports

Weld two sampling ports to [breeching] [stack] at 90 degrees apart. Each port shall consist of a section of 100 mm 4 inch diameter steel pipe with threaded cap.

2.8 FUEL OIL SYSTEM

Provide fuel oil system as specified in Section 33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION), for tanks located above grade, and Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS, for tanks below grade.

2.9 MISCELLANEOUS EQUIPMENT

2.9.1 Condensate Receiver

Provide a [horizontal] [vertical] type tank not less than [_____] meters feet [_____] mm inches in diameter by [_____] meters feet [_____] mm inches [long] [high] overall with a storage capacity of not less than [_____] liters gallons. Tank shall be constructed of welded steel plate not less than 10 mm 3/8 inch thick. Provide condensate tank with a 600 mm 24 inch diameter manway, dual gage glasses with protective guards, saddles, and other connections as indicated.

2.9.1.1 Coating

Surface blast interior of tank to bare metal and coat with a baked-on phenolic lining or corrosion resistant liner consisting of a resin and hardener suitable for immersion in water at not less than 121 degrees C 250 degrees F. Coat tank exterior with one shop coat of manufacturer's standard primer rated for service of not less than 121 degrees C 250 degrees F.

2.9.1.2 Accessories

Provide the condensate receiver with the following:

a. Connections for condensate pumped return, vent, water outlet, drain, sampling outlet, level transmitter and controls.

b. [_____] mm inch vent.

c. Reflex type water gage glasses with shutoff valves and guards.

d. One, 125 mm 5 inch dial, thermometer, 10 to 149 degrees C 50 to 300 degree F range, with lagging extension type wells, for steam and water space.

e. [_____] mm inch overflow trap.

f. One high water alarm switch with stainless steel float and trim. Circuit shall close as liquid level rises. Locate switch to close circuit when water level rises to 25 mm one inch below overflow level of receiver.

g. One low water alarm switch with stainless steel float and trim. Close circuit as liquid level falls. Locate switch to close circuit when water level drops to 25 percent of the storage capacity of the storage tank.

h. Install switches on a single column with valved connections to tank. Provide unions in pipe on each side of each float switch.

i. Furnish pipe, fittings, controls, specialties, bolts, gaskets, drains, valves, necessary for a complete unit. Install at the jobsite.

j. Provide automatic control system to control level in condensate tank by modulating discharge from condensate pumps.

2.9.2 Deaerating Heater

2.9.2.1 General

Provide a deaerating feedwater heater with storage tank conforming to FS W-H-2904 and to ASME BPVC SEC VIII D1, except as modified below. Tank shall be ASME Code stamped. Provide stainless steel trays. No test model will be required.

Model A - Pressurized operation.

Type I - Tray-type heating and deaerating element.

Class 3 - 10 minute water storage capacity (minimum).

Grade A - Guaranteed removal from water of dissolved oxygen in excess of 0.005 cubic centimeters(cc) per liter 0.0012 in3/gal, over a ten to one load swing.

2.9.2.2 Heater Capacity

Provide deaerating heater capable of heating and deaerating makeup water consisting of [_____] kg per second pounds per hour of softened makeup water from [_____] degrees C F to [_____] degrees C F (outlet temperature).

2.9.2.3 Inlet Water Characteristics

Softened makeup water:

Ph: [_____]
Total hardness (as CaC03): [_____]

2.9.2.4 Storage Tank

Horizontal design with steel supports [drilled for bolting] of approved design. Provide storage tank with not less than a 400 by 500 mm 16 by 20 inch minimum size manhole and cover and provide heater section with not less than a 300 by 450 mm 12 by 18 inch minimum size tray access handhole and door.

2.9.2.5 Vent Condensing Arrangement

Provide the deaerating heater with a vent condenser which shall condense the vented steam when the heater is operating at full capacity with the inlet water mixture at a temperature not exceeding 82 degrees C 180 degrees F. Construct the vent condenser, when of the direct contact type, with stainless steel baffling.

2.9.2.6 Materials

Construct trays, tray supports, water distributors, and other parts coming in contact with underaerated water or air laden steam of 430 stainless steel.

2.9.2.7 Accessories

Provide deaerating heater with the following accessories:

a. Pressure Relief Valve: Sized in accordance with FS W-H-2904.

b. Thermometers: Two, 125 mm 5 inch dial thermometers, 10 to 149 degrees C 50 to 300 degrees F, with lagging extension type wells for the storage tank and the heater section. Provide a thermometer similar to above but with range of minus [_____] degrees C F to plus [_____] degrees C F for the makeup water connection.

c. Lifting attachments for the tray section and the storage tank.

d. Water Gage Glasses: Reflex type with shutoff valve and guards.

e. Pressure Gages: One 150 mm 6 inch dial compound pressure gage for the heater section with range from [_____] kPa inches of mercury (vacuum) to [_____] kPa (gage) psig.

f. Float Controllers:

(1) Inlet condensate controller

(2) Makeup water controller

(3) Overflow controller

g. Overflow Control Valve: With pneumatic controller arranged for local automatic operation.

h. Storage Tank Gage Glass: Full height, shielded, for storage tank including shutoff valve and drain cocks.

i. Makeup Water Inlet Control Valve: With pneumatic controller.

j. Switches: For low water level alarm in the storage tank, high water level alarm, condensate pump shutdown in the storage tank, and low steam pressure alarm. Install switches on a single column with connections valved and unions provided in pipe on each side of each float switch.

k. Special tools: One set for maintenance.

l. Condensate Pump Reset: With stainless steel float and trim to reset pump shutdown switch on fall of liquid level in tank to [_____] mm inches below level of overflow level of storage tank.

m. Furnish pipe, fittings, controls, specialties, bolts, gaskets, drains, and valves, necessary for proper attachment of accessories and trimmings and install.

[n. Oil separator

]2.9.2.8 Connections

Provide necessary connections for condensate, steam, makeup water, removal of vented gases, vacuum breakers, discharge of deaerated water, and instruments and controls.

a. Provide heater connections as follows:

(1) [_____] mm inch steam inlet

(2) [_____] mm inch makeup water inlet

(3) [_____] mm inch condensate

(4) [_____] mm inch high pressure trap return

(5) [_____] relief valves sized as required

(6) [_____] mm inch vent

(7) [_____] mm inch for thermometer well

(8) [_____] mm inch for pressure gage

(9) Vacuum breakers as required

(10) [_____] mm inch heater drain

(11) [_____] mm inch spare [capped] [flanged]

(12) [_____] mm inch spare [capped] [flanged]

(13) Handholes and manhole with covers

b. Tank connections shall include:

(1) [_____] mm inch drain

(2) [_____] mm inch boiler feed recirculation ([_____] required)

(3) 25 mm One inch sampling

(4) 25 mm One inch chemical feed

(5) [_____] mm inch for sight glass ([_____] sets required)

(6) [_____] mm inch for high and low level alarm switches

(7) [_____] mm inch thermometer well

(8) Vacuum breakers as required

(9) [_____] mm inch spare (capped)

(10) [_____] mm inch spare (flanged)

(11) [_____] mm inch level transmitter and controller ([_____] sets required)

(12) Downcomer and equalizer as required

(13) [_____] mm inch feedwater outlet

(14) [_____] mm inch overflow outlet with internal water seal

2.9.2.9 Level Control

Provide an automatic control system to control water level in the storage tank, by modulating valves in makeup water lines. Condensate pump output shall be controlled by level in condensate storage tank.

a. Controllers: Provide external cage type air operated level controllers for both the condensate and makeup water lines complete with 40 mm 1 1/2 inch screwed connections, external cage, and controller. Cage body shall be Class 125 cast iron construction. Internal components including displacer, torque tube, displacer rod, displacer rod driver and bearings shall be 316 stainless steel. Displacer shall be 350 mm 14 inches long. Controller shall be direct acting with 20 to 103 kPa (gage) 3 to 15 psig range with proportional band adjustment. Locate controller to maintain an operating level at 2/3-full point of storage tank. Provide level controller with air pressure reducing valve, filter, gages and isolating valves for float cage. Provide unions on each side of float cage.

b. Air Operated Regulating Valves: Provide air operated control valves for both the condensate and makeup water lines. Valves shall have Class 125 or Class 150 rating with iron or semi-steel bodies and 316 stainless steel internals. Provide condensate valve which fails open on loss of air and makeup water valve with an air lock mounted on valve diaphragm to hold valve in last position on loss of air. Design valves for the following conditions:

	Condensate	Makeup Water
Valve size	[_____] mm	[_____] mm
Capacity	[_____] L/s	[_____] L/s

	Condensate	Makeup Water
Maximum pressure drop at above capacity	[_____] kPa (gage)	[_____] kPa (gage)
Available pressure	[_____] kPa (gage)	[_____] kPa (gage)
Minimum Cv at 100 percent open	[_____]	[_____]

	Condensate	Makeup Water
Valve size	[_____] inch	[_____] inch
Capacity	[_____] gpm	[_____] gpm
Maximum pressure drop at above capacity	[_____] psig	[_____] psig
Available pressure	[_____] psig	[_____] psig
Minimum Cv at 100 percent open	[_____]	[_____]

2.9.2.10 Low Pressure Steam Control

Provide an automatic control system to control the steam to the deaerating heater. Maintain steam pressure in the heater by modulating a pressure reducing valve in the steam supply line. Control shall be local and remote from the control panel.

a. Controller: Adjustable proportional band, 0 to 103 kPa (gage) 15 psig brass bellows for input signal, and 20 to 103 kPa (gage) 3 to 15 psig output air pressure range, pilot controller complete with air set (valve, filter, drier and pressure regulator) mounted on control valve yoke.

b. Pressure Reducing Station Control Valve: Provide a [_____] mm inch air operated pressure reducing valve with proper internals to pass a flow of [_____] kg per second pounds per hour of steam. Steam at the valve inlet shall be [_____] kPa (gage) psig saturated, and the outlet shall be controlled at [_____] kPa (gage) psig. Minimum steam flow shall be approximately [_____] kg per second pounds per hour. Minimum valve Cv shall be [_____] at 100 percent open. Valve shall be Class 250 or Class 300 flanged, iron or semi-steel body with stainless steel internals equal percentage flow characteristics and a full size port. Provide valve actuator including travel indicator, hand jack, valve positioner, and air supply filter-reducer set. Valve shall move to open position in case of failure.

2.9.2.11 Gage Glasses

Provide gage glasses to cover the entire range of water level in the storage section. Gage glasses shall not be greater than 600 mm 24 inches center-to-center. Provide gage glasses complete with [chain operated] ball check shutoff and drain cock valves and safety shield.

2.9.2.12 Alarms

Provide high and low water level alarms for storage tank as follows:

a. High Water Level Alarm: Switch with stainless steel float and trim. Locate switch to close circuit when water level rises to 25 mm one inch below overflow level of storage tank.

b. Low Water Level Alarm: Switch with stainless steel float and trim. Locate switch to close circuit when water level falls to [_____] meters feet [_____] mm inches above bottom of storage tank.

c. Coordination: Coordinate alarms with annunciator panel as indicated.

2.9.2.13 Multiport Back Pressure Relief Valve

****
NOTE: Use multiport valve on systems where deaerating heater will be subject to occasionally overpressuring.
****

Provide valve capable of relieving not less than [_____] kg per second pounds per hour of steam with not more than a [_____] kPa (gage) psig pressure rise when set at [_____] kPa (gage) psig initial operating pressure. Set pressure shall be fully adjustable by means of an external handwheel or chain operator for a range of zero to 172 kPa (gage) 25 psig. Locate on low pressure steam header manifold for the deaerating heater. Valve shall be multiport vapor cushion type rated for operating temperatures up to but not greater than 149 degrees C 300 degrees F with Class 125 cast iron body, bronze trim and carbon steel springs.

2.9.2.14 Exhaust Head

CID A-A-50494, Type [I (cast iron)] [II (fabricated steel plate)] of [_____] mm inch size with [_____] mm inch diameter drain, and a capacity of [_____] kg per second pounds per hour of steam at [_____] kPa (gage) psig.

2.9.3 Boiler Feed Pumps

****
NOTE: Use this paragraph for centrifugal boiler feed pumps. Use Style 1, horizontal split case pumps in all sizes. Pump service requirements shall include a minimum pump capacity of 125 percent of boiler requirements at maximum load. Discharge head must be sufficient to deliver water to the boiler at a pressure 3 percent higher than the boiler safety valves setting and up to 6 percent over the maximum operating pressure of the boiler in accordance with the ASME Boiler and Pressure Vessel Code.
****

CID A-A-50562, Type II (boiler feed pump), Style 1 (horizontally split case), Class 2 (multi-stage) except as modified below. Each pump shall be two stage with horizontal split casing, enclosed single suction opposed type impellers, renewable casing and impeller wearing rings, stuffing box with quenching gland and flooded oil lubricated, water cooled bearings.

2.9.3.1 Pump Service Requirements

a. Capacity: [_____] L/s gpm

b. Pumping temperature: [_____] degrees C F

c. Liquid pH: [_____]

d. Discharge head: [_____] Pa feet

e. Available NPSH: [_____] Pa feet

f. In addition to the operating point established above, the pump curve shall also run through the following points:

Capacity	Discharge Head
[_____] L/s	[_____] meters
[_____] L/s	[_____] meters

Capacity	Discharge Head
[_____] gpm	[_____] feet
[_____] gpm	[_____] feet

2.9.3.2 Construction

Boiler feed pumps shall be bronze fitted including bronze impeller and impeller wear rings, and ASTM A48/A48M, Class 30, cast iron casing. Provide casing with suction and discharge gages in tapped openings. Mount each pump and prime mover on a fabricated steel bed plate having a drip collection chamber with tapped drain openings. Provide lifting attachments to enable equipment to be set into its normal position and to enable pumps to be easily dismantled in place.

2.9.3.3 Electric Motors

****

NOTE: The designer shall perform an economic analysis and make a technical evaluation to determine if the boiler feed or condensate pump motors shall be provided with variable speed control. Generally, variable speed drives for boiler feed or condensate pumps over 5 1/2 kW 7 1/2 HP will be cost effective.

****

[Variable speed], [open dripproof], [totally enclosed], [fan cooled], [_____] volt, three phase, 60 Hz of not less than [_____] kW hp, as specified under MOTORS AND DRIVES [and VARIABLE SPEED CONTROL FOR MOTORS] in this section. [Variable speed] electric motors [or turbines] direct connected to respective pumps with a gear type, forged steel, flexible coupling. Provide a shaft and coupling guard.

2.9.3.4 Steam Turbines

Single stage, rated at not less than [_____] kW hp, with inlet steam pressure of [_____] kPa (gage) psig and [_____] degrees C F and normal exhaust back pressure of 34 kPa (gage) 5 psig or a maximum back pressure of 103 kPa (gage) 15 psig. Water rate at full load and normal steam conditions shall not exceed [_____] kg per BkW per second pounds per BHP per hour. Provide a stainless steel steam strainer, sentinel relief valve, sight oil level indicator and one hand valve. [Variable speed] turbines direct connected to respective pumps with a gear type, forged steel, flexible coupling. Provide a shaft and coupling guard.

a. Turbine Construction: Turbine casing split on the horizontal centerline constructed of ASTM A48/A48Mcast iron, with a design pressure rating of 1724 kpa (gage) 250 psig at 232 degrees C 450 degrees F at inlet, and 379 kpa (gage) 55 psig at 232 degrees C 450 degrees F at the outlet.

b. Turbine Bearings and Shaft: Horizontal split, ring oiled, sleeve type, water cooled. The shaft shall be stainless steel or chrome plated under the packing glands. The shaft seals shall be segmented carbon rings with springs and stops.

c. Speed Governor: Variable speed oil relay, NEMA Class D governor for speed control and pneumatic operator to maintain an adjustable, preset pump discharge header pressure by variation of turbine speed. Input to the operator shall be a 20 to 103 kPa (gage) 3 to 15 psig pneumatic signal. Provide an electro-pneumatic transducer to accept the 4 to 20 mA signal from the control system controller specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

d. Emergency Overspeed Governor: Completely independent of the speed governor and shall operate trip valve.

e. Insulation: Turbine shall be insulated and lagged by the manufacturer as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.9.3.5 Minimum Flow Protection for Boiler Feed Water Pumps

a. Automatic Flow Control Valve: Provide with each pump an automatic bypass valve. Valve shall automatically program the recirculation flow, the detection of low flow, the cycling of control valve and pressure letdown for high pressure boiler feedwater return to the feedwater heater. Bypass valve shall be cast steel with stainless steel internals, and shall have a rating of not less than 2068 kpa (gage) 300 psig at 204 degrees C 400 degrees F. Valve shall have a line size body with a 25 mm one inch recirculation connection.

b. Boiler Feedwater Automatic Recirculation System: (Option to Automatic Valve). Provide a boiler feedwater automatic recirculation system to protect the feedwater pumps at low flow conditions. System shall be capable of recirculating the minimum flow recommended by the pump manufacturer. The system shall be an engineered system consisting of the various functional components specified or shall be a self-contained and self-powered mechanical system. Components of the engineered system shall include a flow transmitter with orifice in feedwater line, bypass flow controller with bypass flow control valve, and a bypass pressure reducing orifice.

(1) System Bypass Flow Controller: Include detection of low flow and modulation of a control valve in a bypass line returning to a low pressure sink. Incorporate a pressure let-down feature or device to reduce the pressure from the boiler feedwater pump discharge pressure to that of the low pressure sink.

(2) System Bypass Control Valve: Modulate to provide minimum flow recommended by the pump manufacturer and to provide shutoff or recirculation flow when feedwater flow to the boilers exceeds the minimum flow required for pump protection.

c. Feedwater Stop and Check Valves: Provide a Class 300, flanged, cast steel feedwater stop gate valve and check valve on the feedwater outlet of each pump. Provide piping from the valves to the economizer inlet, and from the economizer to the flanged connection on the boiler drum. Provide connection on pipe at economizer outlet for remote recording thermometer.

2.9.4 Condensate Pumps

****
NOTE: Use this paragraph for centrifugal condensate pumps. Pump service requirements shall include pump capacity a minimum of 125 percent of boiler requirements. Discharge into deaerator heater shall be modulated.
****

CID A-A-50562, Type I, Style [1 (horizontally split case)] [2 (end suction)], Class 1 (single stage) unless modified below.

2.9.4.1 Condensate Pump Service Requirements

a. Capacity: [_____] L/s gpm

b. Pumping temperature range: [_____] to [_____] degrees C F

c. Liquid pH: [_____]

d. Discharge head: [_____] Pa feet

e. Available NPSH: [_____] Pa feet

f. In addition to the operating point established above, the pump curve shall also run through the following points:

Capacity	Discharge Head
[_____] L/s	[_____] meters
[_____] L/s	[_____] meters

Capacity	Discharge Head
[_____] gpm	[_____] feet
[_____] gpm	[_____] feet

2.9.4.2 Construction

Condensate pumps shall have bronze impellers and impeller wear rings. Pump casings shall be [cast iron] [ductile iron], and shall be designed for the specified conditions. Bearings shall be oil lubricated. Casings shall have tapped openings for suction and discharge pressure gages. Provide suction and discharge pressure gages in openings. Mount pump and driver on a fabricated steel bed plate having a drip collection chamber with tapped drain openings. Provide lifting attachments for installation and maintenance.

2.9.4.3 Electric Motors

****
NOTE: The designer shall perform an economic analysis and make a technical evaluation to determine if the boiler feed or condensate pump motors shall be provided with variable speed control. Generally, variable speed drives for boiler feed or condensate pumps over 5 1/2 kW 7 1/2 HP will be cost effective.
****

[Variable speed], [open dripproof], [totally enclosed], [fan cooled], [_____] volt, three phase, 60 Hz of not less than [_____] kW hp, as specified under the paragraph MOTORS AND DRIVES [and VARIABLE SPEED CONTROL FOR MOTORS] in this section. [Variable speed] electric motors direct connected to the respective pumps with a gear type flexible coupling. Provide shaft and coupling guards.

2.9.4.4 Steam Turbines

Single stage, rated at not less than [_____] kW hp, with inlet steam pressure of [_____] kPa (gage) psig and [_____] degrees C F, normal exhaust back pressure of 20 kpa (gage) 5 psig and a maximum back pressure of 103 kPa (gage) 15 psig. Water rate at full load and normal steam conditions shall not exceed [_____] kg per BkW per second pounds per BHP per hour. Provide a stainless steel steam strainer, sentinel relief valve, sight oil level indicator and one hand valve. [Variable speed] turbines direct connected to the respective pumps with a gear type flexible coupling. Provide shaft and coupling guards.

a. Turbine Construction: Turbine casing split on the horizontal or vertical centerline constructed of ASTM A48/A48M cast iron, with a design pressure rating of 1724 kPa (gage) 250 psig at 232 degrees C 450 degrees F at inlet, and 379 kpa (gage) 55 psig at 232 degrees C 450 degrees F at the outlet.

b. Turbine Bearings Shaft: Ring oiled, anti-friction type. Shaft shall be stainless steel or chrome plated under the packing glands. Shaft seals shall be segmented carbon rings with springs and stops.

c. Speed Governor: Variable speed governor for speed limiting and pneumatic operator to maintain an adjustable preset level in [deaerator tank] [condensate receiver] by variation of turbine speed. Input to the operator shall be a 34 to 103 kPa (gage) 3 to 15 psig pneumatic signal and vary the turbine speed from minimum to full speed in a linear response. Maximum and minimum speed shall be adjustable. Provide an electro-pneumatic transducer to accept the 4 to 20 mA signal from the controller specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

d. Emergency Overspeed Governor: Completely independent of the speed governor and shall operate a separate trip valve.

e. Insulation: Turbine shall insulated and lagged as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.9.5 Variable Speed Motor Controller

Remotely installed cabinet housed units with solid state rectification and inverter equipment to vary frequency of electrical power to the drive motors.

2.9.5.1 Housing

House the controller in a [wall] [floor] mounted, NEMA [_____] enclosure finished with manufacturers standard painted finish. Provide control panel complete with fused disconnect switches, magnetic [across the line] [part winding] starters with thermal overload protection, transformer, hand-off-automatic selector switches, hand potentiometer for manual speed control, fuses and running lights.

Manual Switch: Locate the manual switch within the control panel so that in the event failure of any of the components the motor can be put across the line at full voltage to maintain air or pump pressure. Provide a mechanical door interlock that allows the panel to open only when the fused disconnect is in the off position.

2.9.5.2 Variable Frequency Controllers

Variable frequency controllers shall use solid-state semiconductor power conversion equipment. Provide controllers as integrated and assembled products. Controllers shall be furnished by the same manufacturer.

2.9.5.3 Ratings

Each controller shall be rated for a supply of [_____] volts, three phase, 60 Hz. The output shall be [_____] volts, three phase with frequency variable between zero and 60 Hz. Controllers shall be rated to operate the motors continuously at their rated kilowatt horsepower and frequency. Speed regulation shall be within (plus or minus) three percent of set point without tachometer feedback. Electrical supply system shall have an available short circuit rating of [_____] amperes symmetrical.

2.9.5.4 Minimum Speed

Each controller shall be capable of driving the motor continuously at a lower speed no greater than 20 percent of full rated motor speed with stable operation and without overheating the motor under rated ambient

conditions. Provide estimate of minimum speed at which motor can be operated continuously without overheating or problems of instability due to overhauling of the load.

2.9.5.5 Fault Protection

Provide controller fault protection so that a single or three phase short circuit at the controller terminals or inverter commutation failure will not result in damage to power circuit components. Provide overload protection so that motor and controller are protected against operating overloads.

2.9.5.6 Time Delay

Provide adjustable time delay under voltage protection so that motors will continue to operate during momentary voltage fluctuation or loss of voltage. Time adjustment shall be zero to 5 seconds. Provide for orderly shutdown on undervoltage conditions exceeding the time delay interval.

2.9.5.7 Acceleration/Deceleration

Provide adjustable timed linear acceleration and deceleration.

2.9.5.8 Voltage/Frequency Control

Provide volts/Hz control to prevent motor overheating throughout the speed range.

2.9.5.9 Door Interlocks

Provide door interlocks to prevent opening of enclosure doors unless power is disconnected.

2.9.5.10 Shutdown Conditions

Controllers shall be self protecting and shall provide orderly shutdown for, but not limited to, the following conditions:

a. Loss of input power

b. Undervoltage

c. Sustained gradual overload

d. Fault or large instantaneous overload

e. Overtemperature

f. Failure of ventilating system

g. Overvoltage

h. Control circuit failure

Provide contacts for remote annunciation of shutdown or abnormal condition.

2.9.5.11 Electrical Bypass

Provide each controller with manual isolation and bypass switching.

Switch shall be manually operated with controller deenergized. Switch shall be two position with provisions for locking the switch in either position.

a. Normal Position: Bypass shall be open and connect controller to the supply circuit and the load.

b. Bypass Position: Bypass shall be closed and the controller shall be electronically isolated from the supply and the load. Isolating contacts shall be located so that it is possible to verify by visual inspection that the contacts are open and the controller is electrically isolated. In the bypass position the motor shall be operated at constant speed and controlled from the air circuit breaker. Provide auxiliary contacts that close in the bypass position. Auxiliary contacts shall be used to activate the damper control to provide fan load control in the bypass position.

2.9.5.12 Controller Environmental Protection

a. Ventilation: Design controllers enclosed and ventilated for installation in a moderately dusty area. Provide forced filtered ventilation including fans, filters, controls and accessories required for operation. Enclosures shall be operated under positive pressure at all times. Provide filtered ventilating openings and gasketed doors to prevent infiltration of dust.

b. Heating: Provide electric heaters to prevent condensation in the enclosure and to prevent low ingoing air temperatures that exceed the equipment rating. Provide a low temperature alarm to sound when enclosure temperature falls below required minimum temperature. Provide contacts for remote annunciation of alarm condition.

2.9.5.13 Method of Control

Supply each controller from an electrically operated air circuit breaker or motor starter. Controller ventilation and heating shall be from another circuit.

a. Start Signal: Closes the electrically operated air circuit breaker or motor starter to energize the controller. The controller shall accelerate the fan to operating speed. Fan speed shall be controlled from the load control signal.

b. Stop Signal: Opens the electrically operated air circuit breaker or motor starter to deenergize the controller. Upon deenergization, the controller control system shall revert to the stop condition.

c. Boiler Feedwater Pump Speed Control System: Matches pump discharge to system demand and maintains a system header pressure controlled to the set point values. Provide Manual/Automatic control stations for master pressure and for each boiler feed pump. Provide indicators for feedwater header pressure and individual boiler feedwater pump flow. See Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

2.9.6 Valve Actuators

[Electrically] [or] [pneumatically] operated and designed so that valve may be manually operated by removing the drive pins. Actuators shall be operated by push button control. Locate one push button at a position

adjacent to the valve. Locate a second push button within the boiler control room. Provide a valve position indicator utilizing indicating lights. A green light shall indicate the valve is fully open and an amber light shall indicate the valve is fully closed. Both lights on shall indicate when the valve is partially open. [Provide torque limit controls to protect the valve during opening and closing for electrically operated valves.] Actuator electric motor shall be totally enclosed, [_____] volts, [_____] phase, 60 Hz as specified under the paragraph MOTORS AND DRIVES in this section. Provide NEMA 4 control enclosures.

2.9.7 Sump Pumps

CID A-A-50555 with automatic float switch and disconnect switch in NEMA 6 enclosure.

2.9.8 Water Softening System

****
NOTE: One hundred percent makeup shall be assumed in calculating the sustained softening rate.
****

Ion exchange resin type conforming to WQA S-100 except as modified below. [Manual] [Push button automatic] [Fully automatic] in operation with operating controls housed in a NEMA 12 enclosure having a total capacity between regenerations of not less than [_____] liters gallons of water of [_____] grains hardness when operated at a sustained softening rate of [_____] L/s gpm. The maximum effluent water temperature shall be [_____] degrees C F.

2.9.8.1 Raw Water Analysis

****
NOTE: Regarding the text below: Analysis of the water available for makeup shall govern the softener system selected. A competent water treating consultant shall be obtained to formulate specific system recommendations if the makeup water analysis indicates any of the following:

1. Iron in excess of 0.1 ppm as Fe.

2. Mg Alkalinity in excess of 50 ppm as CaCO3.

3. Silica in excess of 6 ppm as SiO2.
****

The source of the raw water is [_____]. It is available at pressures of [_____] to [_____] kPa (gage) psig. The analysis of the water available for makeup is approximately as follows:

TABLE 1: MAKEUP WATER ANALYSIS			
	Constituent	Analysis	Parts Per Million (PPM)

TABLE 1: MAKEUP WATER ANALYSIS			
Cations	Calcium (Ca++)	as CaCO3	[_____]
	Magnesium (Mg++)	as CaCO3	[_____]
	Sodium (Na+)	as CaCO3	[_____]
	Hydrogen (H+)	as CaCO3	[_____]
TOTAL CATIONS		as CaCO3	[_____]
Anions	Bicarbonate (HCO3 -)	as CaCO3	[_____]
	Carbonate (CO3 --)	as CaCO3	[_____]
	Hydroxide (OH -)	as CaCO3	[_____]
	Sulfate (SO4 --)	as CaCO3	[_____]
	Chloride (Cl -)	as CaCO3	[_____]
	Phosphate PO4 ---)	as CaCO3	[_____]
	Nitrate (NO3 -)	as CaCO3	[_____]
TOTAL ANIONS		as CaCO3	[_____]

TABLE 1: MAKEUP WATER ANALYSIS			
	Total hardness	as CaCO3	[_____]
	Methyl orange alkalinity	as CaCO3	[_____]
	Phenolphthalein alkalinity	as CaCO3	[_____]
	Iron, total	as Fe	[_____]
	Carbon dioxide	as Free CO2	[_____]
	Silica	as SiO2	[_____]
	Suspended solids (Turbidity)		[_____]
	Total dissolved solids (TDS)		[_____]
	Free acids		[_____]
	Color		[_____]
	pH		[_____]
	Specific Conductance Microhms/cm		[_____]

2.9.8.2 Softener Effluent Analysis

****

NOTE: At the text below, total solids of 175 ppm (parts per million) in the feedwater concentrated 20 times give 3,500 ppm in the boiler water.

****

a. Hardness: Maintain hardness of the softened feedwater near zero and in no case allow it to exceed 1.0 ppm (parts per million) as CaCO3.

b. Total Solids: Maintain total solids in the softened feedwater at a level to ensure a total solids concentration in the boiler water of less than 3,500 parts per million (ppm) without excessive blowdown.

2.9.8.3 Softener Equipment

Including but not limited to the following:

a. Water Hardness Monitor: Provide a water hardness monitor with an alarm point at 1.0 ppm to ensure compliance for boilers rated above 3150 gram per second (g/s) 25,000 lb/hr.

b. Total Solids Monitor/Controller: Provide a continuous monitor and controller (when required) to control the concentration of dissolved

solids and treatment chemicals in the water for boilers rated above 3150 g/s 25,000 lb/hr.

c. Water Meter: Provide a [_____] mm inch cold water meter on each softener unit.

d. Ion Exchange Resin: High capacity, polystyrene base, sulfonated synthetic type except that the exchange capacity shall be not less than 2 kg per cubic meter 30 kilograins per cubic foot at a salt dosage of 240 kg per cubic meter 15 pounds per cubic foot.

e. Tank Sizing: Minimum acceptable bed depth of 760 mm 30 inches; maximum acceptable bed depth of 1830 mm 72 inches. Base reactor tank sizes on allowing a freeboard above the resin bed of not less than 75 percent of the resin bed depth, and flow rate between 1.11 and 7.14 L/s per cubic meter 0.5 and 3.2 gpm per cubic foot of resin.

2.9.8.4 Brine Storage System

Provide a complete brine storage system including fiberglass storage tank, sight level gage, bulk salt delivery tube, internal distribution system, level control system, tank vent with dust collection system, top and side manholes, access ladder, and other required appurtenances.

2.9.8.5 Brine Storage System Accessories

Provide the following accessories:

a. Steel holddown lugs securely bonded to the tank in adequate number to properly anchor tank to concrete base;

b. Side bottom flanged drain not less than 100 mm 4 inches in diameter;

c. Side and top manholes not less than 560 mm 22 inches in diameter;

d. Flanged top connections for delivery pipe and vent;

e. Ladder for access to top manhole;

f. Water inlet connection;

g. Brine outlet connection;

h. Level control system; and

i. Sight level gage.

2.9.8.6 Storage Tank

Filament wound fiberglass with flat bottom and domed top as recommended by the manufacturer for brine storage. Tank shall be [_____] meters feet [_____] mm inch in diameter by [_____] meters feet[_____] mm inch wall height with a nominal capacity of [_____] liters gallons and a dry salt storage capacity of [_____] Mg tons. Design the water distribution system, internal piping distributors, and brine collection system so that the system shall be capable of dissolving [_____] kg pounds of rock salt per second minute to produce [_____] L/s gallons per minute of brine. System shall be able to dissolve [_____] Mg tons of salt before cleanout.

a. Pneumatic Delivery Pipe: Not less than 100 mm 4 inches in diameter.

b. Dust Collection Vent System and Safety Relief Valve: Provide storage tank with dust collection vent system and safety relief valve.

c. Access Ladder: Of steel construction to be bolted to tank by means of fiberglass reinforced plastic mounting lugs complete with safety cage. Platform shall connect the ladder to the tank for safe access to the manhole. Safety requirements shall be in accordance with ALI A14.3.

d. Tank Internals: Construct tank internals including water distribution piping and brine collectors of fiberglass reinforced plastic (FRP) or polyvinyl chloride (PVC).

e. Tank Nozzles: ASME B16.5, Class 150, reinforced FRP or PVC flanges.

f. Level Control System: Electrode holder and electrodes mounted in a standpipe exterior to the tank. Position electrodes so that a solenoid operated water makeup valve will be opened or closed to maintain the liquid level to within plus or minus one inch of the set level. Provide tank with a high water alarm. Electrodes shall be easily removable for cleaning and constructed of materials, that will allow continual immersion in brine.

2.9.9 Chemical Feed Systems

Provide systems complete with storage tank, supporting framework, hinged cover, mixer, strainers, level indicators, proportioning pumps, relief valves and interconnecting piping for a complete chemical feed packaged unit.

2.9.9.1 Storage Tank

190 liters 50 gallon capacity constructed of fiberglass reinforced plastic. Provide removable, hinged cover.

2.9.9.2 Exterior Gage Glass

Protected, full height of the tank complete with gage cocks.

2.9.9.3 Low Level Alarm

Provide tank with a low level switch to sound alarm and shut down pumps should level drop to preset minimum.

2.9.9.4 Dissolving Baskets

****
NOTE: The chemical feed solution to be used shall be inserted here.
****

Construct baskets of a corrosion resistant material suitable for continuous immersion in a [_____] solution.

2.9.9.5 Tank Strainer

Install tank strainer in suction line to pump.

2.9.9.6 Supporting Steelwork

Provide supporting steelwork to adequately support tank, mixer, and the number of proportioning pumps specified.

2.9.9.7 Agitator

Provide an agitator with mounting bracket to mount to storage tank. Agitator shaft and propeller shall be of stainless steel.

2.9.9.8 Proportioning Pumps

Provide [two] [three] [_____] proportioning pump[s] of the [simplex] [duplex] type. Each pump shall have a minimum capacity of [_____] L/s gallons per hour at a [_____] kPa (gage) psig discharge pressure. Capacity shall be adjustable from zero to 100 percent by a convenient screw adjustment of stroke length. Provide pump with integral check valves. Electric motors shall be [totally enclosed], [fan cooled], [_____] volts, [_____] phase, 60 Hz as specified under the paragraph MOTORS AND DRIVES in this section.

2.9.9.9 Safety Relief Valve

Provide safety relief valve for each pump to discharge back into the tank in event of excessive line pressure.

2.9.10 Blowdown Tank

Provide a welded blowdown tank in accordance with NBBI NB-27, (supplemental to the National Board Inspection Code) latest edition published by the National Board of Boiler and Pressure Vessel Inspectors, Columbus, Ohio.

2.9.10.1 Construction

****

NOTE: The volume of the blowdown tank shall be calculated to be twice the volume of water removed from one boiler when the normal water level is reduced not less than 100 mm 4 inches.

****

Construct equipment and accessories in accordance with the requirements of the ASME BPVC SEC VIII D1 for a working pressure of at least the maximum allowable working pressure of the boiler but in no case shall the plate thickness be less than 10 mm 3/8 inch. Provide corrosion allowance of [2.54 mm] [0.1 inch] [_____]. Tank dimensions shall be [_____] meters feet [_____] mm inches O.D. by [_____] meters feet [_____] mm inches long over the heads (overall). Provide tank with wear plate not less than 10 mm 3/8 inch thick and [280 by 380 mm 11 by 15 inch] [460 by 510 mm 18 by 20 inch] manhole.

2.9.10.2 Tank Connections

Provide the following connections:

a. Blowdown inlet for bottom blowdown [20] [25] mm [3/4] [1] inch;

b. Tangential blowdown inlet [_____] mm inch;

c. Steam vent, flanged [_____] mm inch;

d. Discharge water outlet, flanged [_____] mm inch with internal water seal and 20 mm 3/4 inch siphon breaker;

e. 50 mm Two inch drain;

f. Thermometer connection 20 mm 3/4 inch;

g. Pressure gage connection 6 mm 1/4 inch;

h. Cold water inlet [_____] mm inch with temperature regulating valve and backflow preventer; and

i. Two gage glass connections 5 mm 1/2 inch.

2.9.10.3 Angle Supports and Coating

Provide tank with steel angle support legs extending [_____] meters feet below bottom of the tank. Coat tank with one coat of manufacturer's standard high temperature primer.

2.9.10.4 Accessories

a. Gage Glass: 300 mm 12 inch reflex type with shutoff valves and guard;

b. Thermometer: Bi-metal dial type with separable socket, 125 mm 5 inch dial, 10 to 149 degrees C 50 to 300 degrees Frange;

c. Pressure Gage: Zero to 172 kpa (gage) 25 psig range; and

d. Internal Baffles and Pipes: As detailed.

2.9.10.5 Controls

Provide a self operating regulator to control the flow of cooling water to the tank. Regulator shall include a 20 mm 3/4 inch screwed bronze body with stainless steel trim, reverse acting actuator (for cooling), capillary tubing and a union connection bulb with a stainless steel well. Control setting shall be 60 degrees C 140 degrees F with a minimum Cv of [_____].

2.9.11 Continuous Blowdown System

Provide a complete automatic continuous boiler blowdown system which shall include a controller/programmer unit and flow assembly for each boiler, plus a continuous blowoff heat exchanger, flash tank and boiler water sample cooler.

2.9.11.1 Automatic Blowdown Controller

Intermittent type boiler blowdown system rated for not less than 1724 kPa (gage) 250 psig steam pressure.

2.9.11.2 Flow Assembly

Include a 25 mm one inch ball valve with 316 stainless steel ball and stem

and stainless steel electrode assembly.

2.9.11.3 Controller/Programmer

Include a conductivity meter with zero to 6000 microhms range, valve open/closed indicators and manual/auto control switch. Cycle interval and sample duration shall both be adjustable over a wide range. Mount units at operating floor near boiler front.

2.9.11.4 Accessories and Connections

a. Continuous Blowdown Connection: At each boiler, provide a gate valve and extend piping to header at flash tank.

b. Header Connections: Provide with a tee with valved sampling connection. Provide a 20 mm 3/4 inch, three globe valve bypass around each flow assembly.

c. Common Header: Provide from valved outlet connections on flow assembly units to connection on flash tank.

2.9.11.5 Flash Tank

Designed for [_____] kPa (gage) psig and constructed in accordance with the ASME BPVC SEC VIII D1. Tank shall be [_____] mm inches in diameter by [_____] mm inches long including heads and shall be ASME Code stamped.

2.9.11.6 Blowdown Inlet

Provide tank with blowdown inlet, steam outlet, gage glass, float operated outlet valve, relief valve, and inspection openings. Tank shall have steel angle legs with plate feet for bolting to floor and legs shall be of sufficient length so that bottom of lower head of tank will be not less than 460 mm 18 inches above floor.

2.9.11.7 Automatic Control System

Control level in the flash tank, by modulating a valve in the water outlet line.

a. Level Controller: External cage type air operated level controller, complete with 40 mm 1 1/2 inch screwed connection, 350 mm 14 inch stainless steel float and Class 125 cast iron body. Controller shall be direct acting with 20 to 103 kPa (gage) 3 to 15 psig range with proportional band. Locate controller to maintain an operating level at center line of storage tank. Provide level controller with air pressure reducing valve, filter, gages and isolating valves for float cage. Provide unions on each side of float cage.

b. Outlet Water Valve: [_____] mm inch air operated control valve with a capacity to pass [_____] L/s gpm at a pressure drop of [_____] kPa (gage) psig. Cv shall not be less than [_____] at 100 percent open. Valve shall be Class [_____], flanged, iron or semi-steel body with stainless steel internals. Valve shall have equal percentage flow characteristics with a full size port. Provide an air lock mounted on valve diaphragm and piped to hold valve in last position on air failure.

2.9.11.8 Sample Cooler

Water cooled shell and tube type with valves and accessories required to safely withdraw a water sample from the boiler drum. Provide drain under sampling valve terminating with a 20 mm 3/4 inch splash proof funnel, 230 mm 9 inches below outlet of valve.

2.9.11.9 Heat Exchanger

Provide an ASME code stamped continuous blowoff heat exchanger designed and constructed in accordance with ASME BPVC SEC VIII D1 to transfer heat from the continuous blowoff water leaving the continuous blowoff flash tank to the treated makeup water entering the feedwater heater. Heat exchanger shall be a bare tube, helical coiled bundle, installed in a one piece casing with removable front plate. Bundle shall be removable. Tube diameter shall be not less than 20 mm 3/4 inch. Tubes shall be ASTM B111/B111M copper alloy with cast iron shell. Design tube side for not less than [_____] kPa (gage) psig pressure at [_____] degrees C F. Design shell side for not less than [_____] kPa (gage) psig pressure at [_____] degrees C F.

2.10 PIPING

Piping work shall include the provision of piping systems, including valving and specialty items, for the steam plant and related external auxiliary equipment. Piping materials, design, and fabrication shall be in accordance with ASME B31.1 except as modified below or indicated otherwise. The requirements of ASME B31.1 apply to the building steam heating and steam distribution piping designed for 103 kPa (gage) 15 psig or lower and hot water heating systems 207 kpa (gage) 30 psig or lower. Provide piping materials suitable for the maximum pressure at the maximum temperature at which the equipment must operate. Compute expansion of pipe with operating temperatures above minus 18 degrees C zero degrees F with minus 18 degrees C zero degrees F in lieu of 21 degrees C 70 degrees F specified in ASME B31.1.

2.10.1 Piping Materials

a. Steam Pipe, Boiler Feedwater Pipe, Relief Pipe and Steam Tracer: Pipe Black, ASTM A53/A53M or ASTM A106/A106M seamless steel pipe, Grade A or B. Wall thickness not less than Schedule 40. Steam tracer pipe, with steam up to 103 kPa (gage) 15 psig, may be ASTM B88M ASTM B88, Type K copper tubing.

b. Condensate Pipe and Boiler Blowdown Pipe: Black, welded or seamless ASTM A53/A53M or ASTM A106/A106M, steel pipe, Grade A or B. Wall thickness not less than extra strong (XS or Schedule 80).

c. Chemical Feed Pipe: ASTM A312/A312M austenitic stainless steel.

d. Fuel Oil Pipe: ASTM A53/A53M or ASTM A106/A106M, seamless black steel pipe, Grade A or B.

e. Treated Water, Hot Water Heating, High Temperature Water, Drains (Other Than Sanitary), and Overflow Pipe: ASTM A53/A53M, black, welded or seamless steel up to a maximum pressure of 1724 kpa (gage) 250 psig or ASTM A106/A106M, Grade A or B.

f. Gas Pipe and Compressed Air Pipe: ASTM A53/A53M welded or seamless

pipe up to a maximum pressure of 1724 kPa (gage) 250 psig or ASTM A106/A106M, Grade A or B.

g. Instrument Air Pipe: ASTM B88M ASTM B88 hard copper tubing, Type K or L; except in a corrosive atmosphere or outside pipe shall be copper tubing, Type K or L, with ASTM D1047 PVC jacketing.

h. Steam Tracer Pipe: As an option, the, contractor may provide ASTM B88M ASTM B88, Type K, copper tubing for steam up 103 kPa (gage) 15 psig.

2.10.2 Chlorinated Polyvinyl Chloride (CPVC)

Chlorinated polyvinyl chloride (CPVC) and other plastic tubing and fittings shall not be used in the steam heating plant, unless otherwise specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Systems for potable water, sanitary drains and storm drains are also covered in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.10.3 Fittings

2.10.3.1 Fittings for Steel Pipe

a. Sizes 6 to 50 mm 1/8 to 2 inches: ASME B16.3 malleable iron, screwed end fittings, for working pressures not greater than 2068 kPa (gage) 300 psig at temperatures not greater than 232 degrees C 450 degrees F or ASME B16.11forged steel.

b. Sizes 6 to 50 mm 1/8 to 2 inches: ASME B16.11 steel, socket welded end fittings.

c. Sizes 6 to 65 mm 1/8 to 2 1/2 inches: ASME B16.9 steel, butt welding fittings.

d. Sizes 65 to 600 mm 2 1/2 to 24 inches: ASME B16.5 forged steel, flanged fittings.

2.10.3.2 Welded Outlets and Welding Saddles

Make branch connections of 45 and 90 degrees either with ASME B16.9 forged steel welded outlet fittings or welding saddles. Welding outlets and saddles shall not be smaller than two pipe sizes less than the main pipe sizes.

2.10.3.3 Fittings For Copper Tubing

ASME B16.18 cast bronze solder joint or ASME B16.22 wrought copper solder joint. For instrument air, fittings may be ASME B16.26 compression joint type.

2.10.3.4 Unions

a. Unions For Steel Pipe: ASME B16.11, ASME B16.39threaded. Unions for zinc coated pipe shall be zinc coated.

b. Unions For Copper Tubing: ASME B16.22. For instrument air, unions may be compression joint type.

2.10.4 Flanges

ASME B16.5, forged steel, welding type. Remove the raised faces on flanges when used with flanges having a flat face. Except as specified otherwise, pressure and temperature limitations shall be as specified in ASME B16.5 for the proper class and service, and the type face specified.

2.10.5 Valves

2.10.5.1 Low Pressure

Valves for maximum working pressure of 1034 kPa (gage) 150 psig saturated steam or 1550 kPa (gage) 225 psig W.O.G. (Water, Oil, Gas) at 93 degrees C 200 degrees F, non-shock service. For working pressures not exceeding 862 kPa (gage) 125 psig saturated steam or 1379 kPa (gage) 200 psig water at 93 degrees C 200 degrees F non-shock service, Class 125 may be used in lieu of Class 150 or Class 250.

a. Valve Sizes 50 mm 2 Inches and Smaller:

(1) Non-Throttling Valves: Gate valves, bronze, wedge disc, rising stem, Class 150, MSS SP-80 or ball valves, bronze, double stem seals, stainless steel ball and shaft, tight shutoff.

(2) Globe Valves and Angle Valves: Bronze, Class 150, MSS SP-80.

(3) Check Valves: Bronze, Type [IV, swing check] [III, lift check], Class 150, MSS SP-80.

b. Valve sizes 65 mm 2 1/2 inches and larger.

(1) Gate Valves: Flanged, cast iron, Class 250, MSS SP-70 or steel, Class 150, ASME B16.34. Valves shall have wedge disc, outside screw and yoke (OS&Y), rising stem; valves 200 mm 8 inches and larger shall have globe valved bypass.

(2) Globe Valves and Angle Valves: Flanged, cast iron, Class 250, MSS SP-85 or steel, Class 150, ASME B16.34.

(3) Check Valves: Flanged, cast iron, Class 250 or steel, Class 150, Type [_____], [lift] [swing] check, style [_____], ASME B16.34.

2.10.5.2 Medium Pressure

Valves for maximum working pressure of 1723 kPa (gage) 250 psig steam at a maximum temperature of 232 degrees C 450 degrees F or 3445 kPa (gage) 500 psig W.O.G. at 93 degrees C 200 degrees F (non-shock).

Valve sizes 65 mm 2 1/2 inches and larger:

a. Gate Valves: Flanged or butt welded, cast iron, Class 250, MSS SP-70 (maximum size 300 mm 12 inches) or steel, Class 300, ASME B16.34. Valves shall have wedge disc, OS&Y, rising stem; each valve 200 mm 8 inches and larger shall have globe valved bypass.

b. Globe Valves and Angle Valves: Flanged or butt welded, cast iron, Class 250, MSS SP-85 or steel, Class 300, ASME B16.34.

c. Check Valves: Flanged or butt welded, iron body, Class 250 or steel,

Class 300, Type [_____] [lift] [swing] check, style [_____], ASME B16.34.

2.10.5.3 High Pressure

Valves for maximum working pressure of 2068 kPa (gage) 300 psigsteam at a maximum temperature of 454 degrees C 850 degrees F or a maximum W.O.G. pressure of 4653 kPa (gage) 675 psig at 149 degrees C 300 degrees F (non-shock).

Valve sizes 65 mm 2 1/2 inches and larger:

a. Gate Valves, Globe Valves, and Angle Valves: Flanged or butt welded, ASME B16.34, steel, Class 300, rising stem, OS&Y. Gate valves 200 mm 8 inches and larger shall have globe valved bypass.

b. Check Valves: Flanged or butt welded, steel, Class 300, Type [_____], [lift] [swing] check, style [_____], ASME B16.34.

2.10.5.4 Ball Valves

ASME B16.5 and API Std 607 double stem seal type for bubble tight shutoff. Seats and seals shall be TFE material. Ball and shaft shall be stainless steel. Provide mechanical stops to prevent cycling valve in wrong direction and self-aligning stem seal.

2.10.5.5 Valve Accessories

ASME B16.34 valve operating mechanisms including chain wheels, gear operators, floor stands, electric motors, air motors and cylinder-type actuating devices. Provide accessories as follows and as indicated.

a. Provide power operators with remote position indicators on the following valves: soot blowers, [_____], [_____].

b. Provide floor stands and valve extensions on platforms and floors for the following valves: deaerator drain valves, [_____].

c. Provide motorized actuators or chain wheels with chain and guides on valves with handwheel centerline higher than 2 meters 7 feet above the floor or platform except where specified otherwise. Chains shall extend from valve to within one meter 3 feet above floor. Provide impact chain wheels on steam headers and other locations where valve has a tendency to stick. When a valve is motorized, provide hand operation for emergency.

d. Provide gear operators on ball valves larger than 80 mm 3 inches and on gate valves 200 mm 8 inches and larger.

2.10.5.6 Steam Pressure Regulating Valves

CID A-A-50558, minimum of Class [125] [150] [250] [300], except as specified otherwise. [Cast iron], [cast steel] valve body with valve seats and disc of replaceable heat treated stainless steel. Valves shall be single seated, shall seat tight under dead end conditions, and shall go to the closed position in the event of pressure failure of the operating medium. Valves shall be spring loaded diaphragm operated type, except valves exposed to ambient temperature of less than 2 degrees C 35 degrees F or exposed to the weather shall be piston operated type. Capacity of

valves shall be not less than that indicated. Pilot valves shall have strainer at inlet from external feeder piping.

a. Spring Loaded Diaphragm Operated Valves: Fabricate main spring of stainless steel, which shall not be in the path of steam flow through the valve. Control valve by pilot valve through external feeder piping.

b. Piston Operated Valves: Control valve by integral pilot valve through external feeder piping.

2.10.5.7 Safety Relief Valves

ASME BPVC SEC I ASTM F1508, Style D or E, with Class [150] [300] inlet flange, with test lever, designed for the intended service.

2.10.6 Bolts and Nuts

a. Bolts: ASTM A193/A193M, Grade B8. Lengths of bolts shall be such that not less than two full threads will extend beyond the nut with the bolts tightened to required tensions and washers seated.

b. Nuts: ASTM A194/A194M, Grade 8.

2.10.7 Gaskets

ASME B31.1 and as specified below, except provide spiral wound metal covered non-asbestos gaskets in lieu of compressed sheet non-asbestos. Gaskets shall be as thin as the finish of surfaces will permit. Do not use paper, vegetable fiber, rubber, or rubber inserted gaskets for temperatures greater than 121 degrees C 250 degrees F. Provide metal or metal jacketed non-asbestos gaskets with small male and female and small tongue-and-groove flanges and flanged fittings; they may be used with steel flanges with lapped, large male and female, large tongue-and-groove, and raised facings. Provide fullface gaskets with flat-faced flanges. Raised face cast iron flanges, lapped steel flanges, and raised faced steel flanges shall have ring gaskets with an outside diameter extending to the inside of the bolt holes. Widths of gaskets for small male and female and for tongue-and-groove joints shall be equal to the widths of the male face and tongue. Gaskets shall have an inside diameter equal to or larger than the port opening. Dimensions for nonmetallic gaskets shall be in accordance with ASME B16.21. Materials for flanged gaskets shall be as listed below for service specified:

a. Steam, Boiler Blowdown, Exhaust Steam: Spiral wound metal composition or copper.

b. Boiler Feed Water: Metal jacketed non-asbestos, copper or monel.

c. Hot Water, (above 38 degrees C 100 degrees F): Spiral wound metal non-asbestos.

d. Cold Water: Red rubber or neoprene rubber.

e. Heavy Fuel Oil (No. 6): Spiral wound metal non-asbestos, soft steel, or monel.

f. Diesel Fuel (No. 2): ASME B16.21 metallic.

g. Compressed Air: Spiral wound metal non-asbestos.

2.10.8 Expansion Joints

2.10.8.1 Slip Tube Expansion Joints

ASTM F1007, single or double slip tube as indicated, designed for [1034] [2068] kPa (gage) [150] [300] psig saturated steam working pressure. Expansion joints shall be of the type which permits the injection of semi plastic type packing while the joint is in service under full line pressure. Slip tube shall be of chromium plated, wrought steel construction, guided by internal and external guides integral with joint body. Fit slip tube ends with forged steel pipe flanges or bevel for welding into pipe line where indicated. Deliver joints complete with packing and ready for installation.

2.10.8.2 Flexible Ball Expansion Joints in Piping

Capable of 360 degrees rotation plus 15 degrees angular flex movement. Ball joints shall have steel bodies and polished steel balls. Provide end connections to suit class of piping here in before specified. Seals shall be of pressure molded composition designed for the working pressure. Provide joints for [1034] [2068] kPa (gage) [150] [300] psig saturated steam working pressure. Cold set the joints as necessary to compensate for temperature at time of installation. Do not use ball joints on superheated steam or on joints subject to frequent flexure. Install ball joints in strict accordance with manufacturer's recommendations.

2.10.8.3 Bellows Expansion Joints

ASTM F1120 flexible guided type with stainless steel expansion element, internal sleeves and external covers. Joints shall be designed for a working pressure of [_____] kPa (gage) psig and a temperature of [_____] degrees C F.

2.10.9 Pipe Hangers and Supports

MSS SP-58, Type [_____] or Type [_____] of the adjustable type, except as specified or indicated otherwise. Suspended steam and condensate piping shall have pipe hangers Type [_____] with insulation protection saddles Type [_____]. Provide insulated piping, except steam and condensate piping, with insulation protection shields Type 40. Provide bronze or copper plated collars on uninsulated copper piping. Support rods shall be steel. Rods, hangers and supports shall be zinc plated, except for uninsulated copper piping which shall be copper plated; cast iron rollers, bases and saddles may be painted with two coats of heat resisting aluminum paint in lieu of zinc plating. Axles for cast iron rollers shall be stainless steel. Size hanger rods with a 150 percent safety factor for a seismic design.

2.10.10 Instrumentation

2.10.10.1 Pressure and Vacuum Gages

Conform to the applicable requirements of ASME B40.100.

2.10.10.2 Indicating Thermometers

MIL-T-19646 dial type. Thermometer shall include a separable immersion

well.

2.10.11 Miscellaneous Pipeline Components

2.10.11.1 Cold and Hot Water Meters

CID A-A-59224 for maximum flow of [_____] L/s at 38 degrees C gpm at 100 degrees F and reduced flow of up to [_____] L/s at 121 degrees C gpm at 250 degrees F.

2.10.11.2 Air Traps

Float controlled valves arranged to close properly when water enters the traps. Air traps shall conform to the requirements for float operated steam traps (non-thermostatic), CID A-A-60001, except that the valve mechanism shall be inverted so as to be closed, not opened, by rising water.

2.10.11.3 Steam Traps

CID A-A-60001. Inverted bucket high pressure steam traps designed for use at [_____] kPa (gage) psig at [_____] degrees C F. Low pressure steam traps shall be float and thermostatic type for pressures up to 103 kPa (gage) 15 psig. Provide traps with separate strainers unless specified otherwise.

2.10.11.4 Strainers

FS WW-S-2739, Style Y for Class [125] [250] with blow off outlet. Construct strainers for Class 300 of cast carbon steel in accordance with ASME B16.5 for minimum of 2068 kPa (gage) 300 psigsaturated steam pressure. Provide blow off outlet with pipe nipple and gate valve.

2.10.12 Backflow Preventers

Provide reduced pressure principle type conforming to applicable requirements of AWWA C511, and as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.10.13 Insulation Types and Installation Procedures

Materials and application shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.10.14 Pipe Sleeves

2.10.14.1 Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade

Galvanized steel pipe having an i.d. at least 12.7 mm 1/2 inch larger than the o.d. of the pipe passing through it. Provide sufficient sleeve length to extend completely through floors, roofs, and walls, so that sleeve ends are flush with finished surfaces except that ends of sleeves for floor slabs shall extend 13 mm 1/2 inch above finished floor surface. Sleeves located in waterproofed construction shall include flange and clamping ring.

2.10.14.2 Partitions

Galvanized sheet steel, 26 gage or heavier, of sufficient length to

completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.10.15 Piping Identification

Conform to MIL-STD-101 and place in clearly visible locations; except that piping in the boiler room shall be painted the primary color of the color code. Labels and tapes conforming to ASME A13.1 shall be used in lieu of band painting or stenciling. Labels shall be outdoor grade acrylic plastic. Markings on the labels shall indicate the direction of flow, flowing media, and media design pressure and temperature. Spacing of identification marking shall not exceed 3 meters 10 feet. Provide two copies of the complete color and stencil codes used. Frame codes under glass and install where directed.

2.11 FIRE PROTECTION SYSTEM

Provide the fuel oil [and gas metering] room[s] with a wet sprinkler system as specified in Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION.

2.12 MARKING

Identify equipment, valves, switches, motor controllers, and controls or indicating elements by printed, stamped or manufactured identification plates or tags of rigid plastic or non-ferrous material. Lettering for identification plates or tags shall be not less than 5 mm 3/16 inchhigh. Nomenclature and identification symbols used on identification plates or tags shall correspond to those used in the maintenance manuals, operating instructions, and schematic diagrams. Rigidly affix identification plates or tags to equipment or devices without impairing functions or, when this is not possible, attach using a non-ferrous wire or chain. In addition to the identification plate or tag, each major component of equipment shall have a nameplate listing the manufacturer's name, model number, and when applicable, electrical rating and other information required by pertinent standards or codes.

2.13 TOOLS AND TESTING EQUIPMENT

Provide special tools and wrenches required for the installation, maintenance, and operation of the equipment. Provide testing equipment necessary to perform routine tests:

a. On lubricating oil for acidity (pH-potentiometer), viscosity (saybolt test), and dirt (gravimetric).

b. On softened water for hardness (soap test or colorimetric test), and boiler blowdown water for pH (colorimetric) and conductivity (potentiometer).

c. For water (distillation) and sediment (gravimetric) in fuel oil.

2.14 WELDING MATERIALS

Comply with ASME BPVC SEC II-C. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

2.15 MOTORS AND DRIVES

Alternating current electric motors shall meet requirements of NEMA MG 1. Motors shall be designed for continuous operation at rated load under usual service conditions as defined by NEMA. Motors less than 3/4 kW 1 hp shall meet NEMA High Efficiency requirements. Motors 3/4 kW 1 hp and larger shall meet NEMA Premium Efficiency requirements. Unless specifically noted otherwise, motors less than 3/8 kW 1/2 hp shall be 115 volt, 60 Hz, single phase, capacitor-start, or permanent split capacitor, with Class B insulation for 40 degrees C 104 degrees F ambient. Unless specifically noted otherwise, motors 3/8 kW 1/2 hp and larger shall be 460 volt, 60 Hz, three phase, Design B, squirrel cage induction with a minimum insulation of Class F for 40 degrees C 104 degrees F ambient. Size motors to meet the power requirements of the driven unit at design conditions, including drive and coupling losses which are incurred, without loading the motor beyond its nameplate power rating. Minimum service factor for open drip-proof motors shall be 1.15 and for totally enclosed, fan cooled motors 1.0. Motor shall be quiet operating. Bearings shall be heavy duty, grease lubricated, anti-friction, single shielded, regreasable type and shall have approved lubricating fittings extended to an easily accessible location for field servicing. Provide sole plates for motors installed on concrete pads. Motors shall have copper windings.

2.16 SOURCE QUALITY CONTROL

2.16.1 Plant Equipment Tests

Tests specified below shall be conducted at factory prior to delivering equipment to job site.

2.16.1.1 Plant Air Compressors

Test plant air compressors in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

2.16.1.2 Instrument Air Compressors

Factory test air compressor package at full load for not less than 2 hours. Check capacity, smoothness of operation, alternation of units, and proper operation of the air unloaders during the test.

2.16.1.3 Variable Speed Motor Controller Factory Test

Burn-in tests shall be conducted for at least 50 hours at rated conditions. If a component fails during the burn-in test it shall be replaced, and the entire test shall be run again on the complete assembly for another 50 hours. The burn-in test shall not be complete until the entire assembly has operated for 50 hours without failure.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment as indicated and in accordance with manufacturer's recommendations.

3.1.1 Equipment Installation

Install equipment in accordance with this specification, and the installation instructions of the manufacturers. Equipment mounted on concrete foundations shall be grouted before installing piping. Install piping in such a manner that it will not impart a stress on equipment. Flanged joints shall not be bolted tight unless they match adequately. Expansion bends shall be adequately extended before installation. Support, grade, anchor, and guide all piping so that there are no low pockets, which could accumulate fluids, along the piping run.

3.1.1.1 Equipment Foundations

Equipment foundations shall be of sufficient size and weight, and proper design to prevent shifting of equipment under operating conditions, or under abnormal conditions which could be imposed upon equipment. Equipment vibration shall be limited within acceptable limits, and isolated. Foundations shall be adequate for soil conditions of the site and shall meet requirements of the equipment manufacturer. Trowel exposed foundation surfaces smooth except when properly roughened surfaces are necessary to receive grout.

3.1.1.2 Forced Draft Fan

Fan assembly shall be set, shimmed level, anchored and grouted in place prior to setting driver. Driver shall be properly shimmed on base plate using steel shim stock. Shims shall be full size of feet and shall have a slotted hole for installation. After the drive has been properly aligned and shimmed, by an approved millwright, the millwright shall drill and ream the foot and base plates and, install taper pins with nut on top for pullout removal. One front foot and diagonally opposite rear foot shall be pinned to base plate. Bolt equipment into place in an approved manner. Level and grout the fan and bearing pedestal sole plates into place.

3.1.1.3 Stack

Install, level and plumb. Erected stack shall be no more than 25 mm one inch out of plumb (out of vertical) per 15 meters 50 feet. Remove roughness, marks, and lifting lugs, from stack and grind surfaces smooth and flush with surrounding surfaces.

3.1.1.4 Fuel Oil Tanks

****
NOTE: At the text below, choose one of the following options.
****

[a. Horizontal Fuel Oil Tanks (Below Ground): Provide concrete ballast slabs for tanks and concrete protective ground level slabs for FRP tanks. The ballast slabs shall be full length and width of the tanks and the protective slabs shall extend 600 mm 2 feet beyond the tanks. Concrete work shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

(1) Installation: Install and backfill fiberglass reinforced tanks as recommended by the manufacturer; backfill adjacent to the tanks shall be pea gravel unless otherwise recommended by the

manufacturer. Backfill for steel tanks shall be sand.

(2) Placement: Set steel tanks on a bed of sand not less than 150 mm 6 inches deep over the concrete slab and strap in place with stainless steel hold-down straps with stainless steel turnbuckles. Set FRP tanks on a bed of pea gravel not less than 300 mm 12 inches thick and pre-shape for the tank contours for FRP tanks. Fabricate straps for FRP tanks from FRP resins reinforced with stainless steel to prevent breaking of straps and floating of empty tanks.

(3) Slope tank toward sump not less than25 mmone inch in each 1 1/2 meters 5 feet.

][b. Horizontal Fuel Oil Tanks (Above Ground): Continuously support steel tank saddles along the full length of the base and level and grout to ensure full bearing.

][c. Vertical Fuel Oil Tank: Provide [sand, crushed stone or fine gravel cushion] [concrete base].

][(1) Sand, Crushed Stone or Fine Gravel Cushion: Cover area beneath tank with a minimum 0.51 mm 20 mil thick fuel resistant plastic membrane. Carefully fuse or cement plastic membrane seams. Lay plastic over a thoroughly compacted select subgrade free from rocks that could puncture the plastic. Over plastic, provide a bed of sand, crushed stone or fine gravel not less than 150 mm 6 inches thick. Stabilize bed with an approved material and shape to the tank bottom. Slope bed down to center sump approximately 150 mm 6 inches for each 3 meters 10 feet of tank radius. When in place, tank shell shall be plumb.

][(2) Concrete base shall be as indicated and in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

][(3) Mastic Seal: Place the mastic seal between the tank and the concrete ring to the cross section indicated. Compact the mastic thoroughly. Immediately before placing the mastic, coat the tank surfaces to be in contact with the concrete ring with a coat of AASHTO M 118 bituminous material.

]3.1.2 Piping

Unless specified otherwise, erection, welding, brazing, testing and inspection of piping shall be in accordance with ASME B31.1 and Section 40 17 26.00 20 WELDING PRESSURE PIPING. Piping shall follow the general arrangement shown. Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Install piping connected to equipment to provide flexibility for vibration. Support and anchor piping so that

strain from weight of piping is not imposed on equipment.

3.1.2.1 Fittings

Provide long radius elbows on welded piping to reduce pressure drops. Do not miter pipe to form elbows, notch straight runs to form full sized tees, or use similar construction. Make branch connections with welding tees, except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.1 may be used.

3.1.2.2 Grading of Pipe Lines

Unless indicated otherwise, install horizontal lines of steam and return piping to grade down in the direction of flow with a pitch of not less than 25 mm in 9 meters one inch in 30 feet, except in loop mains and main headers where flow may be either direction. Pitch air lines to the source of supply, and make provisions for draining off condensate. Install water lines to drain to a shutoff valve.

3.1.2.3 Anchoring, Guiding, and Supporting Piping

Anchor and support piping in a manner such that expansion and contraction will take place in the direction desired, prevent vibration by use of vibration dampeners, and prevent undue strains on boilers and equipment served. Fabricate hangers used for support of piping of 50 mm 2 inch nominal pipe size and larger to permit adequate adjustment after erection while still supporting the load. Provide wall brackets where pipes are adjacent to walls or other vertical surfaces which may be used for supports. Provide supports to carry weight of lines and maintain proper alignment. Provide inserts and sleeves for supports in concrete where necessary and place in new construction before pouring concrete. Provide insulated piping with a pipe covering protection saddle at each support. Provide pipe guides and anchors of approved type at points where necessary to keep pipes in accurate alignment, to direct expansion movement, and to prevent buckling and swaying and undue strain. Provide pipe guides for alignment of pipe connected to free unanchored end of each expansion joint. Support pipe rollers in concrete conduits and trenches by extra strong steel pipe with ends inserted in slots provided in concrete walls. Set pipe supports for rollers at correct elevations either by metal shims or by cutting away of concrete and after placing pipe lines in alignment, grout ends of pipe supports and fix in place. Space pipe supports to provide adequate support for pipes. Pipe shall not have pockets formed in the span due to sagging of pipe between supports, caused by weight of pipe, medium in pipe, insulation, valves, and fittings. Maximum spacing for pipe supports for steel pipe shall be in accordance with ASME B31.1; maximum spacing for supports for copper tubing shall be in accordance with MSS SP-58.

3.1.2.4 Copper Tubing

Copper tubing shall have solder joints with solder suitable for the pressure-temperature ratings of the piping system. Tubing 20 mm 3/4 inch and smaller for instrument air may be compression joint in lieu of soldered joint. Tin-antimony (95/5) solder is suitable for saturated steam up to 103 kPa (gage) 15 psig but tin-lead (50/50) solder is not acceptable for steam service. Flux shall be non-corrosive. Wipe excess solder from the joints.

3.1.2.5 Sleeves

Provide pipe sleeves where pipes and tubing pass through masonry and concrete walls, floors, and partitions. Space between pipe, tubing, or insulation and the sleeve shall be not less than 6 mm 1/4 inch. Hold sleeves securely in proper position and location before and during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, and slabs. Sleeves in floor slabs shall extend 15 mm 1/2 inch above the finished floor. Firmly pack space between pipe or tubing and the sleeve with oakum and caulk on both ends of the sleeve with elastic cement.

3.1.2.6 Flashing for Buildings

Where pipes pass through building roofs and outside walls, provide proper flashing and counter flashing and make tight and waterproof.

3.1.2.7 Outlets for Future Connections

Locate as directed capped or plugged outlets for connections to future equipment, when not located exactly by the project drawings.

3.1.2.8 Screwed Joints in Piping

Provide teflon tape or suitable pipe joint compound applied to male threads only for making up screwed joints. Piping shall be free from fins and burrs. Ream or file out pipe ends to size of bore, and remove chips.

3.1.2.9 Welds and Welded Joints

Weld joints in piping by the metal-arc or gas welding processes in accordance with ASME B31.1. Number or mark each weld to identify the work done by each welder on welds which stress relieving or radiographic inspection is required.

a. Recertification: The Contracting Officer reserves the right to require the Contractor to provide re-examination and recertification of welders.

b. Radiographic testing of circumferential butt welded joints of pipe with operating temperature of 177 degrees C 350 degrees F and above shall be required on ten percent of the joints, the location of which will be determined by the Contracting Officer; when more than ten percent of the radiographically tested joints show unacceptable defects radiographically test joints of this type piping.

c. Equipment and Protection: Items of equipment for welding shall be so designed and manufactured, and be in such condition as to enable qualified operators to follow procedures and to attain the results specified. Protect welders and gas cutters from the light of the arc and flame by approved goggles, shields, helmets, and gloves. Replace cover glasses in helmets and shields when they become sufficiently marred to impair the operator's vision. Take care to avoid risk of explosion and fire when welding and gas cutting near explosive or flammable materials. Ventilate welding and gas cutting operations in accordance with paragraph 29 CFR 1910-SUBPART Q.

d. Surface Conditions: Do not weld when atmospheric temperature is less than minus 18 degrees C zero degrees F, when surfaces are wet, when

rain or snow is falling or moisture is condensing on surfaces to be welded, nor during periods of high wind, unless the welder and work are protected properly. At temperatures between zero degrees C 32 degrees F and minus 18 degrees C zero degrees F heat with a torch the surface for an area within 80 mm 3 inches of the joint to be welded to a temperature warm to the hand before welding. Free surfaces to be welded from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth, uniform and free from fins, tears, and other defects which might affect proper welding. Remove slag from flame-cut edges to be welded by grinding, but temper color need not be removed. Thoroughly clean each layer of weld metal by wire brushing prior to inspection or deposition of additional weld metal.

3.1.2.10 Cleaning of Piping

Before installing pipe, thoroughly clean it of sand, mill scale and other foreign material. After erection but before final connections are made to apparatus thoroughly clean the interior of piping. Flush with water piping except air and fuel lines, in addition, blow out steam lines with intermittent high pressure steam blows to promote shedding of internal scale. Blow compressed air and fuel oil lines clean with 552 to 690 kPa (gage) 80 to 100 psig air dried to a 2 degrees C 35 degree F dew point at 552 kPa (gage) 80 psig. Sterilize potable water piping by means of liquid chlorine or hypochlorite in accordance with AWWA C651 before placing water system in service. Take care during fabrication and installation, to keep piping, valves, fittings and specialties free of loose welding metal chips of metal or slag, welding rods and other foreign matter. Blowing or flushing shall in no case be channeled through equipment, pump, control valve, regulating valve, instrument gage or specialty in the system. Provide temporary screens, strainers, connections, spool pieces and bypasses consisting of piping or hoses, pumps and other required equipment temporarily installed for the purpose of cleaning and flushing piping. Drain flushing water and test water to the sanitary sewer system.

3.1.2.11 Reduction in Pipe Size

Provide reducing fittings for changes in pipe size; the use of bushings will not be permitted. In horizontal steam lines, reducing fittings shall be the eccentric type to maintain the bottom of the lines in the same plane. In horizontal water mains, reducers shall be set to maintain the top of the lines in the same plane.

3.1.2.12 Expansion Control

Provide bends, loops, and offsets wherever practical to relieve overstressed piping systems due to thermal expansion and to provide adequate flexibility. Cold spring piping system as indicated but not more than 50 percent of the total linear expansion.

3.1.2.13 Connection to Equipment

Provide unions or flanges where necessary to permit easy disconnection of piping and apparatus. Provide unions and gate valves at each connection to threaded end control valves, strainers and equipment.

3.1.2.14 Valve Installation

Install valves in positions accessible for operation and repair. Install

stems in a vertical position with handwheels or operators on top or in a horizontal position. Do not install handwheels on stop valves below the valve. When centerline of valve is more than 2 meters 7 feet above floor or platform, provide valve with a chain-operated handwheel. When valve is motorized, provide hand operation for emergency use.

a. Gate Valves: Arrange back outlet gate valves for turbine exhaust for hand operation and provide with a floor stand.

b. Globe Valves: Pressure shall be below the disc. Install globe valves with the stems horizontal on steam and exhaust lines, when better drainage is required or desired.

c. Steam Pressure-Reducing Valves: Provide the steam line entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two shutoff valves and with a globe or angle bypass valve and bypass pipe. A bypass around a reducing valve shall be of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure-reducing valve unit with indicating steam gages to show the reduced pressure and the upstream pressure and an adequately sized safety valve on the low pressure side.

d. Valve Tags and Charts: Permanently tag each valve with a black and white engraved laminated plastic tag showing valve number, valve function and piping system and whether another valve must be opened or closed in conjunction with this valve. Provide a typed chart which will show the required valve tagging plus the location of each valve. Frame valve charts under glass and install as directed.

3.1.2.15 Traps and Connections

Traps shall be of the type and capacity for the service required, and shall be properly supported and connected. Except for thermostatic traps in pipe coils, radiators, and convectors, install traps with a dirt pocket and strainer between it and the piping or apparatus it drains. When it is necessary to maintain in continuous service apparatus or piping which is to be drained, provide a three valve bypass so that trap may be removed and repaired and condensate drained through the throttled bypass valve. Provide a check valve on discharge side of trap whenever trap is installed for lift or operating against a back pressure, or it discharges into a common return line. Provide test connections on discharge side of high and medium pressure traps when they are specifically required. Test connection shall include a 15 mm 1/2 inch globe valve with open blow.

3.1.2.16 Pressure Gage Installation

Provide with a shutoff valve or petcock between the gage and the line, and gage on steam lines shall have a siphon installed ahead of the gage.

3.1.2.17 Thermometer and Sensing Element Installation

Provide thermometers and thermal sensing elements of control valves, with a separable socket. Install separable sockets in pipe lines in such a manner to sense flowing fluid temperature and minimize obstruction to flow.

3.1.2.18 Strainer Locations

Provide strainers with meshes suitable for the services upstream of each

control valve and where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.1.2.19 Dissimilar Piping Materials

Provide dielectric unions or flanges between ferrous and nonferrous piping, equipment, and fittings, except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or nonferrous-to-nonferrous connections. Dielectric fittings shall utilize a nonmetallic filler which will prevent current flow from exceeding one percent of the short circuit current. Spacer shall be suitable for the pressure and temperature of the service. Fittings shall otherwise be as specified in this section.

3.1.2.20 Surface Treating, and Pipe Wrapping

Uninsulated steel piping buried in the ground shall have exterior surfaces protected with a tape wrapping system or a continuously extruded polyethylene coating system as specified in Section 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS.

3.1.3 Painting

3.1.3.1 Piping, Fittings, and Mechanical and Electrical Equipment

Equipment shall be factory finished to withstand the intended end use environment in accordance with the specifications for particular end item. Factory finished equipment on which the finish has been damaged shall have damaged areas retouched and then be given a complete finish coat to restore the finish to its original condition. Finish coat shall be suitable for exposure in the intended end use environment.

3.1.3.2 Other Items

Unless specified otherwise, pipe hangers, structural supports, pipe and pipe fittings, conduit and conduit fittings, air grilles, pipe coverings, insulation, and metal surfaces associated with mechanical and electrical equipment including zinc-coated steel ducts shall be painted utilizing the painting systems as specified in Section 09 90 00 PAINTS AND COATINGS. Zinc-coated steel duct in unpainted areas shall not be painted. Except zinc-coated and copper pipe, give piping to be insulated, a protective coating prior to installing insulation.

3.1.3.3 Boilers

After erecting and testing boilers, clean exposed surfaces of the boiler normally painted in commercial practice to remove grease, coal dust, flyash and other foreign matter and finish with one coat of aluminum heat resisting paint applied to minimum dry film thickness of 0.025 mm one mil.

3.1.3.4 Vertical Fuel Oil Tank

Clean interior surfaces to bare metal in accordance with SSPC SP 10/NACE No. 2. Clean to bare metal by powered wire brushing or other mechanical means surfaces that cannot be cleaned satisfactorily by blasting. Wash members which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Remove weld backing plates prior to blast cleaning; when left in place, round off the corners prior to blast cleaning and coating. Tanks shall be

internally coated in accordance with Section 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS.

3.1.3.5 Surfaces Not to be Painted

Unless specified otherwise, do not paint equipment having factory applied permanent finish, switchplates and nameplates, motor starters, and concrete foundations.

3.1.4 Insulation

Insulate mechanical equipment, systems and piping as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2 FIELD QUALITY CONTROL

Provide labor, equipment, test apparatus and materials required for preparation and performance of tests and inspections specified to demonstrate that the boilers and auxiliary equipment as installed are in compliance with contract requirements. During startup and during tests, factory trained engineers or technicians employed by the boiler manufacturer and system suppliers or manufacturers of such components as the boiler, burner, forced draft fan, feedwater treatment equipment, and other auxiliary equipment shall be present, to ensure the proper functioning, adjustment, and testing of the individual components and systems. The Government will furnish, when available, water, electricity and fuel for the tests, except fuel required for retesting. The Contractor shall rectify defects disclosed by the tests and retest the equipment. The Contractor's boiler plant personnel shall be experienced in starting up and operating boiler plants.

3.2.1 Tests and Inspections (Piping)

3.2.1.1 General Requirements

Examine, inspect, and test piping in accordance with ASME B31.1except as modified below. The Contractor shall rectify defects disclosed by the tests. Necessary subsequent tests required to prove system tight after additional work by the Contractor shall be provided by the Contractor. Make tests under the direction of and subject to the prior approval of the Contracting Officer.

3.2.1.2 Hydrostatic and Leak Tightness Tests

a. Test piping systems attached to the boilers and included under the jurisdiction of the ASME BPVC SEC I in accordance with the requirement of that Code. Piping bearing ASME Code symbol stamp will be accepted only as indicating compliance with the design and material requirements of the code.

b. Test piping which is a part of the steam generation or auxiliary systems, including piping within the boiler room and external to the boiler room, by the following methods:

(1) Perform hydrostatic test at 150 percent of design pressure for welded and screwed steel piping systems except those for air, oil, and gas. Hold hydrostatic tests for a period of one hour with no pressure loss. Temperature of the testing fluid shall not exceed 38 degrees C 100 degrees F.

(2) Test air and oil lines in accordance with the requirements of ASME B31.1 for pneumatic tests with the exception that the test pressure must be held for one hour. Examination for leaks by a soap or other foaming agent test.

(3) Inspection and test of gas piping shall conform to the requirements of NFPA 54.

c. For tests install a calibrated test pressure gage in the system to observe loss in pressure.

3.2.2 Preliminary Operation

The Contractor under the direction of the respective manufacturer's representative shall perform the work of placing into operation equipment provided except as specifically noted otherwise. Make adjustments to equipment that are necessary to ensure proper operation as instructed by the manufacturer of the equipment.

a. Lubricate equipment prior to operation in accordance with the manufacturer's instructions. Lubricants shall be provided by the Contractor. Contractor shall furnish lubrication gun with spare cartridges of lubricant to operating personnel.

b. Dry out motors before operation as required to develop and maintain proper and constant insulation resistance.

c. Check drive equipment couplings for proper alignment at both ambient and operating temperature conditions.

3.2.3 General Startup Requirements

Prior to initial operation of any complete system, check each component as follows:

a. Inspect bearings for cleanliness and alignment and remove foreign materials found. Lubricate as necessary and in accordance with manufacturer's recommendations. Replace bearings that run roughly or noisily.

b. Adjust direct drives for proper alignment of flexible couplings. Provide lubrication when a particular coupling so requires. Check security of couplings to driver shafts. Set drive components to ensure free rotation with no undesirable stresses present on the coupling of attached equipment.

c. Check motors for amperage comparison to nameplate value. Correct conditions that produce excessive current flow and that exist due to equipment malfunction.

d. Check speeds of each motor and driven apparatus to ensure that they are operating at the desired point.

e. Check actual suction and discharge pressure of each pump against desired performance curves.

f. Check pump packing glands or seals for cleanliness and adjustment before running each pump. Inspect shaft sleeves for scoring and

proper placement of packing; replace when necessary. Ensure piping system is free of dirt and scale before circulating liquid through pumps.

g. Inspect both hand and automatic control valves. Clean bonnets and stems, tighten glands to ensure no leakage, but permit valve stems to operate without galling. Replace packing in valves that require same to retain maximum adjustment after system is judged complete. Replace entire packing in valves that continues to leak after adjustment. Remove and repair bonnets that leak. Coat packing gland threads and valve stems with a suitable surface preparation after cleaning.

h. Inspect and make certain that control valve seats are free from foreign material and are properly positioned for the intended service.

i. Check flanges and packing glands after the system has been placed in operation. Replace gaskets in flanges that show signs of leakage after tightening.

j. Inspect screwed joints for leakage and remake each joint that appears to be faulty. Do not wait for rust to form. Clean threads on both parts, apply compound and remake joint.

k. Strainers installed shall be thoroughly blown out through individual valved blow-off connection on each strainer prior to placing in operation.

l. Thoroughly blow out or dismantle and clean strainers after systems have been in operation one week. Thoroughly clean, repair, and place back in service traps or other specialties in which foreign matter has accumulated, causing malfunction or damage.

m. Adjust pipe hangers and supports for correct pitch and alignment.

n. Remove rust, scale and foreign materials from equipment and renew defaced surfaces. When equipment is badly marred, the Contracting Officer shall have the authority to request that new materials be provided.

o. Adjust and calibrate temperature, pressure and other automatic control systems.

p. Inspect each pressure gage and thermometer for calibration, and replace those that are defaced, broken or read incorrectly.

[q. Vertical Fuel Oil Tank Calibration: After completing installation of tank, prepare a calibration table for tank showing the volume of fuel in liters gallons in the tank to height of liquid in meters and mm feet and inches, when measured by a steel tape lowered through the roof. Calibrate tank in accordance with ASTM D1220 for "critical measurement" "operating control." Calibration of the tank shall be done by a qualified organization that can certify to at least 2 years of prior successful and accurate experience in calibrating tanks of comparable type and size. Correct the data obtained for use with the product to be stored.

]3.2.4 Fuel Oil Tanks

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NOTE: Choose one of the following options.
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[a. Horizontal Fuel Oil Tanks (Below Ground):

(1) Test tanks before placing in service, in accordance with the applicable paragraphs of the code under which they were built. An UL label, ASME Code Stamp, or API monogram on a tank shall be evidence of compliance with code requirements.

(2) Holiday Detection Test: Inspect coal tar epoxy coating system for film imperfections using a low voltage (75 volt) holiday tester. Inspect FRP coated tanks with a 10,000 volt spark test for imperfections or holidays (voids). Repair holidays or pinholes in the coatings.

][b. Vertical Fuel Oil Tank: Inspect and test as specified in API Std 650. Use the radiographic method of inspection of butt welds as required by API Std 650; sectioning method will not be acceptable as an alternative to radiographic inspection.

]3.2.4.1 Blowdown Valves and Try Cocks

Test blowdown valves and try cocks for proper operation.

3.2.4.2 Fans, Heaters, Pumps, and Motors

Test draft fans, fuel oil heaters, fuel pumps, and electric motors to determine compliance with the referenced standards. Standard symbols and certifications from the referenced organization may be accepted at the discretion of the Contracting Officer. Closely observe the operation of fans, fuel oil heaters, fuel pumps, and electric motors for possible defects or nonconformance.

3.2.5 Boilers and Auxiliaries Tests and Inspections

The Contractor, with qualified personnel provided by the Contractor, shall make tests and inspections at the site under direction of and subject to approval of the Contracting Officer. The respective manufacturer's representatives and consultants shall direct the Contractor's boiler plant personnel in the operation of each boiler and appurtenances through the entire testing period and shall ensure that necessary adjustments have been made. The Contractor shall notify the Contracting Officer in writing, at least 7 days in advance, indicating that equipment is ready for testing. The Contractor shall provide testing equipment, including gages, thermometers, calorimeter, flue gas analyzers, thermocouple pyrometers, fuel flow meters, water meters and other test apparatus and calibrate instruments prior to the test. Draft, fuel pressure and steam flow may be measured by permanent gages and meters installed under the contract. The Contractor is responsible for providing an analysis of the fuel being used for the tests. Control of noise levels developed by exhaust steam shall be as directed by the Contracting Officer to satisfy environmental conditions of the surrounding area. The Contractor shall perform the following tests in the sequence as listed when feasible:

a. Strength and tightness tests

b. Standards compliance tests

c. Preliminary operational tests (steady state combustion test and variable load combustion test)

d. Tests of auxiliary equipment

e. Feedwater equipment test

f. Capacity and efficiency tests

3.2.5.1 Strength and Leak Tightness Tests

Subject boiler[s] to the following strength and tightness tests:

a. Watersides Including Fitting and Accessories: Hydrostatically test watersides in accordance with the requirements of the ASME BPVC SEC I. Since damage to the boiler components may have occurred during shipping, the factory ASME label will not be accepted as evidence of this test. Therefore, the final hydrostatic test must be performed after the installation of the boiler and its auxiliary components have been installed.

b. Boiler Casing, Air Casing, and Ducts: Test air casing and ducts exterior to the furnace pneumatically at the maximum working pressure. Use the soap bubble method to verify tightness. Test gas sides of boilers normally operated under pressure for tightness at one and one half times the predicted operating pressure in the furnace at maximum continuous output. For this test, tightly seal the boiler with a suitable means to blank off openings. Admit air to the boiler until the test pressure is reached, and then hold. If in a 10 minute period the pressure drop does not exceed 1245 Pa 5 inches water gage, the casing shall be regarded as tight and accepted.

3.2.5.2 Boiler Inspection

The Boiler Inspector shall be on hand to witness the appropriate tests which need to be observed in order to certify the safety of the boiler. The inspection shall include the requirements of NAVFAC MO 324Inspection and Certification of Boilers and Unfired Pressure Vessels. The Boiler Inspector shall complete NAVFAC form 9-11014/40, Data Record Sheet; NAVFAC form 9-11014/41, Inspection Report; NAVFAC 9-11014/32 Inspection Certificate for each boiler after boiler has been inspected and found to be safe. No boiler may be fired until it has passed the inspection of the Boiler Inspector. Boiler inspection forms shall be submitted through the Contractor to the Contracting Officer. Place Inspection Certificate under framed glass, mounted on or near the boiler in a conspicuous location.

3.2.5.3 Boiler Cleaning and Startup

Dry out, boil out, and operate firing rate of new boiler(s) under direct responsibility and supervision of the manufacturer, [and in the presence of boiler room operating personnel]. Provide required chemicals. Allow sufficient time for boiling out process to ensure interior surfaces are clean. This time shall be at least 24 continuous hours and generally not more than 36 hours; boil out shall continue until water is clear. Boil out, cleaning and starting procedures shall be in accordance with requirements of ASME BPVC SEC VII and FM DS 12-17.

3.2.5.4 Boiler Preliminary Operational Tests

Conduct a boiler operational test on each unit continuously for two weeks. Operate one boiler at a time to demonstrate control and operational conformance to specified requirements including ability to respond to load swings from the specified capacity to minimum turndown. Conduct operational test under the supervision of a registered professional engineer or a licensed power plant operator and demonstrate operation of safeties, controls, maintenance of stable combustion at low loads, proper flame lengths and patterns to avoid flame impingement on the tubes for oil firing [or gas firing], and proper mechanical and electrical functioning of systems. This test shall include items mentioned in this specification as well as items mentioned in the specification of the particular pieces of equipment. Conduct tests with factory trained combustion equipment engineers as previously specified. Test and record steam quality, steam flowrates, flue gas temperature, percentages of carbon dioxide, carbon monoxide, oxygen and nitrogen in the flue gas and percent excess air for each boiler at tested load and graphically present test data.

3.2.5.5 General Controls Operational Tests

Conduct operational tests, performance tests, and demonstration tests with boiler controls functional and on line. No bypassing, use of jumpers, or other disablement of control systems will be allowed unless specified elsewhere.

3.2.5.6 Steady State Combustion Tests

Test fuel burning and combustion control equipment with each of the specific fuels at the minimum limit of the turndown range and at increments of 50, 75 and 100 percent of full rated load. Each test run shall be at least two hours on each fuel and until stack temperatures are constant and capacity and efficiency requirements of this specification have been verified and recorded. Verify proper operation of instrumentation and gages during the tests.

3.2.5.7 Varying Load Combustion Tests

Test boilers continuously under varying load conditions to demonstrate proper operability of the combustion control, flame safeguard control, programming control and safety interlocks. Conduct these tests after the adjustment of the combustion controls has been completed under the steady state combustion tests. Continue the variable load operational tests for a period of at least 8 hours.

a. Sequencing: Boiler shall start, operate and stop in strict accordance with the specified operating sequence.

b. Flame Safeguard: Verify operation of flame safeguard controls by simulated flame and ignition failures. Verify the trial-for-pilot ignition, trial-for-main flame ignition, combustion control reaction and valve closing times by stop watch.

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

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

] e. Boiler Limit and Fuel Safety Interlocks: Safety shutdown shall be caused by simulating interlock actuating conditions for each boiler limit and fuel safety interlock. Safety shutdowns shall occur in the specified manner.

f. Combustion Controls: Demonstrate accuracy, range and smoothness of operation of the combustion controls by varying the steam demand through the entire firing range required by the turndown ratio specified for the burner. Control accuracy shall be as specified.

g. Safety Valves: High pressure limit switch shall be locked out or otherwise made inoperative and the boiler safety valves shall be lifted by steam. Determine the relieving capacity, popping pressure, blowdown and reseating pressure by observation and measurement in accordance with the ASME BPVC SEC I. The ASME standard symbol will be accepted only as indicating compliance with the design and material requirements of the code.

3.2.5.8 Auxiliary Equipment and Accessory Tests

Observe and test blowdown valves, stop valves, try cocks, fans, fuel oil heaters, pumps, electric motors, and other accessories and appurtenant equipment during operational and capacity tests for leakage, malfunctions, defects, and for compliance with referenced standards.

3.2.5.9 Feedwater Equipment Tests

Perform tests of feedwater treatment equipment in two steps. Conduct one test concurrently with the combustion tests. The Government will perform a second test during the first period of heavy loading after plant has been accepted and put in service. Correct deficiencies revealed during the Government tests under the guarantee provisions of the contract. Both the first and second series of tests shall determine compliance with limits for chemical concentrations of this specification. Supply equipment for taking samples and test kit for analyzing samples. Sampling equipment and test kit shall become the property of the Government when tests are completed.

3.2.5.10 Capacity and Efficiency Tests

Perform capacity and efficiency tests after satisfactorily completing operating tests and after operating boiler continuously for at least 14 days with no nuisance shutdowns and without the necessity for frequent or difficult adjustments. Perform these tests on each boiler. Conduct tests using [the] [each] specified fuel. Test procedures shall be in accordance with the heat loss method [and the input-output method] of ASME PTC 4. Before tests are performed, the Contracting Officer and the Contractor shall reach agreement on those items identified in ASME PTC 4, Section 3, paragraph 3.0l "Items on Which Agreement Shall be Reached." A test run shall not start until boiler and accessories have reached an equilibrium

and stabilization condition for at least one hour in duration. Duration of tests shall be sufficient to record necessary data but in no case shall each run be less than [4] [10] [24] hours.

3.2.5.11 Test Runs

Accomplish maximum output testing by means of a single 2 hour run at 110 percent load on the boiler under test. Calculate boiler efficiency, using [the][both input-output and] heat loss method[s], from the consistent readings taken during the runs. Make runs at four different loads 30, 50, 70, and 100 percent of boiler rating during which take both heat loss and input-output data. Predict unmeasured losses used in conjunction with heat loss calculations and include with equipment data when submitted for approval. Subsequent tests required because of failure of equipment to perform adequately during specified capacity and efficiency tests shall be financial responsibility of the Contractor, including fuel cost.

3.2.5.12 Fuel Analysis

When analysis of fuel being burned during performance tests vary from that specified as the performance fuel the guarantees shall be adjusted in accordance with accepted engineering practice to determine compliance. Carbon loss shall be determined in accordance with ABMA Boiler 103, American Boiler Manufacturers Association curves for carbon loss.

3.2.5.13 Temporary Waste Steam Connection

When necessary to obtain sufficient load for these tests, provide a temporary steam line at a point outside of the building. Provide necessary pipe, fittings, supports, anchors and appurtenances including a field fabricated silencer as directed by the Contracting Officer. Remove temporary piping and silencer after tests have been satisfactorily completed.

3.2.5.14 Fire Safety for Oil-fired Boilers

Conduct tests as necessary to determine compliance with the applicable UL Safety Standards. The presence of the applicable Underwriters' label will be accepted as evidence of compliance in this respect.

a. Oil-Fired Boilers: Oil fired boilers shall meet test requirements of UL 726.

b. Oil Burners: Oil burners shall meet test requirements of UL 296.

3.2.5.15 Plant Acceptance Operation

After satisfactory completion of tests specified, operate the complete plant including each boiler, [its related flue gas cleaning equipment] and subsystems for a period of 30 continuous 24 hour operational days prior to final acceptance by the Government. Furnish labor, chemicals, test equipment and apparatus; the Government will furnish fuel, electricity and water. During this 30 day period, furnish readily available, the services of qualified representatives from manufacturers of plant components and systems for the purpose of additional operational assistance, component and system adjustment and repairs. Government personnel will observe Contractor's operational procedures. The Contractor's representatives shall be prepared to answer pertinent questions from the Government, about the plant operation.

3.2.6 Manufacturer's Field Services

3.2.6.1 Erection/Installation Supervisors and Service Engineers

a. Boiler: Furnish the services of a competent supervisor who is in the direct employ of the boiler manufacturer. This supervisor shall remain on the construction site the full 8 hours per day, 5 days per week, or the same hours, that the boiler installation takes place. This supervisor shall be responsible for the complete steam generating unit, including the steam generator, forced draft fan, burner and other related work, such as refractory, or insulation regardless of whether the forced draft fan, burner or the other related items of work are furnished by manufacturers other than the boiler manufacturer.

b. Forced Draft Fans: The Contractor shall furnish a company service engineer to advise on the erection or installation of fans and related equipment.

c. Service Engineers: Services of the manufacturing companies' service engineers and the system suppliers' service engineers shall be provided by the Contractor to advise during erection and installation of other systems and equipment such as air compressors, air dryers, boiler feedwater pumps, fuel oil pumps, condensate pumps, water treatment equipment, chemical feed pumps, deaerating feedwater heater and stacks.

3.2.6.2 Boiler and System Representatives

a. Furnish factory trained engineers or technicians who are representatives of the boiler manufacturer and system suppliers to supervise testing of the boilers and auxiliary equipment.

b. Furnish the services of a Boiler Inspector who is qualified and certified as such by the National Board of Boiler and Pressure Vessel Inspectors and who is presently employed full time by a firm, such as Hartford Steam Boiler Inspection and Insurance Company, which has a business of inspecting boilers.

3.2.6.3 Instruction to Government Personnel

In accordance with the provisions of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, supervisors and service engineers shall provide instruction for the Government's operators in the operation and maintenance of the equipment furnished under this section. The minimum number of hours of instruction provided shall be as follows:

Equipment	Operation Instruction	Maintenance Instruction
Boiler and auxiliaries	40 hours	16 hours
Forced draft fans	16 hours	16 hours
Fuel handling system	16 hours	32 hours

Equipment	Operation Instruction	Maintenance Instruction
Air compressors and dryers	8 hours	16 hours
Boiler feedwater pumps	8 hours	8 hours
Miscellaneous equipment	16 hours	16 hours

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurement, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

Products	Inch-Pound	Metric
Boilers	Capacity-18,000 #/hr	Capacity 2 1/4 kg/sec
Fan Motor	Size - 19 hp	Size - 7/12 kW
Thermometer	5 inch Dial; 50 to 300 degrees F	125 mm Dial; 10 to 149 degrees C
Pressure Gage	6 inch Dial	150 mm Dial
Electric Motor	Size - 7 1/2 hp	Size - 5 1/2 kW

-- End of Section --