****
USACE / NAVFAC / AFCESA / NASA **UFGS-23 51 43.00 20 (February 2010)**

Preparing Activity: NAVFAC **Superseding UFGS-23 51 43.00 20 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2012
****

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 51 43.00 20

DUST AND GAS COLLECTOR, DRY SCRUBBER AND FABRIC FILTER TYPE

02/10

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCESA / NASA	UFGS-23 51 43.00 20 (February 2010)
Preparing Activity: NAVFAC	Superseding
UFGS-23 51 43.00 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2012
****

SECTION 23 51 43.00 20

DUST AND GAS COLLECTOR, DRY SCRUBBER AND FABRIC FILTER TYPE
02/10

****
NOTE: This guide specification covers the requirements for furnishing, installing, adjusting, and testing of a dry flue gas desulfurization (FGD) scrubber(s) and fabric filter baghouse(s) system.

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 items(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).
****

****
NOTE: The dry FGD scrubber(s) is intended to be used for flue gas sulfur dioxide removal and collection associated with coal-fired boilers. Coal-fired boilers applicable to this specification are those designed with capacities ranging between 6.30 and 31.50 kg of steam per second 50,000 and 250,000 pounds of steam per hour. The design shall be as a system where one manufacturer is responsible for the fabric filter baghouse and the dry FGD scrubber. There are probably no manufacturers that can meet all the specifications. Discretion must be exercised to determine which deviations are acceptable. Removing either the dry FGD or the fabric filter baghouse out as a separate design or purchase is not acceptable.
****

PART 1 GENERAL

1.1 REFERENCES

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

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

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

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.54	(2011) Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Engineering Method in an Essentially Free Field over a Reflecting Plane

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2007) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating
AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines
AMCA 802	(2002; R 2008) Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models
AMCA 99	(2010) Standards Handbook

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 2008) Load Ratings and Fatigue

	Life for Roller Bearings
ABMA 9	(1990; R 2008) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2010) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2010) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2010) Power Piping
ASME B36.10M	(2004; R 2010) Standard for Welded and Seamless Wrought Steel Pipe
ASME BPVC	(2010) Boiler and Pressure Vessels Code
ASME HST-4	(1999; R 2010) Performance Standard for Overhead Electric Wire Rope Hoists

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2011) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123/A123M	(2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A126	(2004; R 2009) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2012) Standard Specification for Chromium

	and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A242/A242M	(2004; R 2009) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A269	(2010) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276	(2010) Standard Specification for Stainless Steel Bars and Shapes
ASTM A307	(2010) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A325	(2010) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2009) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A36/A36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2003; R 2008) Standard Specification for Gray Iron Castings
ASTM A490	(2012) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A490M	(2012) Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A580/A580M	(2012a) Standard Specification for Stainless Steel Wire
ASTM A743/A743M	(2006; R 2010) Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM B103/B103M	(2010) Standard Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar
ASTM B443	(2000; R 2009) Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625)and

	Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219)* Plate, Sheet, and Strip
ASTM B584	(2011) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B61	(2008) Standard Specification for Steam or Valve Bronze Castings
ASTM B75	(2002; R 2010) Standard Specification for Seamless Copper Tube
ASTM B75M	(1999; R 2011) Standard Specification for Seamless Copper Tube (Metric)
ASTM C110	(2011) Standard Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone
ASTM C25	(2011) Standard Test Method for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
ASTM D1682	(1964; R 1975e1) Test for Breaking Load and Elongation of Textile Fabrics
ASTM D1777	(1996e1; R 2011) Thickness of Textile Materials
ASTM D2176	(1997a; R 2007) Folding Endurance of Paper by the M.I.T. Tester
ASTM D3775	(2008) Warp End Count and Filling Pick Count of Woven Fabric
ASTM D3776/D3776M	(2009ae1e2) Standard Test Method for Mass Per Unit Area (Weight) of Fabric
ASTM D3887	(1996; R 2008) Standard Specification for Tolerances for Knitted Fabrics
ASTM D396	(2010) Standard Specification for Fuel Oils
ASTM D578	(2005) Glass Fiber Strands
ASTM D737	(2004; R 2008e1e2) Air Permeability of Textile Fabrics
ASTM E515	(2011) Leaks Using Bubble Emission Techniques
HYDRAULIC INSTITUTE (HI)	
HI M100	(2009) HI Pump Standards Set
INSTITUTE OF CLEAN AIR COMPANIES (ICAC)	
ICAC EP-7	(2004) Electrostatic Precipitator Gas Flow

	Model Studies
ICAC F-2	(1972) Fundamentals of Fabric Collectors and Glossary of Terms
ICAC F-3	(2002) Operation and Maintenance of Fabric Filters
ICAC F-5	(1991) Types of Fabric Filters

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 112	(2004) Standard Test Procedure for Polyphase Induction Motors and Generators
IEEE 114	(2001) Test Procedure for Single-Phase Induction Motors
IEEE 85	(1973; R 1986) Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
IEEE C37.90.1	(2002; Errata 2003; Errata 2004) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

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

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MATERIAL HANDLING INDUSTRY OF AMERICA INC (MHIA)

MHI MH27.1	(2003) Specifications for Underhung Cranes and Monorail Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C50.41	(2000) American National Standard for Polyphase Induction Motors for Power Generating Stations
NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1793	(2012) Architectural Sheet Metal Manual, 7th Edition

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC PS 12.01	(2002; E 2004) One Coat Zinc-Rich Painting System
SSPC SP 1	(1982; E 2004) Solvent Cleaning
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS W-C-375	(Rev D) Circuit Breakers, Molded Case, Branch Circuit and Service

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

40 CFR 60	Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 67	(2009; Reprint Sep 2010) Standard for Panelboards
UL 845	(2005; Reprint Jul 2011) Motor Control Centers

1.2 GENERAL REQUIREMENTS

1.2.1 Mechanical General Requirements

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section.

1.2.2 Electrical General Requirements

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, applies to this section.

1.2.3 General Application of Reference Specifications

In regard to referenced Federal Specifications and Military Specifications, the following exceptions apply:

a. Preproduction samples are not required.

b. Certified test reports are not required.

c. The preservation and packing requirements shall be the manufacturer's standard method.

1.2.4 Steam Generators

****
NOTE: Use fuel oil that is available at activity and that can be burned in the steam generators. A similar fuel oil should be used in all steam generators. The maximum steam demand shall be determined by the activity and the number of steam generators shall reflect turn down ratios, low steam demand, and swing conditions.
****

The steam generators will be [stoker] [pulverizer] coal-fired and will also be capable of 100 percent oil firing. Boilout and start-up of the boilers will be with No. [_____] fuel oil. The steam generators will be used to supply steam to [a steam distribution system serving process and space heating loads][a cogeneration system]. Consequently, the units will operate with a wide load range and rapid load changes. The maximum steam demand can be met by operation of [_____] steam generators. A steam generator will be available for emergency or standby service.

1.3 DEFINITIONS

****
NOTE: Refer to ICAC FGD1 for additional flue gas desulfurization terminology.
****

a. Adiabatic Saturation Temperature: The temperature resulting when water is evaporated into the flue gases, in adiabatic process, until the flue gases are saturated. The adiabatic saturation temperature is equal to the wet-bulb temperature.

b. Approach Temperature: The temperature difference between the actual temperature of a given gas-vapor mixture and the adiabatic saturation temperature of that gas-vapor mixture.

c. Spray/Dryer: An apparatus in which flue gas is contacted with a slurry or solution such that the flue gas is adiabatically humidified and the slurry or solution is evaporated to apparent dryness.

d. Stoichiometry: The moles of slaked sorbent introduced to the system divided by the moles of sorbent theoretically required for complete reaction with all of the sulfur dioxide entering the system whether or not it is all removed.

1.4 DESIGN REQUIREMENTS

1.4.1 Detail Drawing

1.4.1.1 Dust Collector System

Submit drawings and diagrams necessary to erect, install, startup, and place the FGD system into regular operation. Indicate the kind, size, arrangement, weight of each component, and breakdown for shipment; the

external connections, location of local controls, remote control panels, anchorages, and support required; the dimensions needed for installation and correlation with other materials and equipment; and structural steel and foundations. Submit fabrication details including reinforcing and embedded items cutouts, holes, welds, and attachments, and identify components with piece mark numbers. Include the erection, assembly, and installation sequences, and the tolerances to be maintained in erection, assembly, and installation.

1.4.1.2 Dust Collector Components

Submit drawings for each component showing design and assembly. Include the arrangement of internal apparatus and components, and the location of internal piping, tubing, valves, wireways, busses, and terminal blocks, and flow diagrams with flow rates, pressures, temperatures, valving, and instrumentation. Submit drawings for each gage board, instrument rack, mounting plate, and transmitter bracket showing at least the construction features, bracing, brackets, device mounting holes, and dimensions required for fabrication. Submit schematic drawings of processing sensing lines for each type of installation, instrument, or special case including water level columns and draft lines. Submit layout drawings of control boards and system cabinets showing component arrangement. Submit drawings for each graphic subpanel, to include symbols, flow lines, indicating lights, switches and other devices. Damper submittals shall indicate information for the general arrangement and outline, insulation, instrumentation, erection, electric motors, details of seal air systems, and design flows and pressures for transmittal to damper manufacturers. For instrument and control devices, submit outline drawings and listing of tag numbers for each type of device furnished. One drawing may be used for devices of the same type, but the drawing shall be marked to list the tag number of devices to which it applies. Indicate tag numbers on device drawings, instrument lists, functional diagrams, and logics. Include drawings that apply to each item listed below.

a. Spray dryer sulfur dioxide absorbers

b. Lime system

c. Dampers

d. Instruments and control devices

e. Control panels

f. Electric motors

g. Atomizers

h. Fabric filter baghouse

i. Ductwork

j. Expansion joints

k. Fans

l. Pumps

m. Access systems

1.4.1.3 Piping Drawings

Submit general arrangement and outline, piping fabrication, erection, piping connection, valves, pipe hangers, insulation, and instrumentation. Contractor shall submit complete drawings for piping furnished in plan and elevation. Submit dimensions required for fabrication and assembly of piping components and location of field joints and identify components with piece mark numbers, location of hangers and supports, and the location of instrument, vent, and drain connections. Submit drawings showing approximate field routing for instrument control tubing bundles. Include details of engineered hanger assemblies showing plan location, elevations of piping and support steel in the design, cold and hot positions, design loads, and a complete bill of materials.

1.4.1.4 Wiring Diagrams

Include a wiring diagram with each wire or wire bundle shown by a line, or a point-to-point type wiring diagram with individual wire designations listed at the location of each termination and identify device and equipment terminals, and internal and external connection terminal blocks.

1.4.1.5 Schematic Control Diagrams

Submit elementary diagrams of control and alarm functions, both internal and external to the equipment, wire colors, ANSI symbols circuit designations, and identify external connection terminals and terminal blocks. Submit process and piping instrumentation diagrams, analog control system functional diagrams and associated logic, logic diagrams of digital systems, flow charts or word logic of software systems, description of operation of each control system, electrical interconnection drawings showing external terminal blocks for each input, output, and power cable connection and destination of other end of cable, analog and digital signal input and output lists, and nameplate lists.

1.4.1.6 Printed Circuitboards Information

Include a schematic diagram and board photographs or component layout drawings, with parts labeled, for each type of board and as a parts list containing complete description of discrete components and integrated circuits.

1.4.2 Calculations

Submit hangar load calculations and equipment foundation design loading requirements for conditions of testing and operation including a loading plan showing design base loads for each piece of equipment and equipment support. Submit FGD system panelboard heat load for use in design of control room air-conditioning system.

1.4.3 Additional Product Data

For resistance temperature detectors, submit calibration curve showing predicted resistance versus temperature for the range of 0 C to 1,000 degrees C 32 to 1832 degrees F. For vanes and dampers requiring control drives, submit the maximum allowable torque and forces to avoid damage to the damper or vane components. For insulation, include a tabulation including manufacturer, manufacturer's designation, and complete specifications including density, thermal conductivity, sound transmission

loss, flexural strength, compressive strength, temperature rating, and dimensional stability. Submit detailed specifications of any rubber hose and rubber-lined pipe proposed for use. For electric motors, submit nameplate data for motors including the manufacturer's name, model, serial number, type and frame designation, power horsepower rating, and time rating. For fans, provide octave band sound pressure levels, fan performance curves, class, air flow, pressure, power horsepower, and efficiency. For draft equipment, submit certified performance data including performance curves showing flow vs. head, efficiency and brake power horsepower from zero flow to at least 120 percent of maximum design flow.

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer Experience

****
NOTE: Contractor equipment used for experience requirements shall be at least as efficient as local or state percent sulfur dioxide removal regulations.
****

The Contractor shall have successfully met air pollution emission requirements on two coal-fired boilers each with a minimum of 4719 L/s 10,000-actual cubic feet per minute (acfm) or larger similar spray dryer sulfur dioxide absorber and fabric filter baghouse systems. The completed system shall have utilized lime slurry as the absorbent material. Slurry atomization shall have been by rotary atomization or by two-fluid nozzle atomization. The completed system spray dryer sulfur dioxide absorber shall have been designed for and operated at inlet flue gas temperatures of 177 degrees C 350 degrees F or less, and shall have achieved at least [_____] percent sulfur dioxide removal including sulfur dioxide removal in the baghouse during performance testing. The Contractor shall have also successfully met air pollution emission requirements at least five fabric filter baghouse installations of a size comparable to or larger than that [proposed][bid]. At least two of the five installations shall have been a fly ash application and at least two of the five shall have utilized the pulse jet cleaning method. The Contractor shall also have provided at least one dry FGD system on a coal-fired boiler that has been utilizing a spray dryer sulfur dioxide absorber and a fabric filter baghouse is in operation at least 24 months prior to the close of bid date for the proposed system. The previous commercial system shall have the following design features in common with the system to be provided under this contract:

a. Lime slurry preparation system including storage bin and lime slaker;

b. Rotary atomization, or two-fluid nozzle atomization using compressed air;

c. Spray dryer design inlet temperature of 177 degrees C 350 degrees F or lower; and

****
NOTE: 80 to 85 percent sulfur dioxide removal is possible with most commercial units. Negotiate with most commercial units. Negotiate with state and local air pollution authorities prior to bidding emission trading should be utilized. Emission

trading includes trading, off-sets, and banking. Ensure that any reductions in emissions are banked for future use or sale.

****

d. Minimum [_____] percent sulfur dioxide removal over a gas flow range of 30 percent to 100 percent of design gas flow. Process control system used and instrumentation provided shall be the same as those in applications at pilot plant or commercial installations use for qualifying experience.

1.5.1.1 Auxiliary Manufacturer Experience

The lime slurry individual equipment may be the manufacturer's standard, but the particular combination of that equipment into a lime slurry preparation system shall have a history of successful and reliable operation for a period of at least three years. Mechanical draft equipment and appurtenances and ductwork and expansion joint equipment and materials shall have an acceptable history of satisfactory reliable operation in industrial steam plant use for a period of at least three years at comparable temperature, pressure, voltage, and design stress levels. The Contractor shall provide information necessary to demonstrate history of operation.

1.5.2 Certificates

1.5.2.1 Pipe Welding Procedures

Submit the welding procedures and the heat treatment records for pipe fabrication.

1.5.2.2 Weld Testing Procedures

Describe procedures for nondestructive testing which shall be performed on the welds or base material of the fans.

1.5.2.3 Welding Shops

Submit certification that welding shops are qualified as specified.

1.5.2.4 Qualifying Experience Certification

Submit proof that the dust collector manufacturer has installed the following systems:

a. Spray dryer system

b. Lime slurry system

c. Mechanical draft equipment

d. Fabric filter baghouse

e. Dry FGD systems

Manufacturer shall certify that no failures have occurred on this type collector built by the manufacturer within 5 years preceding contract award date, as required by paragraph entitled "Certification."

1.5.2.5 Factory Test Certification

Submit certificates of completion of factory tests of mechanical draft equipment.

1.5.2.6 Dry FGD System Experience Certification

Indicate compliance with paragraph entitled "Quality Assurance." Submit a listing of other applications of the [proposed] [bid] dry scrubber system within the range of 4719 to 47,190 L/s 10,000 to 100,000 acfm and shall have demonstrated operation for 8,000 hours. Include a narrative description of the specific design changes which must be made to apply application experience to dry flue gas desulfurization (FGD) systems. Specifically note the use of the completed dry FGD system test results to verify the feasibility of the design changes. Information to be contained in the certificate shall include:

a. List of at least two installations meeting the requirements set forth in the paragraph entitled "Manufacturer Experience."

b. Owner and location of each such installation including name of contact, address, and telephone number.

c. Design inlet gas volume, actual liter per second cubic feet per minute; inlet gas temperature, degrees C degrees F; inlet dust loading, grams per liter grains per acf; outlet dust loading; grams per liter grains per acf; and dry FGD system model number.

d. Type of coal-fired boiler.

e. Description of fabric filter bag material and cleaning mechanism.

f. Completed bid forms for dry FGD systems.

1.5.3 Test Reports

1.5.3.1 Pump Tests Reports

Include certified curves showing pump performances.

1.5.3.2 Damper Tests Reports

In each damper factory test report, report, discuss the test conditions, results, defects found and corrective action taken. In lieu of factory tests on poppet dampers, include the results of field tests performed on similar installations.

1.5.3.3 Dust Collector Model Tests Report

Submit model test reports within 30 days of test completion. The test reports shall include a scale drawing of the model showing actual dimensions and a scale drawing of the full-size installation showing modifications made and devices added to the ductwork and transitions as a result of the model study. The test report shall also include uniform gas velocity diagrams and histograms, indicating the root mean square velocity deviation, standard deviations, and mean velocity, at strategic locations which shall include, but not be limited to the following:

a. Inlet to spray dryer sulfur dioxide absorbers.

b. Inlet to baghouse.

c. Inlet to each fabric filter baghouse module.

d. Inlets to induced draft fans.

e. Stack inlet.

f. Two stack diameters located downstream of the stack inlet.

Submit a complete explanation of the test procedures including flow rates, pressures, sample calculations and assumptions prior to testing. Deviations in dynamic or geometric similitude by the model from the full-size installation shall be listed and justified. Conclusions that show type and location of devices required for proper gas distribution and modifications necessary to the proposed ductwork, that result from model testing, shall be incorporated into the Contractor's final ductwork design. The report should recommend the location of test ports, the location and type of flow distribution devices in stack, and the location of gas flow instrumentation points and monitors. Provide a complete listing of pressure drop data taken at each pressure tap during each test run and also include data from runs before and after the addition of supplemental flow distribution devices that correct distribution problems identified by initial runs. Pressure taps shall be located as required to accurately determine the pressure drop across critical ductwork components and the effect of the additional distribution devices on the pressure drop. Submit with the report a complete set of photographs and videotapes recordings of model during air flow test.

1.5.3.4 Instrument Calibration and Testing

For instrument calibration and testing, certify that instruments were calibrated and testing readings indicated are true, that computations required for testing are accurate, that acceptable methods were used, and that the equipment satisfactorily performed in accordance with the requirements.

1.5.4 Records

Submit text of each required posted operating instructions. For device purchase information, submit data or specification sheets for each device furnished by this contract. These sheets shall be the actual sheets used for ordering and fabrication, and shall include the final vendor's own sheets, where applicable, in addition to the Contractor's purchase order forms. Provide an index for the data sheets. These sheets shall include technical data for the devices including tag number, manufacturer, complete catalog or model number, scale range, complete electrical information including current voltage ratings, contact action (SPST, DPDT, etc.), data or specification sheet number, scheduling information showing dates for ordering, fabrication, shipment, etc., manufacturer's data for tubing, fittings, valves and accessories, and material.

1.5.5 Model Test

****

NOTE: Contracting Officer shall have authority to select an experienced modeller from list supplied by contractor.

****

****

NOTE: Test model system scale shall meet good engineering practices. In no case shall scale be less than 1:100 1/8 scale.

****

****

NOTE: Dust used for testing shall be sifted, bleached wheat flour or approved vendor selection.

****

Conduct a three-dimensional model study as defined in ICAC EP-7 to verify air flow design of the spray dryer sulfur dioxide absorbers, ductwork, fabric filter baghouse, and inlet transition to stack and to determine the flow distribution and requirements for distribution devices to provide adequate operating conditions in all of the equipment. The model study shall be used by the Contractor to determine flow distribution and pressure drop through out the system. Make necessary modifications to the model to minimize pressure drop in ductwork. The scope of the model study shall begin at the [economizer][air heater] outlets and end in the inlet transition to the stack. Model shall represent the complete system, as specified, reduced to not less than 1:100 1/8 scale. Test model shall have dimensional tolerance of plus or minus 1 1/2 mm 1/16 inch. Dynamic and geometric similitude shall be observed in all phases of the model study. Flow conditions in the spray dryer sulfur dioxide absorbers, fabric filter baghouse, ductwork, and inlet transition to the stack shall be tested and the results submitted to the Contracting Officer. Flow and dust distribution tests shall be performed at 30 percent, 50 percent, 75 percent, 100 percent, and 125 percent of maximum continuous flow rating. The Contractor shall notify the Contracting Officer no less than 15 working days before the tests are scheduled to be made so that Contracting Officer may witness test. Dust used for testing shall be [_____].

1.5.6 Tabulations

Submit a tabulation of piping connections with each assigned a unique designation including size and type of each connection in all views. Submit a tabulation of valves furnished, with each assigned a unique designation including manufacturer, pressure and temperature rating, body material, trim material, and manufacturer's model or figure number, and a detailed cross section of each different model or figure number, and valve. Submit a tabulation of instruments and instrument connections furnished in spray dryer sulfur dioxide absorbers, fabric filter baghouse, ductwork, and auxiliary equipment. Assign a unique alphanumeric designation and show type, location, and quantity for each connection.

1.6 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Tabulation of piping connections

Tabulation of valves

Instruments and instrument connections

SD-02 Shop Drawings

Dust collector system

Dust collector components

Piping drawings

Wiring diagrams

Schematic control diagrams

Printed circuitboards

Model testing shall be completed and approved prior to submittal of drawings. Drawings of typical installations will be acceptable provided that the individual applications are noted.

SD-03 Product Data

Vanes and dampers

Insulation

Mechanical draft equipment

Pumps

Atomizers

Motors

Lime system component equipment

Instrumentation and control devices

Piping

Ductwork

Fabric filter baghouse

Fans

Expansion joints

Bag material

Fabric filter

Valves

Spray dryer sulfur dioxide absorbers

Control panels

Monorail and hoist

Resistance temperature detectors

Rubber hose and rubber-lined pipe

SD-05 Design Data

Equipment foundation design loading requirements

Hangar load calculations

FGD system panelboard heat load

Guillotine dampers design pressures and flows

SD-06 Test Reports

Lime system component equipment

Instrumentation and control devices

Atomizers

Piping

Pump tests

Bag material

Fans

Motors

Damper tests

Mechanical draft equipment

Instrumentation and control devices

Dust collector model tests

Smoke tests

System stoichiometry tests

System power consumption tests

Instrument calibration and testing

Include field data sheets and show the calculation of stoichiometry with stoichiometry field test report. Include an explanation of the method used for the system power consumption determination.

SD-07 Certificates

Pipe welding procedures

Weld testing procedures

Welding shops

Qualifying experience certification

Dry FGD system experience certification

Factory test certification

SD-10 Operation and Maintenance Data

Atomizers, Data Package 3

Fans, Data Package 2

Lime system component equipment, Data Package 2

Pumps, Data Package 2

Valves, Data Package 2

Dampers, Data Package 2

Motors, Data Package 2

Fabric filter baghouse, Data Package 2

Instrumentation and control devices, Data Package 3

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include the manufacturer's recommended supply list for each type of instrumentation recorder furnished. The lists shall include as minimum information, the chart paper type, size, and order number, ink type (cartridge or pen) order number, capillary tube order number, and pen point order number.

SD-11 Closeout Submittals

Device purchase information

Posted operating instructions

1.7 DELIVERY AND STORAGE

Equipment shall be shipped factory assembled, except when the physical size, arrangement, or configuration of the equipment, or shipping limitations, makes the shipment of assembled equipment impracticable.

1.8 AMBIENT ENVIRONMENTAL REQUIREMENTS

****
NOTE: Insert extreme temperatures experienced at site. Do not use heating or cooling design conditions.
****

The dry FGD system design shall be such that the electrical equipment shall perform satisfactorily in the ambient environment of [_____] to [_____] degrees C degrees F and [_____] to [_____] percent relative humidity.

1.9 EXPERIENCE CLAUSE

1.9.1 Certificate

****
NOTE: Select air flows, temperatures, and dust loadings similar to design conditions.
****

Units which have been replaced within 3 years of start-up, have had retrofit, overhaul, or repair cost exceeding 10 percent of the original price of the collector (excluding transportation and erection), have failed to meet specified removal efficiency, or have allowed emissions to exceed specified limits shall be considered failures. Off-line time exceeding five percent of the planned annual operation or 300 hours per annum, whichever is less, within the first 3 years of operation due to collector or component failure shall be considered a failure. System failure due to natural disaster or a result of damage from fire or explosion in appurtenant structures will not be considered failure. Pilot or research projects will be excluded from failure analysis. The certificate must certify that the manufacturer has constructed not less than two dry FGD

systems of the same design as proposed for this project treating flue gas from a boiler with [automatic][manual] combustion control [and a mechanical cyclone-type dust collector]. Each dry FGD system shall have performed satisfactorily, normal maintenance or downtime of the associated [boiler][dust collector] included, for a period of not less than 2 years treating at least [_____] L/s acfm of inlet gas at a temperature of at least [_____] degrees C degrees F, with inlet dust loading of at least [_____] grams per liter grains per acf and outlet dust loading of at most [_____] grams per actual liter grains per actual cubic feet. In determining this experience:

a. Only collection of fly ash as produced by [pulverized coal-fired boilers] [stroker coal-fired boilers] is considered as equivalent experience.

b. Only experience at the maximum continuous flow rate, plus or minus 40 percent, maximum continuous inlet flue gas temperature, plus or minus 46 degrees C 50 degrees F, and maximum continuous inlet dust loading, plus or minus 50 percent, is acceptable.

1.10 OPERATOR TRAINING PROGRAM

Provide an organized training program for the Government's operating personnel including the system specified herein. The purpose of the training program is to familiarize personnel with the operation and maintenance of the flue gas cleaning system and the individual equipment components. The training program shall be designed to provide the operators with a working knowledge of the theory and principles of operation of the system, the activities required for operation and control of the system and the tools and techniques required for maintenance of the system. The training program shall provide classroom instruction, testing, and hands-on training to ensure that operators who complete the organized program will be able to operate and maintain the flue gas cleaning system for the Government. Furthermore, the training manuals and testing materials shall provide information so that, in conjunction with the operation and maintenance manuals furnished under this contract, future training of new operators can be accomplished without the assistance of the Contractor.

1.10.1 Training Manuals

Provide training manuals covering the complete FGD system and including separate sections devoted to each major equipment item including spray dryer sulfur dioxide absorbers, fabric filter baghouses, lime system, induced draft fans, and system control panel. Each section shall include equipment description, principles of operation, control philosophy, control hardware, and relation to other equipment. Furnish [_____] copies and an original of the complete training manual.

1.10.2 Testing Program

Furnish a written testing program designed to objectively determine the individual level of comprehension of the material presented in the training program to the participants. Use the testing program in conjunction with the classroom instruction. Provide [_____] copies of the complete testing program.

1.10.3 Classroom Instruction

Develop and present 40-hour course of organized classroom instruction by experienced engineers. The classroom instruction shall cover theory and principle of operation and shall utilize and augment the information provided in the training manuals. Administrate the testing program at the conclusion of the course. Present the course at least twice in order to accommodate Government operating personnel. The Contractor shall arrange with the Contracting Officer for classroom space and times for the classes to be given.

1.10.4 Field Instructions

Service engineer shall provide 8-hour per day supervision of the system for a period of 30 days after start-up to assist and instruct Government's operations. Instruction shall include, but not be limited to the following:

a. Actual start-up and shutdown of the FGD system for each boiler.

b. Indoctrination to the lime handling system, stressing safety.

c. Remove and install one atomizer.

d. Disassemble and assemble one atomizer to the extent required for normal maintenance.

e. Review of instrument, gage, and control functions in the control room.

f. Deliberate upset of FGD system and instruction on making necessary corrections.

g. Simulation of induced fan failure.

h. Review of fabric filter baghouse maintenance including removal and replacement of bags.

1.10.5 Video Recording

Furnish color video tapes made during field instruction or prepared color video tapes covering the field instruction material. Video tapes instruction and hands-on-training, along with prepared video instruction tapes, shall become the property of the Government.

1.11 MODEL DELIVERY

The model shall remain the property of the Government, and shall be delivered to the Government upon request by the Contracting Officer within one year of start-up. The model shall include a support table as part of the deliverable items.

1.12 POSTED OPERATING INSTRUCTIONS

Provide for the following:

a. Atomizers

b. Lime feeders

c. Baghouse

d. Lime slakers

e. Lime unloading

PART 2 PRODUCTS

2.1 APPLICATION

****
NOTE: Refer to ICAC FGD1 for additional flue gas desulfurzation terminology.
****

The Flue Gas Cleaning System and induced draft fans shall be used to control emissions of sulfur dioxide and particulate matter and furnace draft from steam generators. The steam generators will be [stoker][pulverized] coal-fired and will also be capable of 100 percent oil firing. Boilout and start-up of the boilers will be with No. [_____] fuel oil. The steam generators will be used to supply steam to [a steam distribution system serving process and space heating loads][a congeneration system]. Consequently, the units will operate with a wide load range and with rapid load changes. The maximum steam demand can be met by operation of [_____] steam generators. A steam generator will be available for emergency or standby service. A separate FGD system for each steam generator as indicated. Also, provide facilities for reagent storage, preparation, and feed. The system shall be designed to use lime as the alkali material.

2.2 EQUIPMENT AND MATERIALS PROVIDED UNDER THIS CONTRACT

****
NOTE: It is not the intent of this specification to require a reagent recycle system. Life cycle cost analyses indicate that the reasonably expected lime savings do not justify the additional capital and operating costs for a recycle system. Proposers or bidders including a recycle system as an essential portion of their process must include in their scope of supply equipment and material required for a complete and operational recycle system including all necessary instrumentation and controls. The proposer's or bidder's scope of supply must include all ash handling and conveying equipment associated with the recycle system.
****

Equipment to be provided under this contract includes the items listed below and other equipment required for a complete and operable FGD system although not specifically mentioned in these specifications. The following items are listed for the convenience of the Contractor in understanding the scope of supply.

2.2.1 Spray Dryer Sulfur Dioxide Absorbers

****
NOTE: Air compressor is specified in paragraph entitled "Two-Fluid Nozzle Atomizers."
****

Provide spray dryer sulfur dioxide absorbers, complete with slurry atomizers, inlet gas dispersers, conveying system for continuous removal of absorber products, absorber product holding bin(s), frames for penthouse and hopper enclosures, mechanism for atomizer removal, and spare atomizers. For systems utilizing two-fluid nozzle atomizers, provide a dedicated air compressor system to provide air for slurry atomization.

2.2.2 Fabric Filter Baghouse

Provide fabric filter baghouses, complete with inlet and outlet manifolds, pulse jet or reverse gas cleaning systems, bags, bag attachment and support hardware, and frames for penthouse and hopper level enclosures.

2.2.3 Lime Slurry Preparation System

Provide lime slurry preparation system including lime feed bin, fill pipe and truck unloading connection, bin vent filter, bin vibrators, lime feeders, slakers, grit removal equipment, slaker product tank, agitators, and drives. Provide accessory equipment and control panels to control lime slurry preparation system. Provide tanks as required by specific system design including slurry mixing tanks, feed tanks, and head tanks.

2.2.4 Pumps, Valves, and Motors

Provide pumps including slurry feed pumps and process water pumps. Provide sump pumps as required as a result of the specific system design. Provide water, slurry and air piping (excluding field-installed instrument air tubing), piping support systems, valves, and expansion joints required for the FGD system within the battery limits indicated. Provide electric motors for induced draft fans, pumps, and other equipment included in this system. Provide motor control centers as required for motors furnished under this contract rated at 480 volts and less. Provide separate motor control centers for each spray dryer absorber-baghouse unit, and for the lime slurry preparation system, complete with internal controls wired and interlocked together and brought out to terminal blocks for remote field connection by the Contractor.

2.2.5 Ductwork and Draft Equipment

Provide induced draft fans including inlet boxes, dampers, and drives. Provide ductwork between [economizer][air heater] outlet interfaces and stack inlet including spray dryer absorber bypass reheat ducts, as necessary. Provide test ports. Provide expansion joints, turning vanes, dampers, damper operators, and seal air systems including fabric filter baghouse dampers. Provide gas distribution devices in ductwork ahead of baghouse to assure even flow of gases into baghouse.

2.2.6 Instrumentation and Control Devices

Provide system controls and instrumentation including local control panels and a remote control panel to be located in the main plant control room.

2.2.7 Structural and Miscellaneous Steel

Provide structural and miscellaneous steel including structural steel for support of equipment, ductwork, platforms, walkways and stairs, and miscellaneous framing. Provide stairs, walkways and access platforms, and as required for normal operation and maintenance.

2.3 SITE FABRICATED AUXILIARY CONSTRUCTION

****

NOTE: Penthouse and hopper enclosures shall be specified. Enclosed areas improve maintenance and lower heating requirements.

****

Provide concrete foundations with anchor bolts conforming to ASTM A307for structural steel columns and equipment. Also, provide metal siding and roofing, insulation, doors, windows, and heating and ventilating equipment for spray dryer sulfur dioxide absorber, for fabric filter baghouse penthouse and hopper enclosures, and for the lime slurry preparation system enclosure. Provide insulation and lagging including necessary subgirts for spray dryer sulfur dioxide absorbers, baghouses, and ductwork. Also, provide insulation and heat tracing for piping, as necessary, and in accordance with the equipment specification requirements. Provide a remote bulk lime storage silo, conveying system, and piping for connection to Contractor's lime feed bin fill piping. Provide ash conveying equipment from hopper flanges on the fabric filter baghouses and the absorber product holding bins. Also, water storage tanks along with potable (non-process) water piping, fire protection water piping, and field-installed instrument air tubing. Provide electrical field wiring and conduit, lighting, and motor control centers for 4,000-volt motors.

2.4 SITE CONDITIONS

****

NOTE: Dry and Wet Bulb Temperature and Duration:

Parameter	Season	Temperature (Degrees C)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

Parameter	Season	Temperature (Degrees F)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

****

Contractor shall use site conditions of elevation, design ambient temperature, and design dry and wet bulb temperature, and duration (differentiate for different seasons including frequency of occurrence of higher temperatures) specified.

2.5 OPERATING INSTRUCTIONS

2.5.1 Steam Generators

****
NOTE: Insert appropriate Section number and title in the blanks below using format per UFC 1-300-02.
****

The system shall be designed for operation with [the boiler(s) specified in [_____]] [boiler(s) manufactured by [_____], Type [_____], Model No. [_____]]. The steam generator is [a new] [an existing] [pulverized coal-fired] [spreader stoker-fired] [underfeed stoker-fired] boiler. Operating conditions for each steam generator at its maximum rating are:

a. Type firing [_____]

b. Steam flow, kg/s lb/hr [_____]

c. Steam pressure, kPa (gage) psig [_____]

d. Steam temperature, degrees C degrees F [_____]

e. Gross heat input, kW 106 Btu/hr [_____]

f. Excess air leaving boiler, percent [_____]

g. Grade elevation, meters feet above mean sea level [_____]

For purposes of the proposal, the Contractor shall assume that the gross heat input at any fractional load rating is that same fraction of the maximum rated heat input given above.

2.5.2 Fuels

The steam generator shall utilize a fuel with following properties:

Coal:

****
NOTE: Coal sources vary year to year when purchased by Defense Fuel Supply Agency (DFSA). Request a contract for a longer period of time. Specified coal properties shall be maintained throughout length of contract.
****

a. Source:	
State	[_____]

Seam	[_____]	
Area	[_____]	
b. Proximate Analysis-- Percent (as received)	Average	Range
Moisture		
Volatile Matter		
Fixed Carbon		
Ash		
Higher Heating Value, kJ/kg Btu/lb		
c. Ultimate Analysis--Percent (as received)		
Moisture		
Carbon		
Hydrogen		
Nitrogen		
Chlorine		
Sulfur		
Ash		
Oxygen (by Difference)		
Total		
d. Mineral Analysis of Ash-- Percent		
Phosphorus Pentoxide, P205		
Silica, Si02		
Ferric Oxide Fe203		
Alumina, A1203		
Titania, Ti02		
Lime, Ca0		
Magnesia, Mg0		

Sulfur Trioxide, S03
Potassium Oxide, K20
Sodium Oxide, Na202

Oil burned in the steam generators will be grade [_____] fuel oil conforming to ASTM D396. Boiler combustion is controlled [manually] [automatically]. The standby fuel is [_____].

2.5.3 Lime

****
NOTE: Contract for lime shall be for a period longer than one year. Ca0 content and amount of grit shall be maintained throughout length of contract.
****

The lime to be used in the system will be high-calcium pebble quicklime (20 mm by 0) (3/4 inch by 0). The high-calcium pebble quicklime will have a "high" reactivity as defined and as determined by ASTM C110. The expected chemical analysis based on ASTM C25 is as follows:

Typical, Percent	Range, Percent
Ca0 (Available)	92.0
Ca0 (Total)	96.0
Mg0	0.4
Si0	0.7
Fe203	0.09
A1203	0.07

2.5.4 Slaking Water

The water to be used for lime slaking will be boiler blowdown which has been diluted with city water for cooling to a temperature of 38 degrees C 100 degrees F. The following water quality criteria will be maintained:

Constituent	Concentration
Combined sulfate, sulfite and bisulfate ions	Less than 500 mg/1
Total dissolved solids	Less than 1,000 mg/1
Total suspended solids	Less than 100 mg/1

2.5.5 Process Water

****
NOTE: Due to the variable proportioning of the plant wastewater streams which will make up the process water, the quality of this water is expected to be more variable than that of the slaking water.
****

FGD system processes other than lime slurry preparation and slurry line flushing will utilize plant wastewater. Plant wastewater will consist of a mixture of variable proportions of boiler blowdown, cooling tower blowdown, process wastewater and potable water.

2.5.6 Compressed Air

****
NOTE: When retrofitting an existing power plant specify increased volume for compressed air system. Insulate system where applicable. Compressed air supplies will be as follows.

1. Service Air: [_____] kPa (gage) psig, dew point up to [_____] degrees C degrees F at [_____] kPa (gage) psig.

2. Instrument Air: [_____] kPa (gage) psig, dew point [_____] degrees C degrees F at [_____] kPa (gage) psig.

3. Instrument Air (for outdoor use): [_____] kPa (gage) psig, dew point [_____] degrees C degrees F at [_____] kPa (gage) psig.
****

The FGD system utilizes compressed air supplies for service air and indoor and outdoor instrument air.

2.6 DESIGN PARAMETERS

2.6.1 Expected Flue Gas Conditions

****
NOTE: Pressures, rates, and duration of sootblowing will depend on site conditions and acceptable operating procedures.
****

Flue gas conditions leaving each steam generator are expected to be as follows: (at [economizer][air heater] outlet, except as noted).

	Design	Range
a. Gas flow, L/s		
b. Gas temperature, degrees C (before [economizer][air heater])		

	Design	Range
c. Specific volume, L/kg		
d. Dust loading, gram/L		
e. Absolute humidity, kg H20/kg dry gas		
Normal operation		
During sootblowing		
f. S02, kg/s (full load)		

	Design	Range
a. Gas flow, acfm		
b. Gas temperature, degrees F (before [economizer][air heater])		
c. Specific volume, acf/lb		
d. Dust loading, gr/acf		
e. Absolute humidity, lb H20/lb dry gas		
Normal operation		
During sootblowing		
f. S02, lb/hr (full load)		

Conditions during sootblowing are based on the injection of steam [_____] kPa (gage) psigat a rate of [_____] kg/s lbs/min during the sootblowing cycle. The cycle is expected to last approximately [_____] minutes.

2.6.2 Spray Dryer Absorbers

****
NOTE: Specified percent sulfur dioxide removal must be identical to paragraph entitled "QUALITY ASSURANCE."
****

Each spray dryer absorber shall be designed in conjunction with its associated fabric filter baghouse to remove a minimum of [_____] percent of the sulfur dioxide present in the flue gas leaving the steam generator for any flue gas condition specified and burning any coal within the range specified.

2.6.3 Fabric Filter Baghouses

****
NOTE: Emission rates will depend upon local or

state air pollution regulations. Negotiations with the agencies may be necessary.
****

****
NOTE: Typical fly ash densities are 560 kg/m 335 lbs/ft3 for hopper design capacity and 1440 kg/m3 90 lbs/ft3 for hopper design load.
****

****
NOTE: Dry and Wet Bulb Temperature and Duration:

Parameter	Season	Temperature (Degrees C)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

Parameter	Season	Temperature (Degrees F)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

****

Each fabric filter baghouse shall be designed to reduce maximum particulate emissions leaving the baghouse to not more than [_____] kg/106 kJ lbs/106 Btu of heat input to the boiler for any gas flow conditions specified and burning any coal within the specified range. Each fabric filter baghouse shall be divided into a minimum of flue modules. The maximum air-to-cloth ratio excluding one module for cleaning and one module for maintenance shall be 4.0 for pulse-jet units or 2.25 including the reverse gas volume, for reverse gas units with the spray dryer operating at the design gas flow specified in paragraph entitled "Expected Flue Gas Conditions." Calculation of air-to-cloth ratio for reverse gas fabric filter baghouses shall exclude thimble, ring, and cuff area covered by bags. Pulse-jet fabric filter baghouses, if provided, shall be designed for off-line cleaning during normal operation with the capability for on-line cleaning when required. Reverse gas fabric filter baghouses shall provide a maximum of three-bag reach. Reverse gas bag cleaning systems shall provide a minimum of 9 liter per second per square meter 1.75 cubic feet per minute per square foot of fabric to be cleaned. Hopper capacity shall allow for a

minimum of ten hours storage at maximum fly ash and absorber product material loading. Hopper design capacity shall be based on a fly ash density of [_____] kilogram per cubic meter pounds per cubic feet. Hopper design strength shall be based on fly ash density of [_____] kg per cubic meter pound per cubic feet plus the support of 454 kg 1,000 pounds of ash handling equipment per hopper. Structural design shall be based on the assumption that the hopper is full of ash up to the bottom of the bags for pulse-jet units or up to the tube sheet for reverse gas units. Fabric filter baghouse structural design temperature range: [_____] to [_____] degrees C degrees F.

2.6.4 Lime Slurry Preparation System

****
NOTE: Design slaker enclosure with adequate access area around feeders, slakers, and grit removal equipment to perform required maintenance.
****

A single lime slurry preparation system shall serve all spray dryer absorbers. The lime feed bin shall be sized to store at least the quantity of lime required for 72 hours operation of two steam generators at the maximum sulfur dioxide rate specified and at the guaranteed stoichiometry. The minimum storage volume shall be [_____] cubic meter feet. Provide the bin with two conical hoppers. The lime feed bin shall be capable of receiving lime either directly from self-unloading blower trucks or from a remote silo and pneumatic conveying system to be provided by the Contractor. Lime shall be slaked with detention or paste-type slakers. Two full-capacity lime feeders and slakers shall be provided. Each lime feeder and slaker shall be sized to provide 110 percent of the slurry quantity required during operation of 2 steam generators at the maximum sulfur dioxide rate specified. The turndown capability from this design capacity shall be at least 10 to one. The lime slurry preparation system shall provide 100 percent installed spare capacity feeders, slakers, and grit removal equipment. The lime slurry system will operate with one equipment train in operation and one as backup. The FGD system control panel in the steam plant control room shall provide complete operational monitoring of and alarm annunciation for each equipment train. Capability for emergency shutdown of the lime slurry preparation system shall be provided at the FGD system control panel. Failure of the operating equipment train to respond to the automatic start signal from the low tank level switch shall be alarmed in the control room. The slurry tank storage capacity between the low and low-low levels shall be sufficient to allow time for the control room operator to dispatch operations personnel to the lime slurry preparation system to start-up the backup train and to provide slurry to the tank before the low-low level is reached. Enclosed feeders shall include equipment to protect the lime from moisture. Slakers shall discharge slurry by gravity flow into product tank. Slurry preparation system shall include positive means of removing sufficient grit from the slurry to assure proper operation of the slurry feed system and the spray atomizers. Grit shall be conveyed to a disposal bin provided by the Government. Provide emergency eyewash stations at each level in the lime slurry preparation system enclosure. Provide piping to exterior of enclosure for connection to potable water piping system provided by the Contractor.

2.6.5 Ductwork

****

NOTE: Ductwork velocities shall be such to maintain self-cleaning conditions.

****

Ductwork upstream of the fabric filter baghouse outlets shall be designed for a velocity of [_____] meter per second feet per minute at the design flue gas flow, specified in paragraph entitled "Expected Flue Gas Conditions." Ductwork downstream of the fabric filter baghouse outlets shall be designed for a velocity of [_____] m/s fpm at the design flue gas flow, specified in paragraph entitled "Expected Flue Gas Conditions." Ductwork from the fabric filter baghouse outlet to the stack inlet shall be designed to withstand a transient internal pressure (80 percent of yield strength) range of minus 2490 Pa to plus 7470 Pa 10 inches Water Column (WC) to plus 30 inches WC without permanent deformation of any structural member at yield or in buckling.

2.6.6 Induced Draft Fans

****

NOTE: Pressures and air flows will be site specific and will require system analysis.

****

****

NOTE: Dry and Wet Bulb Temperature and Duration:

Parameter	Season	Temperature (Degrees C)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

Parameter	Season	Temperature (Degrees F)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

****

Test block flow capacity shall be [_____] actual liter per second cubic feet per minute. Test block static pressure shall be 140 percent of the static pressure required to withdraw [_____] L/s cfm from the [economizer][air heater] outlet interface through the FGD system and to

provide [_____] Pa inches WC at the stack inlet plus [_____] Pa inches WC which is equal to 140 percent of the static pressure required to withdraw the design flow from the steam generator to the [economizer] [air heater] outlet. The static pressure requirement shall be based upon normal operation of the FGD system, except that the fan inlet temperature shall be assumed to have the value specified in paragraph entitled "Sulfur Dioxide Removal Performance Guarantees." The design and construction of the fan shall be capable of withstanding operation at the maximum gas flow and temperatures which would result, if the spray dryer was not in operation. Test block capacity and static pressure shall be calculated assuming inlet gas temperature to be 93 degrees C 200 degrees F. Design ambient temperature for lubrication system shall be [_____] degree C degree F to [_____] degree C degree F. Induced draft fan speed shall not exceed [_____] rpm.

2.6.7 Sulfur Dioxide Removal Performance Guarantees

****

NOTE: Stoichiometry for dry scrubbing is defined as the moles of fresh slaked sorbent introduced to the system divided by the moles theoretically required for complete reaction with all of the sulfur dioxide entering the system whether or not it is all removed. This is opposed to wet scrubbing where stoichiometry is generally based on moles of sulfur dioxide removed by the system. Absorbent stoichiometry directly affects sulfur dioxide removal in the spray dryer. For example, a reported stoichiometric ratio of 1.2 for a dry system achieving 80 percent sulfur dioxide removal would be equivalent to 1.5 for a wet scrubbing system. The absorbent stoichiometry may be raised by an increase in the amount of absorbent fed to the spray dryer. A higher absorbent stoichiometry enhances removal of sulfur dioxide.

****

****

NOTE: The compensatory damages for exceeding the guaranteed stoichiometry will be determined on the basis of $_____ for each 45 g mole CaO/g mole 0.10 lb mole CaO/lb mole sulfur dioxide increase above the guaranteed stoichiometric ratio. Deduction of compensatory damages, if any, shall be included in the processing of the final payment. The compensatory damages exceeding guarantees power consumption will be determined on the basis of $_____ /kW. Deduction of compensatory damages, if any, shall be included in the processing of the final payment. The total power consumption will be measured at the Government's power input to the FGD system during the final acceptance tests.

****

The guaranteed sulfur dioxide removal efficiency of the Flue Gas Cleaning System shall not be less than [_____] percent and the outlet sulfur dioxide emission shall not exceed [_____] kg/106 kJ lb/106 Btu for any load on the steam generators down to 30 percent of maximum rating while in any normal operating mode (excluding sootblowing) and burning any coal within the

range specified, when the Government provides lime, water, compressed air, and other utilities to the interface points in accordance with the Contractor's process flow diagrams, material balances, and these specifications. Contractor shall guarantee the removal efficiency specified with any two boilers and their associated flue gas cleaning equipment in operation at full load. For [_____] percent sulfur dioxide removal efficiency, the Contractor shall guarantee the maximum system stoichiometry (lb-mole of Ca0 per lb-mole of S02 entering the system) at both 100 percent and 50 percent of the maximum rating of the steam generator and burning any coal within the range specified. The guarantee at 50 percent rating shall be based on 50 percent of the design gas flow by weight and an inlet gas temperature of 121 degrees C 250 degrees F. Contractor shall specify minimum quality of lime on which stoichiometry calculations are based as 90 percent available CaO by weight. Any increase in the guaranteed stoichiometry at 50 percent rating and firing the average coal will reduce the contract price. The operating stoichiometry will be measured during the final acceptance tests. The measurements will be made under normal operation and no special cleaning, adjustments or other preparations will be allowed. Contractor shall include in the design of the FGD system the necessary provisions for accurate determination of operating stoichiometry. The proposal shall include a description of the method by which stoichiometry may be determined. Contractor shall guarantee that an atomizer can be changed out while the steam generator which it serves is operating.

2.6.8 Particulate Removal Performance Guarantees

****
NOTE: Emission rates will depend upon local or state air pollution regulations. Negotiations with the agencies may be necessary.
****

The maximum particulate emission leaving the fabric filter baghouses shall not exceed [_____] kg/106 kJ lb/106 Btu for any flue gas conditions as specified while in any operating condition and burning any coal within the ranges specified. The maximum particulate emission shall be defined as the average of three complete test runs which shall include a proportional part of the boiler sootblowing cycle. Bag life shall be guaranteed for a minimum of two years after date of first flue gas passage through the bags. Fabric filter baghouse will normally be bypassed during 100 percent oil firing due to plugging of bags, bag guarantee shall be based upon coal/oil and soot combination firing only. Soot blowing, with fabric filter baghouse in operation, shall not void guarantee. If 10 percent or more of the bags in any given compartment fail within the guarantee period, the Contractor shall replace and install all bags in that compartment at his own expense. Replacement of bags on a one-by-one as-fails basis will not normally be allowed. However, the Contractor will be granted the opportunity to locate and replace bags which fail within 30 days of initial start-up of each baghouse due to deficiencies in manufacture or improper installation.

2.6.9 Lime Slurry System Performance Guarantees

The Contractor guarantees that the Gas Cleaning System shall meet the above specified performance, based on the process material balances submitted. The guaranteed process material balances shall be based on the following: (a) Lime analysis and coal analysis as specified, (b) slaking water analysis and temperature as specified, and (c) specified gas flows and

operating conditions. The Contractor shall guarantee the capacity of each lime slaker at 110 percent of lime quantity required at maximum sulfur dioxide rate.

2.6.10 Draft Equipment Performance Guarantees

The Contractor shall guarantee that dampers have no leakage of flue gas to the atmosphere. The Contractor shall guarantee the maximum leakage across each damper when the dampers are in the closed position and are operating at the design conditions.

2.6.11 FGD System Operational Performance Guarantees

****

NOTE: The compensatory damages for exceeding the guaranteed stoichiometry will be determined on the basis of $_____ for each 45 g mole CaO/g mole 0.10 lb mole CaO/lb mole sulfur dioxide increase above the guaranteed stoichiometric ratio. Deduction of compensatory damages, if any, shall be included in the processing of the final payment. The compensatory damages exceeding guarantees power consumption will be determined on the basis of $_____ /kW. Deduction of compensatory damages, if any, shall be included in the processing of the final payment. The total power consumption will be measured at the Government's power input to the FGD system during the final acceptance tests.

****

The Contractor shall guarantee the maximum FGD system power consumption with one boiler unit in operation at the maximum rating and burning any coal within the range specified. The guaranteed maximum power consumption shall include the power consumption for equipment of the FGD system provided under this contract which would be in use when one boiler is in operation. Any increase in this total guaranteed power consumption will reduce the contract price. The total power consumption will be measured at the Government's power input to the FGD system during the final acceptance tests. Specifically, watt-hour meters accurate to within one percent will be used to measure average power consumption at the motor control centers, the induced draft fan drive motor and the atomization air compressor drive motor (if applicable) during the period of the performance tests. The measurements will be made under normal operation and no special cleaning, adjustments or other preparations will be allowed. Design and operation of the FGD system shall be based upon the requirement that stack inlet temperature differential above acid dew point shall not drop below minus 7 degrees C below 20 degrees F and that fabric filter baghouse inlet temperature differential above acid dew point shall not drop below 17 degrees C 30 degrees F. Operating temperatures will be maintained at or above these levels during performance testing. The Contractor shall guarantee the maximum pressure drop across the entire system at design flue gas flow rate. The Contractor shall guarantee that the sound levels specified for the baghouses, pumps, motors, and valves will not be exceeded.

2.7 SPRAY DRYER ABSORBERS

****

NOTE: Dry and Wet Bulb Temperature and Duration:

Parameter	Season	Temperature (Degrees C)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

Parameter	Season	Temperature (Degrees F)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

****

Furnish and deliver [_____] spray dryer absorbers, complete with slurry atomizer units and accessories for a complete and operable installation. Each spray dryer absorber shall meet the performance criteria specified in paragraph entitled "Sulfur Dioxide Removal Performance Guarantees." The absorbers shall be constructed of steel plate of 6 mm 1/4 inchminimum thickness, conforming to ASTM A36/A36M. Structural steel design shall be as specified in paragraph entitled "Structural and Miscellaneous Steel." Structural design temperature range shall be [_____] to 204 degrees C 400 degrees F. External stiffening ribs shall be spaced as required to provide support for the vessel shell, equipment, walkways, penthouse, monorail, and hoist. Stiffeners shall be sized and positioned to provide a uniformly curved surface for the installation of insulation and lagging. Structural welded seams shall be seal welded. Joints shall be provided so that they can be assembled airtight. Each spray dryer absorber shall be provided with the necessary framing for a penthouse to provide shelter of atomizers, motors, lubrication systems, control devices and other equipment located above the spray chamber. Emergency eyewash stations shall be provided in each penthouse. Potable water piping to eyewash stations will be provided by the Contractor. The penthouse design shall be such that the overall cylindrical appearance of the absorber shall be maintained. The rotating assembly of each atomizer unit shall be tested for dynamic and static balance using the actual driver. Complete test reports shall be submitted to the Contracting Officer. Notify the Contracting Officer, in writing, at least 20 days in advance of the tests so that he or his representative can be present. The motor drivers shall be tested as specified in paragraph entitled "Pumps, Valves, Motors." Two-fluid nozzle atomizer assemblies shall be tested for proper atomization performance, plugging resistance and wear resistance during actual flow of lime slurry and compressed air through the nozzle, as required during operation. Submit information on the categories general arrangement, foundation design, structural fabrication, piping, erection, insulation, instrumentation, wiring, and electric

motors. Exterior ferrous metal surfaces of the spray dryer absorber systems including, but not limited to, absorber vessels, holding bins, support steel, manifolds, handrails and kickplate shall be properly cleaned and shop primed, as specified. Mechanical and electrical component equipment, such as atomizer machinery and control panels shall be provided with the manufacturer's standard finishes. Ferrous surfaces which should not be painted and are subject to corrosion shall be protected for the period during shipment and storage with a suitable rust-preventative compound as recommended by manufacturer.

2.7.1 Spray Dryer Absorber Vessel

The spray dryer vessel shall be cylindrical with a 60-degree conical bottom section or with a trough-shaped bottom section with a minimum sideslope of 60 degrees above the horizontal. Provide replaceable wear plates, where necessary. The absorber vessel shall be gas-tight and designed for a transient condition (80 percent of yield strength) at internal pressures of at least plus 4980 and minus 7470 Pa 20 and minus 30 inches water gage. Stiffeners shall be of equal depth to provide a uniform surface to receive insulation. The bottom section of the vessel shall be provided with hopper heaters as specified in paragraph entitled "Fabric Filter Baghouse." Heaters shall cover the bottom one-third of the hopper surface area. Provide the hopper with poke holes, flanged discharge opening, mechanical vibrators, strike plate and nuclear level switches, as specified in paragraph entitled "Hoppers." A minimum of one access door on side of vessel, as specified in paragraph entitled "Access," shall be provided for access to the vessel interior for maintenance. Provide access doors with external latches and tightening devices which will allow for gasket shrinkage and yet produce a gas-tight seal. Doors shall be provided with means for padlocking in the open position. Access shall be sufficient to allow inspection of the vessel interior and removal and replacement of any internal parts subject to erosion or corrosion.

2.7.2 Spray Dryer Atomizers

Each spray dryer sulfur dioxide absorber shall be provided with slurry atomizers of the rotary or two-fluid nozzle type, as specified in the following sections. Equip the spray dryer sulfur dioxide absorbers with vanes, dampers, dispersers, and distributors required to ensure proper contact of the flue gas with the atomized lime slurry. These devices shall be designed to prevent maldistribution and short circuiting of flue gas and localized abrasive impingement of fly ash on absorber internals. The gas dispersers shall be designed to prevent the atomizer spray from impinging on or wetting the vessel wall. Design the gas distribution devices to provide contact between the gas and the atomized slurry as necessary to maintain system performance throughout the gas flow range. Materials of construction shall be suitable for use in the flue gas environment.

2.7.2.1 Rotary Atomizers

Provide a single slurry atomizer for each spray dryer absorber, complete with electric motor drive, power transmission assembly, lubrication system, atomizer wheel, and operational monitoring and control system. Atomizers supplied under this paragraph shall be of the rotary design and shall have a proven record of efficient and reliable service in previous lime slurry applications. Provide atomizers with quick disconnects on the atomizer motor and feed system to allow rapid changeout of atomizers while the steam generators are on-line. The atomizers motor drive shall be as specified in paragraph entitled "Pumps, Valves, Motors." The transmission connecting

the drive motor to the atomizer shall be of the belt or gear-box type. The transmission assembly shall be designed to produce the wheel tip speed required for proper slurry atomization over the range of operating conditions, and shall be provided with a simple means of changing the wheel tip speed, so that the design value can be changed if operational experience indicates the need for adjustment. The wheel tip speed shall be a minimum of 137 meters per second 450 feet per second. Gear units shall comply with all applicable AGMA standards. Bearings shall be the manufacturer's standard design for this application. Bearings shall have an operating life of at least 6,000 hours. Provide a complete lubrication system for each installed atomizer including necessary pumps, reservoirs, filters, heat exchangers, piping, valves, instrumentation and controls, and other accessories, as required, to circulate, clean, and cool the lubricating oil for the atomizer drive and transmission bearings. The lubrication system shall be designed with redundant features and controls required to provide safe and reliable operation of the atomizer and to prevent damage to the atomizer motor or transmission assembly due to loss of lubrication. The atomizer wheel shall be designed so that parts exposed to abrasion from the slurry are wear resistant and replaceable. The wheel body shall be constructed of stainless steel. The orifices in the wheel shall be provided with silicon carbide inserts. The wheel shall be dynamically balanced to minimize vibration of the atomizer unit. Provide instrumentation and controls as specified in Section entitled "Instrumentation and Controls." Include as a minimum the monitoring of the following atomizer operating conditions: motor amperage, lubricating oil pressure, oil temperature, oil reservoir level, motor temperature, atomizer vibration, slurry feed rate, and water feed rate. One complete, ready to run, spare atomizer including motor and drive shall be provided for the Flue Gas Cleaning System. Provide two stands for storing one spare atomizer in an upright position. Provide a stand to hold one atomizer for maintenance. Provide two complete, ready to install, spare atomizer wheels. Two complete sets of tools, as required to disassemble and assemble the entire atomizer, shall be provided. Atomizers shall be designed so that normal maintenance can be performed by plant maintenance personnel who have been trained, as specified in paragraph entitled "Operator Training Program."

2.7.2.2 Two-Fluid Nozzle Atomizers

****
NOTE: Alternate arrangement applicable only when plant design includes idle boiler at plant maximum demand load.
****

Provide multiple-slurry atomizers for each spray dryer absorber, each with its own flue gas plenum to ensure adequate contact of the flue gas with the atomized slurry. Atomizers supplied under this paragraph shall be of the two-fluid nozzle design using compressed air as the atomizing fluid and shall have a proven record of efficient and reliable service in previous lime slurry applications. Atomizers shall be provided with quick disconnects on the compressed air and lime slurry feed lines to allow rapid changeout of atomizers while the steam generators are on-line. Air compressors shall be as specified in this paragraph. Nozzles shall be the internal mixing type so that the compressed air and the lime slurry are mixed internally to the nozzle orifice, resulting in the atomization of the slurry. Internal surfaces of the nozzle which are subject to wear shall be made of a suitable abrasion-resistant material and shall be easily replaceable. Atomizer operation shall be monitored remotely in the steam

plant control room and locally in the absorber penthouse. Provide instrumentation, controls, and alarms, as necessary, to ensure proper operation of the atomizers. Slurry flow and pressure and air flow and pressure in each atomizer feed line shall be monitored continuously. Provide flow and pressure switches to indicate nozzle flow malfunction. Control system shall automatically isolate any malfunctioning atomizer and provide alarm annunciation in steam plant control room. Sufficient control interlocks shall be furnished to assure that air flow to nozzle commences first and terminates last relative to slurry flow during atomizer start-up and shutdown. Atomizers shall be designed so that normal maintenance can be performed by plant maintenance personnel who have been trained, as specified in paragraph entitled "Operator Training Program." The dedicated air compressor system provided with FGD systems utilizing two fluid-nozzle atomization shall be complete with two air compressors, one operating and one backup, and necessary controls and accessories required for automatic operation. Each compressor shall be sized to provide at least 120 percent of the maximum atomization air flow and pressure required. [As an alternative to the preceding specified arrangement, individual air compressors may be provided for each spray dryer absorber. Each unit shall be sized to provide at least 120 percent of the maximum atomization air flow and pressure required for operation of one spray dryer, and with all [_____] units connected together, so that the unit normally dedicated to the spray dryer for the idle boiler provides the required backup.] [For either arrangement], [the] following features shall be provided: The air compressors and all controls and accessories specified herein shall be located inside an enclosure to provide an environment suitable for compressor operation. Provide the structural and miscellaneous steel for framing of the enclosure. Instrumentation and controls shall provide both, local and remote monitoring, alarm annunciation, and automatic transfer to backup unit in the event of failure of the operating unit.

2.7.2.3 Spare Equipment

One complete spare atomizer assembly shall be provided for every two installed assemblies. Spare atomizer assemblies shall require only the connection of lime slurry and air feed lines to allow insertion and operation in place of a malfunctioning assembly. In addition, provide spare nozzle wearing surface component parts, and other atomizer component parts as required for one year's operation. Provide two complete sets of tools required for disassembly and assembly of atomizer units.

2.7.3 Monorail and Hoist

Provide permanent hoist and monorail system for each spray dryer absorber, as required, to install and remove atomizers. Monorail and hoist system shall conform to NFPA 70. Monorail shall extend beyond edge of absorber with sufficient clearance to allow lowering of atomizer assembly to ground level and raising from ground level. Hoisting system shall be designed in accordance with MHI MH27.1 and ASME HST-4. Provide wire rope electric hoist with motor-operated trolley. Rope drum shall be sized for full lift from ground level. Hoist capacity shall be 150 percent of heaviest piece of equipment to be lifted during atomizer installation or removal or 908 kilograms 2,000 pounds, whichever is heavier. Capacity shall be clearly indicated on hoisting equipment. Factor of safety for hoisting equipment shall be not less than five on load-sustaining parts based on ultimate strength. Hoist shall be provided with automatic mechanical load brake and electric motor brake, either of which will sustain rated load in any position. Monorail shall have minimum capacity of 150 percent of heaviest piece of equipment to be lifted or 908 kg 2,000 pounds, whichever is

heavier. Provide angle stops on the monorail at each end to prevent trolley over-travel. Provide 460 volt, 3-phase, 60-hertz, totally-enclosed, roller ball-bearing type motor rated on 30-minute, 55-degree C rise-duty basis, specifically designed for NEMA Class 2--Light Duty Industrial Service for cranes. Monorail and hoist control shall be by push button station suspended from hoist on pendant cord of sufficient length to allow operation from penthouse floor or walkway level. Push buttons shall control all hoist and trolley motions and shall provide "dead-man" control action. Enclosed reversing-type magnetic starters shall be mounted on hoist. Upper and lower limit switches shall be provided to prevent hood over-travel. Provide double-acting limit switch to prevent trolley over-travel in either direction. Conductor system shall be rigid enclosed safety-type runway conductor, supported and insulated to conform to NFPA 70.

2.7.4 Absorber Product Removal System

Provide necessary equipment, structural support steel, instrumentation, and controls required for continuous removal, transfer, and short-term storage of absorber product material and fly ash from the bottom hopper section of each spray dryer absorber vessel. The design capacity of the conveying equipment provided shall be at least 120 percent of the maximum expected rate of accumulation of fly ash and absorber product in the vessel based on the specified maximum inlet loadings of sulfur dioxide and particulate. The Contractor's conveying system shall continuously transfer the collected material to a holding bin or bins from which the ash handling system will intermittently convey it to an ash silo. The total capacity of the holding bins provided shall be not less than that required to store the quantity of fly ash and absorber product material representing ten hours of operation of the conveying system at design capacity. The holding bin or bins shall be provided with auxiliary equipment, controls and instrumentation required to keep the control room operator informed as to the system status, minimize fugitive dust emissions and maintain the flow of material to the ash handling system when needed. Structural design requirements shall be as specified. Structural design shall be based on a density of 47 kg per cubic meter 100 pounds per cubic feet. Capacity shall be based on a density of 16.5 kg per cubic meter 35 pounds per cubic feet. Provide a flanged outlet connection for interface with the ash handling system to be provided by the Contractor.

2.8 FABRIC FILTER BAGHOUSES

****

NOTE: The use of an electrostatic precipitator (ESP) with the dry scrubber instead of a fabric filter baghouse is not acceptable.

****

Provide [_____] fabric filter baghouses, complete with flue gas bypass, inlet and outlet flue gas manifolds, dampers, bags and bag attachment with support hardware, ash collection hoppers, pulse jet or reverse gas cleaning systems, and accessories required for a complete and operable installation. Each fabric filter baghouse shall meet the performance criteria specified in paragraph entitled "Particulate Removal Performance Guarantees." The fabric filter baghouses will be operated on the suction side of the induced draft fans, as indicated. Each fabric filter baghouse shall have a minimum of four lighted modules. The modules shall be arranged in two rows with the inlet and outlet flue gas manifolds located between the rows of modules. The design and arrangement of the fabric filter baghouses shall complement the spray dryer absorbers, fans and ductwork such that the

complete Flue Gas Cleaning System installation meets the space requirements indicated. Each fabric filter baghouse shall be provided with framing for a penthouse area as required to allow bag replacement, [damper and damper operator maintenance] [and] [pulse valve maintenance] in a protected environment. Structural design requirements shall be as specified in the paragraphs entitled "Fabric Filter Baghouses," "Structural and Miscellaneous Steel," and in this paragraph. Submit information on the categories general arrangement, foundation design, structural fabrication, piping, erection, insulation, instrumentation, internal arrangement, and valves. Exterior ferrous metal surfaces of the baghouse system including, but not limited to, fabric filter baghouse modules, hoppers, support structures, manifolds, handrails, and kickplate shall be properly cleaned and shop primed, as specified. Surfaces that will be exposed to the flue gas flow need not be painted, but shall be protected during shipment and storage with a suitable rust-preventative coating, as recommended by manufacturer. The fabric filter baghouses shall conform to ICAC F-2, ICAC F-3, and ICAC F-5.

2.8.1 Pulse Jet Cleaning Systems

****
NOTE: Air compressor is specified in paragraph entitled "Two-Fluid Nozzle Atomizers."
****

****
NOTE: Factors involved in selecting fabric filter bag materials include:

1. Duration of cleaning.

2. Type of cleaning arrangements.

3. System temperature level.

4. Coal type.

5. Sulfur dioxide removal efficiency.

NEEDLED felts are most commonly specified for pulse-jet units. Precoat bags with fly ash prior to operation. Fabric specifications are dependent upon material.
****

****
NOTE: Insert appropriate Section number in the blanks below.
****

The fabric filter baghouse assembly shall be of modular construction. The inner housing casing and tube sheet of each module shall be fabricated from carbon steel plate of 5 mm 3/16 inch minimum thickness, conforming to ASTM A36/A36M. The inner casing shall be of welded construction, gastight and watertight, designed for a transient condition (80 percent of yield strength) at internal pressures of at least plus 4980 and minus 7470 Pa plus 20 and minus 30 inches water gage. Joints shall be sealed by continuous fillet or continuous complete penetration groove welds, as applicable. The tube sheet opening arrangement and bag clearance shall

limit gas velocity between the bags at any point within the module to not more than 1.27 m/s 250 ft/min at design conditions. Bag to wall clearance used in calculating gas velocity shall not exceed bag to bag clearance. Minimum bag clearance shall be 50 mm 2 inches. Additional space shall be provided between rows of bags, as necessary, to clear access door supports crossing the tube sheet. Tube sheet shall be continuous fillet or continuous complete penetration groove welded gastight so that all flue gas must pass through the bags. No caulking or sealing materials shall be used. Tube sheet shall be arranged for individual top bag and cage removal and reinforced, as required for pedestrian traffic (minimum support shall be 488 kg per square meter 100 pounds per square foot). Modules shall have shop insulated, double-cased lift-off doors with quick-opening handles for access to the tube sheet. Doors shall have high-temperature gaskets to prevent air infiltration. Multiple tube sheet access doors shall be provided such that each door shall be easily removable by two men. The doors shall be provided with lifting handles. Top surface of access doors shall be 6 mm 1/4 inch thick ASTM A36/A36M four-way raised pattern floor plate. The manufacturer's standard tube sheet access door arrangement and design will be considered provided the design provides adequate insulation and protection against infiltration. The bag cleaning system shall be designed to ensure efficient cleaning operation with a minimum pressure drop across the system and with the gentlest possible cleaning mechanism to ensure long bag life. Source of compressed air is specified under Section [_____] COMPRESSED AIR SYSTEMS. Compressed air used in the cleaning system shall pass through a dryer/filter system. The dryer shall be provided to remove moisture from compressed air used in system. Dryer shall remove sufficient moisture to provide a maximum dewpoint of [_____] degree C at 690 kpa (gage) degree F at 100 psig. A filter system shall be provided to clean compressed air used in system. Filter system shall remove a minimum of 90 percent to 95 percent of particles greater than 0.6 microns in diameter. Filters shall be sized to operate for 90 days without service under normal operating conditions and shall be easily accessible for inspection and service. Dryer/filter system shall be sized service. Dryer/filter system shall be sized for 120 percent of design air flow. Dewpoint should be 6 degrees C 10 degree F lower than design minimum temperature. In no case should a dewpoint be greater than 2 degrees C 35 degrees F. Each module shall have a factory-installed compressed air header, pulse valves, and distribution piping. Valves and wiring shall be located in a weather protected enclosure with forced air ventilation to prevent freezing or overheating. The enclosure shall be readily accessible through hinged doors. Diaphragm valves shall be factory prewired to a junction box. Entire pulsing system shall be removed with top door or other provisions shall be made such that piping does not interfere with bag replacement. Connections to compressed air headers and distribution pipes shall be made with flexible hose with automatic shutoff quick connect fittings for ease of removal during maintenance. Each row of bags shall be serviced by its own pulse valve and distribution pipe so that only one row of bags shall be cleaned per each compressed air pulse. The pulse valves shall be heavy-duty diaphragm type with solenoid actuators and stainless-steel internals. Pulse valves shall be designed to limit noise from pulse valve operation to not more than 84 dBA measured 1 1/2 meters five feet from the valves. Compressed air and instrument air piping for each fabric filter baghouse shall be piped back to a single point within the battery limits of the collector(s) as indicated for connection with the steam plant piping system to be provided by the Contractor. Contractor's piping shall include shut off valves, pressure gages, pressure regulating stations, filters, surge tanks, and other equipment required for complete operation of the cleaning system. For off-line cleaning modules shall be sequentially isolated by closing the outlet valve. Manufacturer to

recommend off-line times. When the module is off-line, each row of bags shall be individually pulsed with 483 to 690 kPa (gage) 70 to 100 psig compressed air through a solenoid-piloted, heavy duty diaphragm valve. Each bag support cage shall be fitted with a diffuser element. After bags are cleaned, the module shall be held off-line for a period of time sufficient to allow the dust to settle into the hopper. The bags to be furnished shall be of a fabric type, weight, finish, and construction suitable for the intended service. Bags shall be suitable for continuous exposure to the flue gas temperature conditions at the economizer outlet. Bags and cages shall be provided with coatings as necessary to minimize abrasion and to resist acid or alkali attack. Bags shall not be more than 150 mm 6 inches in diameter and not more than 4 1/2 meters 15 feet in length. Bag cage design and construction shall be suitable for the intended service. Bags shall be clamped at top between cage and tube sheet in such a manner that bags will not sway, but can be readily removed without special tools. The manufacturer's standard cage design will be considered, provided that it has a proven record of reliable services with the bag material proposed. The method of attachment of bags and cages to the tube sheet shall provide proper air seal, bag tension, and cage alignment. If venturis are provided, they shall be the manufacturer's standard type for this application. Special care shall be taken to assure there are no rough spots on cages to cause bag abrasion. Provide equipment and materials necessary for bag leak detection. Leak detection system provided shall utilize a fluorescent powder for detection with ultraviolet light. Furnish portable light and sufficient powder for one year of normal inspections. Furnish sufficient bag capping devices for 5 percent of the total installed number of bags. The Contractor shall precoat the bags for initial start-up on oil.

2.8.1.1 Spare Equipment

Ten percent extra bags and two percent extra cages shall be furnished.

2.8.2 Reverse Gas Cleaning System

****

NOTE: Factors involved in selecting fabric filter bag materials include:

1. Duration of cleaning.

2. Type of cleaning arrangements.

3. System temperature level.

4. Coal type.

5. Sulfur dioxide removal efficiency.

NEEDLED felts are most commonly specified for pulse-jet units. Precoat bags with fly ash prior to operation. Fabric specifications are dependent upon material.

****

****

NOTE: Specify air pressure available for pneumatic operators or electrical characteristics available for electric operators.

****

The baghouse assembly shall be of modular construction. The inner housing casing and tube sheet of each module shall be fabricated from carbon-steel plate of 6 mm 1/4 inch minimum thickness, conforming to ASTM A36/A36M. The inner casing shall be of all-welded construction, gastight and watertight designed for a transient condition (80 percent of yield strength) at internal pressures of at least plus 498 and minus 7470 Pa 20 and minus 30 inches WC. Joints shall be sealed by continuous fillet or continuous complete penetration groove welds as applicable. Tube sheets shall be continuous fillet or complete penetration groove welded gastight so that flue gas must exit through the thimbles. Thimbles shall be fabricated of carbon-steel plate with a minimum thickness of 12 gage and minimum length of one nominal bag diameter and shall be spaced on not less than 241 mm 9 1/2 inch centers for 200 mm 8 inch diameter bags and not less than 356 mm 14 inch centers for 300 mm 12 inch diameter bags. Thimbles shall be inline and not staggered. Tubesheet/baghanger alignment shall be within 3 mm 1/8 inch for plumb and centering hanger adjustment shall be provided to allow maintenance of bag alignment. Internal walkways with kickplates shall be provided to access both upper and lower bag supports. Upper access walkways shall be at least 457 mm 18 inches wide. Lower access walkways shall be at least 610 mm 24 inches wide. If the upper walkways are located between upper support frames, upper walkways shall be one meter 3 feet below the upper support frame and a crawl space at least 1.22 meters 4 feet high shall be provided above the support frames. Each reverse gas fabric filter baghouse shall be provided with a bag cleaning system including two 100 percent capacity reverse gas fans, connecting ductwork, dampers, and automatic controls. Each fan shall be provided with automatic operated inlet louver dampers for control and shutoff. Automatic-operated dampers shall also be provided to isolate the "standby" fan and the modules not being cleaned. The reverse gas-cleaning system shall provide for gradual reinflation of the bags after cleaning. The reverse gas for cleaning shall be taken from the outlet plenum. Reverse gas fans shall be specified in paragraph entitled "Ductwork and Draft Equipment." Motor drives shall be as specified in entitled "Pumps, Valves, Motors." Louver dampers for reverse gas fans shall be as specified in paragraph entitled "Ductwork and Draft Equipment." The collector manufacturer shall furnish valves necessary for each module to cause effective reverse air cleaning of each module. The clean gas outlet valve and the reverse air inlet valve for each module shall be of the [air cylinder] [electric motor] operated, poppet-type arranged for manual lockout capability with position indicating switches at both ends of the travel. The clean gas outlet valves shall be the adjustable slow opening type arranged for manual lockout capability with position indicating switches at both ends of the travel. The clean gas outlet valve shall be arranged to fail-safe in the closed position. The dirty gas inlet valve for each module shall be of the manually operated, poppet-type or butterfly-type suitable for isolating each module for maintenance. The manual operator shall be of a type that is readily accessible. Bags shall be suitable for continuous exposure to the flue gas temperature conditions at the economizer outlet. Bags shall be provided with coatings, as necessary, to minimize abrasion and to resist acid and alkali attack. Bags shall be 300 mm 12 inches in diameter and a maximum of 10 meters 35 feet in length or 200 mm 8 inches in diameter and a maximum of 7.32 meters 24 feet in length. Each bag shall have at least eight for 300 mm 12 inch bags or five for 200 mm 8 inch bags sewn-in rings of welded steel, galvanized or cadmium plated, or welded stainless steel after fabrication. Bags shall attach to the thimbles by means of quick release clamps. Clamps shall not require tools for adjustments or installation. Upper bag suspensions shall provide for ease of adjustment, tensiding, and

bag replacement. The suspension shall not use threaded members such as bolts and nuts for adjustment or attachment of bags. Bag caps and other suspension hardware that comes in direct contact with the bag fabric shall be cadmium-plated steel or stainless steel. The method of attaching the bags to the cap and thimble shall provide a leakproof seal. The Contractor shall supply insert materials necessary to precoat the bags for initial start-up on oil.

2.8.2.1 Spare Equipment

Furnish ten percent extra bags and ten percent extra clamps.

2.8.3 Bag Guarantee

Bags and cages, or bags and sliprings, as applicable, shall be guaranteed for 2 calendar years from startup. In case of failure during that period, Contractor shall supply a replacement without cost to Government. Contractor shall provide the number of spare bags, and cages, if applicable, required to replace the bags in baghouse. These bags, and cages if applicable, shall not be used as replacement during startup and testing. If bag, and cage, if applicable, replacement exceeds 10 percent in any compartment during the first 2 years, replacement of all bags, and cages, if applicable, in that compartment shall be provided by the Contractor at no cost to the Government. The replacement bags, and cages, if applicable, shall be guaranteed for an additional 2 years. Bags shall be inspected for creases, folds, abrasions, holes, and tears prior to installation. Any bag with one or more of the preceding imperfections shall be rejected. Cages or rings, as applicable, shall be inspected for corrosions, sharp edges, bends, bad or broken welds, eccentricity, or burrs prior to installation. Any cage or ring with one or more of the preceding imperfections shall be rejected.

2.8.4 Bag Quality Assurance

****

NOTE F: Factors involved in selecting fabric filter bag materials include:

1. Duration of cleaning.

2. Type of cleaning arrangements.

3. System temperature level.

4. Coal type.

5. Sulfur dioxide removal efficiency.

NEEDLED felts are most commonly specified for pulse-jet units. Precoat bags with fly ash prior to operation. Fabric specifications are dependent upon material.

****

Bag manufacturer shall furnish following actual test data for each bag material lot used:

Permeability (ASTM D737)
MIT Flex (ASTM D2176)

Tensile Strength (ASTM D1682--Method IR-T)
Mullen Burst (ASTM D3887)
Weight (ASTM D3776/D3776M)
Thickness (ASTM D1777)
Count (ASTM D3775)
Yarn Weight (ASTM D578)
Fabric Treatment Content

The fabric shall meet the following specifications.

Permeability	[_____]
MIT Flex	[_____]
Tensile Strength	[_____]
Mullen Burst	[_____]
Weight	[_____]
Thickness	[_____]
Weave Thread Count (warp x fill)	[_____]
Yarn Weight	[_____]
Type of Finish	[_____]
Weight of Finish	[_____]
(Percent of fabric weight)	[_____]

Provide material lot analyses prior to manufacture of bags. Prior to processing, the yarn shall be inspected for cleanliness, binder content, broken filaments, denier and tensile strength. Substandard yarns shall be rejected. Sizing applied to yarns shall be removed from the fabric prior to applying the finish. Stitching used in filter bag fabrication shall be made using [_____] thread. Filter bags shall be packaged and protected as necessary to prevent damage during shipping and outdoor storage at the job site. Material not meeting the requirements of this specification shall be rejected and replaced with materials of the specified type and quality at no additional expense to the Government. The Contracting Officer or his representative shall have uninhibited access to areas in which the fabrication of materials governed by the specifications takes place.

2.8.5 Hoppers

Hoppers shall be pyramidal-type fabricated from ASTM A240/A240M, type 317L cold-rolled steel plate having a minimum thickness of 6 mm 1/4 inch. Hoppers shall be properly stiffened, from the outside only, and shall be constructed with a minimum valley angle of 60 degrees from the horizontal. Hoppers shall be of welded construction and shall be welded to the modules to form a gas-tight unit. Welded joints shall be sealed by continuous fillet or continuous complete penetration groove welds as applicable. Hoppers shall span no more than one module. Steel reinforcements not in contact with the gas or ash may be either type 317L stainless steel or

ASTM A242/A242M structural steel. If the latter is used, welding rods shall be specifically selected for the service. Provide protection of rods against moisture whether for factory or field assembly. Provide key interlocked access doors on each hopper on both sides of any hopper baffle. Hopper access doors shall be interlocked to fly ash level detectors to prevent access when the nuclear level detectors are operational. Doors shall be in accordance with the requirements specified in paragraph entitled "Structural and Miscellaneous Steel." Each hopper shall be furnished with provisions for attachment of vibrators. Hoppers shall have adequate flexibility for vibrating. Each hopper shall be provided with two 100 mm 4 inch poke holes with a tee wash connection and screw caps. Poke holes shall be positioned to permit downward thrusts into the hopper. A special plate reinforced "pounding area" shall be furnished on each hopper face for external manual vibrating. Each pounding plate shall be 300 by 300 by 25 mm 12 by 12 inches by 1 inch thick plate steel ASTM A36/A36M. A work platform with stairs shall be provided to each pounding area for units with pounding areas more than 1 1/2 meters five feet above ground. Approve location and arrangement of poke holes and pounding areas by the Contracting Officer. Pounding plate shall not be insulated. Insulation shall be neatly finished at this discontinuity. Each hopper shall include a 300 mm 12 inch diameter 57 kg 125 pound flat face flanged outlet connection to match ash conveying system to be provided by the Contractor. Provide access hatch not less than 200 by 200 mm 8 by 8 inch for cleanout within 200 mm 8 inches above the flange. Ash valve shall be a minimum of 150 mm 6 inch diameter. Bolt-down type hatch is acceptable for clean-out hatch. Provide each hopper with two mechanical vibrators, to be located at mid-height on opposite sides. Vibrator controls shall be interfaced with ash collection system to provide vibrator operation only at the inception and during an evacuation cycle. Operation shall be automatic. Manual override control for hopper vibrators and evacuation system shall be provided in hopper area and shall be enclosed in cases to prevent accidental energization of systems. A warning shall be placed over the vibrator manual control with the following inscription: "Warning: Vibrator Control. Do not activate unless hopper evacuation system is operating." Provide nuclear hopper level switches as specified in paragraph entitled "Instrumentation and Controls." Provide a hopper heater system for each fabric filter baghouse. Each system shall be as specified herein. Hopper heaters for each hopper shall be furnished by the collector manufacturer and shall include material required for mounting. The system shall be designed to provide a 93 degrees C 200 degrees F rise in temperature in the hopper, in the vicinity of the heaters, during offline and startup conditions. The system shall be designed to provide maximum heater coverage between hopper stiffeners. The system shall be designed with a minimum heating safety factor of 1.1 and a minimum wind heat loss factor of 1.12. The system shall include a flexible throat heater for each hopper. Heaters shall be of modular design except for throat heaters. Flexible electric heating blankets or tapes, capable of withstanding 454 degrees C 850 degrees F, shall be used for areas where modular equipment will not fit. Heater modules shall be designed for easy installation. Heater modules shall cover at least 20 percent of the hopper area (covered hopper area not to include exposed areas of poke holes, level detectors, strike plates, stiffeners, access doors, etc.), shall cover the bottom portion of the hopper to the maximum extent possible, and shall extend at least 50 percent up the hopper height. Hopper throats shall be heated with blanket or tape heaters. Equipment furnished shall be designed and tested to withstand natural and induced vibrations including manual rapping of the strike plates. The hopper heater system shall be individually thermostatically controlled with adjustable setpoint between 66 to 121 degrees C 150 to 250 degrees F internal skin temperature, the minimum

specified ambient temperature, and shall be furnished and installed complete including power, control, and alarm components. Heater voltage shall be [_____] volts AC. Control voltage shall be 120 volts AC. Modular heaters shall be furnished complete. Heater modules shall be self-contained. The modules shall have a flexible heating face to conform to the irregularities of the hopper surface, providing intimate contact between the heaters and the hopper, and providing maximum heat transfer. Hopper heaters shall be of low watt density design (maximum of three watts per 645 square mm square inch of resistance element) with a minimum of six parallel resistance paths per heater (continuous blanket type elements shall be deemed to meet the multipath requirement). Each heating element in the module shall be capable of being operated at 2152 watts per square meter 200 watts per square foot. Heating elements shall be made of 600 series stainless steel alloy or nichrome encased in a 20 gage minimum aluminum or aluminized steel mounting pan or casing. Cold lead wires and interconnecting wires shall be multistrand copper wire with high temperature (454 degrees C) (850 degrees F) insulation. Cold leads shall be furnished with strain relief constructed in such a manner as to prevent damage to the heater modules due to rough handling. Leads shall be of sufficient length to reach the terminal box. Splices shall not be permitted in leads from modules, tapes, or blankets to the terminal box. Each module, blanket, or tape shall be tested for electrical integrity at 1,000 volts prior to installation. Individual modules shall be designed to fit between the hopper stiffeners and other hopper well obstructions to provide the maximum coverage possible. Heating units supplied shall have metal labels firmly attached to the unit listing the wattage and voltage of the unit. Heating units and mounting hardware shall be constructed of high temperature materials capable of withstanding 454 degrees C 850 degrees F. Heating units shall be insulated with high temperature woven glass cloth or mineral fiber. Mica or magnesium oxide insulated heaters shall not be provided. Cold leads from each heater shall be provided for external circuit connection. The cold leads shall be contained in hot-dip galvanized NEMA Type 4, as defined in NEMA ICS 6, cast iron fitting for connection to field installed solid conduit or waterproof raceway. NEMA 4 as defined in NEMA ICS 6 hopper heater terminal boxes with terminal blocks for connection to heater leads and thermostat leads shall be provided. Terminal blocks in each terminal box shall contain a sufficient number of terminals to connect the heaters for each hopper, one control thermostat, and one low temperature alarm thermostat. The thermostats for monitoring hopper temperature shall be 120 volts AC adjustable type in NEMA 4 enclosures. Each hopper heater terminal box, fed from a panel, shall include one 3-pole fused main switch, magnetic contractor and alarm relay with two normally open contacts, terminal blocks for power, control and alarm circuits, a fused control transformer having a 120-volt secondary, and auxiliary relays for automatic operation of the heater system. The cover shall have the following devices mounted, for each contractor: "HAND," "OFF," "AUTO" selector switch.

a. 120 volt red light--"ON" with integral transformer.

b. 120 volt white light--"LO TEMP" alarm with integral transformer.

c. Device and enclosure nameplates.

The following components shall be provided for each fabric filter baghouse for thermostatic control of the hopper heater system:

a. A master hopper heater control panel.

b. Hopper heater terminal panels at each hopper. The contractor shall furnish materials, tools, and labor required for connections of circuits and wiring between local hopper heater control panels and the master heater control panel.

This panel shall contain relays, contractors (fused switches or circuit breakers), control transformers, and other devices required for complete control of the heater system. Master heater control panel shall be located as indicated. Panel components shall be factory installed and wired in a NEMA 4 enclosure and shall include the following.

a. A main-fused switch or circuit breaker.

b. A fused switch or circuit breaker, contractor alarm relay, with two normally open contacts. A selector switch, "HAND," "OFF," "AUTO," red "ON" light, and white "LOW TEMP" alarm light for each local heater panel. The contractor shall have a 120-volt operating coil.

c. Device and enclosure nameplates.

d. Auxiliary relays and equipment required for operation of the heating and alarm systems.

2.8.6 Manifolds and Draft Equipment

Furnish inlet an outlet manifold ducts as part of each fabric filter baghouse. Manifolds shall be sealed by continuous fillet or complete penetration groove welds to provide gas-tight construction, fabricated from minimum 6 mm 1/4 inch thick ASTM A36/A36M steel plate, and properly stiffened. Manifolds shall have necessary expansion joints conforming to the requirements of the paragraph entitled "Ductwork and Draft Equipment" and access doors and shall be supported from the fabric filter baghouse structure. Structural design shall be based on assumption the ducts may be 30 percent full of fly ash. Taper inlet manifolds to maintain a uniform gas velocity to all modules. Size manifolds to minimize pressure drop, but also so that velocities shall be between 28 to 30 meters per second 5,500 to 6,000 feet per minute at 100 percent of boiler load capacity to minimize ash drop out of the gas stream. Inlet manifold take-offs to each module shall be located in or near the bottom of the duct to assist in sweeping the dust into the modules. A replaceable, abrasion resistant baffle plate shall be furnished at the inlet to each module to prevent abrasion of the bags. Each module shall be provided with inlet and outlet dampers. Inlet and outlet dampers shall be the manufacturer's standard type. Each fabric filter baghouse shall be provided with bypass dampers to bypass the fabric filter baghouse during start-up and shutdown, during oil firing, and in the event of excessive flue gas moisture conditions due to spray dryer absorber malfunction Bypass dampers shall be as specified in paragraph entitled "Ductwork and Draft Equipment."

2.9 LIME SLURRY PREPARATION SYSTEM

****
NOTE: Pressures, rates, and duration of sootblowing will depend on site conditions and acceptable operating procedures.
****

Provide a single lime slurry preparation system to serve [_____] spray dryer absorbers. Provide the lime slurry preparation system with equipment

for receiving, storing, feeding, and slaking pebble quicklime, and for storing and pumping lime slurry of sufficient quantity and quality as required for use in the FGD system. Lime system component equipmentand controls shall be as specified in paragraph entitled "Lime Slurry Preparation System," and herein. Motors shall be as specified in paragraph entitled "Pumps, Values, Motors." Provide structural and miscellaneous steel as required for support of equipment, framing of the equipment enclosure, and access to equipment, as specified. Structural design shall be as specified in paragraph entitled "Structural and Miscellaneous Steel." Equipment shall be arranged within the lime system enclosure to allow easy access for operation and maintenance. Arrange equipment on multiple levels as follows: Slurry storage tank and pumps shall be located on the lower level; lime feeders, slakers, and grit screens shall be located on a level above the tanks so that slurry flows by gravity into the tank. Headroom between each level and the structural supports for the level above shall be 3 meters 10 feet minimum. The lime system enclosure shall be located in the area between spray dryer absorbers. The plan area of the enclosure shall be not less than 37 square meters 400 square feet. The length and width of the enclosure shall be selected to be compatible with the Contractor's general arrangement to minimize displacement of the spray dryer absorbers. The length and width of the enclosure shall be selected to be compatible with the Contractor's general arrangement to minimize displacement of the spray dryer absorbers and fabric filter baghouses from the boiler centerlines. To provide for adequate lime system equipment layout the Contractor's structural framing arrangement may provide for connection of the enclosure for the lime system and that for one or both of the hopper enclosures for spray dryer absorbers and fabric filter baghouses from the boiler centerlines. Provide interior access to each lime system equipment level to provide Class one personnel access as specified in the paragraph entitled "Structural and Miscellaneous Steel." The enclosure framing shall allow for the location of an 2440 mm 8 foot wide roll-up door (to be provided by the Contractor) to provide access to the Government's grit disposal bin by forklift truck. Components shall be tested at the factory to verify proper operation of controls, motors, and equipment components. Notify the Contracting Officer, in writing, at least 30 days in advance of the final complete system factory tests, so that he may have a representative observe the tests. Provide information necessary to determine the structural design requirements of the concrete foundation pad. Provide necessary erection drawings and installation instructions. Include submittal information on the categories general arrangement, foundation design, piping, erection, instrumentation, internal arrangement, wiring, valves, and electric motors. The exterior of the lime storage and feed bin shall be cleaned and primed as specified in the paragraph entitled "Structural and Miscellaneous Steel." Other lime slurry preparation system component equipment shall be provided with the manufacturer's standard finish.

2.9.1 Lime Storage and Feed Bin

The lime preparation system shall have an integral storage and feed bin for pebble lime. The bin shall be shop fabricated, all welded construction of carbon steel plate with a minimum thickness of 6 mm 1/4 inch, conforming to ASTM A36/A36M. The bin shall be structurally supported as necessary to provide for enclosed areas for equipment levels directly beneath the bin cone hoppers. The lime preparation system structure shall be designed for wind, snow, seismic and other loads, as specified in paragraph entitled "Structural and Miscellaneous Steel." Structural design shall be based on a bulk density for pebble lime of 1040 kg per cubic meter 65 pounds per cubic foot. Bin diameter shall be 3.70 meters 12 feet. Bin height shall

be based on pebble lime bulk density of 880 kg per cubic meter 55 pounds per cubic foot and angle or repose of 55 degrees. Bin shall be cylindrical with twin, 60 degree minimum conical bottom hoppers. Roof shall be sloped 1:12 for drainage. The roof shall have an inlet target box located at the center and provisions for mounting the bin vent filter, pressure relief valve and high-level switch. Provide for access to the interior of the bin from the roof through a hinged manway. Access, handrails, and kickplate for the roof shall be provided as specified in paragraph entitled "Structural and Miscellaneous Steel." A fill pipe shall be provided for transporting pebble lime from self-unloading trucks to the storage and feed bin. The fill pipe shall extend from the truck fill connection point, approximately 1.22 meters 4 feet above grade, to the center fill collar. The fill pipe shall be 100 mm 4 inch O.D. Schedule 40 carbon steel pipe. A 1219 mm 4 inch centerline radius bend shall be used for the direction change at the top of the fill tube riser. The fill tube shall be complete with a quick coupling hose connection with security chain, dust cap and limit switch at the truck connection point and a clean-out cap at the inlet target box. The inlet target box shall be provided with two openings for fill piping connections: One for use with the 100 mm 4 inch fill pipe to be provided under this contract and one for use with the pneumatic conveying system piping to be provided by the Contractor. The opening for use by the pneumatic conveying system piping shall be 150 mm 6 inches in diameter and shall be suitable for attachment of a reducer for compatibility with the conveying line size selected later for use with the pneumatic conveying system. Provide a bin vent filter for mounting on top of the bin, with retained dust discharge directly into storage bin. This unit shall have a venting capacity of at least 472 L/s 1,000 scfm. Filter bags must be readily removable for inspection or replacement without tools. Construction of filter manifold shall prevent filter bags from falling into storage bin. Operation of the filter shall be such that there will be no escape of dust during truck unloading. Filter unit shall be fabricated weatherproof and dripproof construction, with self-contained bag cleaning system and fan assemblies. Weather and dripproof gasketed access doors to bag compartment shall be provided. Parts of unit subject to service or maintenance shall be not more than 1 1/2 meters 5 feet above the bin roof and shall be accessible by a person standing on top of the bin without use of ladders or platforms. The bin filter exhaust fan shall be the squirrel-cage type, operating at less than 3,500 rpm, with mounting on the bin vent filter. This unit shall have air handling capacity of at least 472 L/s 1,000 scfm. It shall provide a negative pressure within the bin during unloading operations. The fan outlet shall be provided with a louvered damper which automatically opens during operation and closes when the bin is not being filled and shall be fitted with a removable bird and insect screen. Electric connections shall be NEMA 3R, rainproof. A disconnect switch in NEMA 3R steel enclosure shall be provided and mounted on the vent filter unit to allow local shutoff of power supply to electrical devices located at the bin roof level. Wiring connections to these units shall be made by the Contractor. Two bin level switches shall be mounted at a high and at a low level on the bin. These switches are to be of the stainless steel, rotating-paddle type, electrically operated. Indicating lights coincident with these switches shall be provided in both the truck unloading panel and the main control panel. Top-mounted units must have extension shafts and guards. Side-mounted units shall be provided with inside shields and all units must be mounted adjacent to ladders or on top of storage bin. The lower bin switch shall be located to represent capacity in terms of complete truck loads of material, based on truck load capacity of 18.82 cubic meter 665 cubic feet per load of quicklime density at approximately 960 kg per cubic meter 60 pounds per cubic foot. One heavy-duty vibrator shall be connected to the outside of each bin cone and

provided with suitable controllers and timers to allow pacing from the quicklime feeder. Each vibrator shall be interconnected with the associated feeder, in order that it operates in proportion to feed rate only when the bin gate is open and the feeder operates. Live bottom type bin dischargers may be provided in lieu of the outside vibrators. A manually-operated, dust-tight slide gate shall be mounted at the termination of each bin cone to allow isolation of the equipment below for maintenance.

2.9.2 Lime Slakers

The lime slakers shall be of the detention or paste type. The slakers shall be designed for continuous operation at the required capacity. Slaking temperature and slaking performance shall be automatically maintained, so that at least 90 percent of the calcium hydroxide particles formed are smaller that 2 microns in size, when lime quality is as specified. Slakers shall be capable of slaking all grades of 20 mm 3/4 inch pebble quicklime at a controlled temperature. Automatic controls shall be provided to inject excess water into the slaking chamber should the temperature exceed a preset limit. Slakers shall be provided with an exhaust system to prevent water vapor from rising into the feeder mechanism. The slakers shall be of all welded steel construction and shall be completely dust-tight. Access covers for all compartments shall be provided. Slakers shall be designed for ease of maintenance and shall be capable of shutdown for up to 24 hours without requiring cleanout prior to restart. Provide a hose connection at each slaker level for use by maintenance personnel. Lime feeders shall be of the gravimetric or volumetric type as required for compatibility with the lime slakers. Feeders shall be designed to prevent flooding of the slakers with lime. Feeders shall be capable of handling pebble quicklime, including fines. Feeders shall be dust-tight and shall be provided with dust-tight, stainless-steel inspection doors on the discharge side of the feeders. Flexible connections shall be provided between the bin cone outlets and the feeders. Feeders shall be provided with adjustable rate setters and totalizers. Each lime slaker shall be provided with a positive means of removing grit from the lime slurry prior to discharging the slurry to the tank. The grit removal system shall include classifiers or screens or both as required to remove any grit which could produce operational problems in the slurry pumps, piping, valves, or atomizers. The grit removal system shall include a means of rinsing the grit with water to minimize lime carryover to the grit disposal bin. The degritted slurry shall flow by gravity to the slurry tank. The grit shall be conveyed to a disposal bin (bin provided by the Government) located on the lower level within the lime system enclosure at a point accessible to a forklift truck. The Contractor shall provide conveyors and chutes as necessary to discharge grit to the disposal from a point not more than 1.83 meters 6 feet above the lower level floor. A slurry storage tank shall be located beneath the slakers in the lime system enclosure. The tank shall be constructed of 6 mm 1/4 inch carbon steel. The slurry tank shall be designed with a minimum storage capacity of one hour at the maximum slurry use rate. The tank shall be covered to minimize contact of the slurry with air. The tank shall be provided with heavy-duty, top-mounted turbine agitators of a quantity and design as necessary to keep the slurry particles in uniform suspension without vortex formation. Tank shall have internal baffles to promote agitation. Agitators shall be interlocked with pump controls so that pumps cannot start unless at least one agitator is on. The tank shall be provided with level monitors required for proper system operation. Level switches shall be electrode probe type. Bubbler-type level switches are not acceptable. The tank shall be provided with all necessary inlet,

outlet, and overflow connections. The bottom of the tank shall be pitched for drainage and provided with a cleanout easily accessible by maintenance personnel. The Contractor shall provide additional slurry tanks as required for his specific system design. Tanks furnished under this contract shall be shop fabricated, all-welded construction of carbon steel with a minimum shall thickness of 6 mm 1/4 inch. Structural design requirements of paragraph entitled "Structural and Miscellaneous Steel" including seismic design, are applicable to tanks furnished.

2.10 PUMPS, VALVES, MOTORS

Centrifugal pumps shall be used for applications for which unique flow and head requirements necessitate the use of positive displacement pumps. The general requirements specified in this paragraph shall be applicable to pumps furnished except as specifically noted. Positive displacement pumps furnished for use with lime slurry shall have a history of reliable operation for that application at pilot plant or commercial installations. Positive displacement slurry pumps for which shaft seals are necessary shall be provided with mechanical seals which do not require the use of seal water which could infiltrate into the slurry. Provide piping, valves, and fittings required to connect the spray dryer absorbers, lime slurry preparation system, fabric filter baghouses, pumps, and tanks complete with hangers and connection for instruments, vents, flushing, and drains as required. Provide properly sized bypasses for equipment and control valves. Instrumentation and controls shall be as specified in paragraph entitled "Instructural and Controls." Piping materials and fabrication shall conform to ASME B31.1 (Power Piping Code). Furnish alternating current high efficiency electric motors required to drive the equipment furnished under this Contract. Provide each pump assembly with the manufacturer's standard finish. Protect exposed machine surfaces with a rust-preventative compound. Cover flanged openings with plywood covers held by a minimum of four bolts. Plug or cap screwed connections with standard fittings.

2.10.1 Pumps

Furnish the pumps required or specified complete with motor drives, accessories, and field service. Provide 100 percent installed spare capacity for pumps. Provide water pumps for slaking water and cooling water supply as shown on the process flow diagram. These locate pumps at the water storage tanks to be provided by the Contractor. For purposes of the proposal, these tanks shall be assumed to be located at grade at a distance of 18.30 meters 60 feet from the piping interface point indicated. Contractor shall provide piping from these tanks to the points of application within his system. Each pump assembly shall include pump, driving motor, baseplate, drive coupling or multiple V-belt drive, and coupling guard, as applicable. Include dowelling of pumps to baseplate. Each pump shall be of a design and construction for service intended. Overhead motor mounting structure shall have provision for drive belt tension adjustment. Structure shall be such that motor and mounting are supported independently of the pump bearing assembly. Provide structure to allow for removal of pump bearing assembly without disturbing the motor. Structure shall be of fabricated steel, and shall provide support for V-belt drive guard. Drive couplings and matched multiple V-belt drive (MVD) sets shall be rated at not less than 140 percent of the motor power. Guard for matched MVD sets shall have solid metal cover on pump side and expanded metal mesh on outboard end. Flexible drive coupling guards shall comply with applicable safety requirements. Flexible coupling guards shall be arranged for ease in disassembly or removal for access to couplings.

Coupling guards shall be rigidly fastened to baseplate. Prevent any external thrust from being transmitted to the motor shaft under any operating conditions. Provide double-screw adjustment bases on nonadjustable horizontal arrangements. Suction and discharge connections shall be standard Class 150 ANSI flat-faced flanges, rubber lined, if pump is rubber lined. Furnish drawings and data as specified in paragraph entitled "Submittals." Include in submittals information for the general arrangement and outline, instrumentation, piping connection, electric motors sound pressure ratings, description of flushing system for slurry pumps, and performance curves.

2.10.1.1 Centrifugal Pumps

Pump speed shall be such that the upper limits of specific speed, as defined by the applicable figure of the HI M100 are not exceeded at any pump operating condition. Total dynamic head of pumps shall be maximum at zero flow and continuously decreasing from zero flow to design flow. Head capacity characteristics shall permit stable operation when pump is operating alone or in parallel with other pumps of the same designation. Pump shut-off head shall be more than 110 percent of design point head and less than 150 percent of design point head. Pump shaft critical speeds shall not occur from 10 percent of design point head. Pump shaft critical speeds shall not occur from 10 percent to 120 percent of design rpm. Pump shaft shall be free from excessive vibration at discharge rates from 10 percent to 120 percent of design delivery. Impeller shall not be maximum or minimum size for pump casing furnished to allow for possible future modification of head capacity furnished to allow for possible future modification of head capacity characteristic by changing impeller size. The maximum allowable sound pressure level shall be 84 dB for each pump-motor unit. Slurry pumps shall be vertically split-case, rubber-lined single-stage pumps designed for indoor service. Water pumps shall be vertically split-case single-stage pumps designed for outdoor service. Slurry pumps shall be provided with shaft seals which do not require water flushing. Provide water pumps with mechanical shaft seals which do not require an external source of seal water. Pumps shall be provided with flexible inlet and outlet connections.

2.10.1.2 Vertically Split-Case Rubber-Lined Pumps

Vertically split-case rubber-lined pumps shall be end suction, single-stage, single-suction centrifugal, of the volute type. Pump trim shall be stainless steel suitable for the service and designed for continuous operation at specified operating conditions. Pumps shall be frame mounted with pump shaft carried on its own bearings with multiple V-belt drive between pump and motor. Pumps shall have bottom horizontal discharge. Pump casing shall be split vertically into suction inlet assembly and pump assembly designed for ease of disassembly. Casing shall have replaceable secured rubber liner, minimum 10 mm 3/8 inchthick designed for long life under operating conditions specified. Pump impeller shall be enclosed type, of soft natural rubber on steel skeleton. Pump shaft shall be provided with ceramic faced shaft sleeves designed to prevent water leakage between shaft and sleeve. Sleeve shall be adequately anchored to the shaft to prevent any rotation of the sleeve relative to the shaft. Shaft shall be keyed on the driven end for easy removal of the coupling half. Shaft shall be completely encased along its entire length within the wetted area by the impeller and shaft sleeves. Provide adequate fillets for changes in diameter. Pump bearings shall consist of two bearing assemblies, ball or tapered type roller type, mounted in an oil-filled or grease-lubricated housing. Provide adequate seals to prevent leakage of

lubricant to outside and dust entry to inside of housing. Bearings shall have 60,000-hour minimum B-10 life under design conditions in accordance with ABMA 9 and ABMA 11. Design to limit maximum shaft deflection to 0.05 mm 0.002 inch. Provide with lubrication system consisting of a constant-level oiler with level indicator or easily accessible grease nipples as appropriate to the bearing design. Provide mechanical or centrifugal shaft seals conforming to paragraph entitled "Centrifugal Pumps." Furnish one spare set of shaft seals for each pump. Support frames for all vertically split pumps shall be fabricated of structural steel and heavy plate extending the full length of pump and driver. Design to adequately support equipment under operating conditions without grout fill inside the frame. Frame shall not be covered with a thin steel plate which requires grouting under the plate, but the frame may be filled with concrete as required for drainage. Grout shall be required under the basic frame only. Contractor to provide minimum 25 mm one inch pipe drain in the perimeter of the frame. Drawings shall indicate the required concrete fill lines for proper drainage. The pump shall be dowelled shall be dowelled to the frame in the shop; the driver shall be dowelled in the field. Furnish bolts or screws for attaching pumps and motor drives to the support frame. Frames shall have grouting holes, 100 mm 4 inch minimum size, to facilitate proper grouting, if area is covered. Materials of construction shall be as specified below.

Part Name	Material
Casing	Cast iron or steel, ASTM A48/A48M with replaceable rubber liners
Impeller	Soft rubber on steel skeleton
Shaft	Heat-treated carbon, or stainless steel, ASTM A276, Type 410
Shaft Sleeve	Ceramic faced
Baseplate Steel	ASTM A36/A36M

2.10.1.3 Vertically Split-Case Pumps

Vertically split case pumps shall be end suction, single-stage, single-suction centrifugal, of the volute type. Pumps shall be bronze trimmed, and designed for continuous operation at specified operating conditions. Pumps shall be frame-mounted with pump shaft carried on its own bearings with flexible coupling between pump and motor. Pump orientation to fit piping arrangement. Pump casing shall be split into suction inlet assembly and pump assembly. Design for ease of disassembly, allowing the rotating assembly and bearing housing to be removed without disconnecting pipe or moving the motor. Provide renewable casing rings locked against rotation, with one ring mounted in suction inlet assembly and the other ring mounted in pump assembly. Provide with casing vent and drain connections. Pump casing shall be back pull out design. Pump impeller shall be enclosed type, fully machines throughout. Axial balance shall be obtained by balancing ports and rear sealing rings. Casing and impeller wear rings shall be of different hardness designed for long wearing qualities. Pump shaft shall be provided with shaft sleeve designed to prevent water leakage between shaft and sleeve. Sleeve shall be anchored to the shaft to prevent any rotation of the sleeve relative to the shaft. Shaft shall be keyed on the driven end for easy removal of the coupling half. Shaft shall be completely encased along its entire length within the wetted area by the impeller and shaft sleeves. Provide adequate

fillets for changes in diameter. Design to limit the maximum shaft deflection at the stuffing box to 0.05 mm 0.002 inch. Pump bearings shall consist of two bearing assemblies, tapered-roller type, mounted in an oil-filled housing. Provide adequate seals to prevent leakage of oil to outside and dust entry to the inside. Bearings shall have 60,000 hour minimum B10 life under design head conditions. Bearing loading for thrust determination shall be at the most adverse operating condition of the pump. Provide with oil lubrication system including oil level indicator. Seals shall be single, mechanical type of the inside, balanced design. Seal face materials shall be selected to provide long life in the service intended. Factory-installed seal water piping shall be provided from pump discharge to inlet connection on seal housing as required to cool and lubricate the seal faces. Seal water loop shall include a valve or orifice to control flow. Provide a spare seal for each pump. Support frames for vertically split pumps shall be fabricated of structural steel and heavy plate extending the length of pump and driver, rigid enough to maintain alignment of machinery, and designed to adequately support equipment under all operating conditions without grout fill inside of the frame. Frame shall not be covered with a thin steel plate which requires grouting under the plate, but the frame may be filled with concrete as required for drainage. Grout shall be required under the basic frame only. Contractor to provide one inch minimum drain in the perimeter of the frame. Drawings shall indicate the required concrete fill lines for drainage. The pump shall be dowelled to the frame in the shop, the driver will be dowelled in the field by others. Furnish bolts or screws for attaching pumps and motor drives to the support frame. Frames shall have grouting holes, 100 mm 4 inch minimum size, to facilitate proper grouting. Materials of construction shall be as specified.

Part Name	Material
Casing	Cast iron or steel, ASTM A48/A48M with replaceable rubber liners
Impeller	Bronze, ASTM B584
Shaft	Heat-treated carbon, or stainless steel, ASTM A276, Type 410
Shaft Sleeve	11-13 percent chrome steel, 450 minimum Brinell hardness, ASTM A743/A743M
Casing rings	Bronze, ASTM B103/B103M
Impeller rings	Bronze, ASTM B103/B103M
Baseplate Steel	ASTM A36/A36M

2.10.1.4 Vertical Wet Pit Pumps

Vertical wet pit pumps shall be end suction, single-stage, single-suction centrifugal of the volute type. Pump trim shall be 316L stainless steel designed for continuous operation at specified operating conditions. Pumps shall be frame mounted with pump shaft carried on its own bearings with multiple V-belt drive between pump and motor. Provide suitable connections on the frame for lifting and lowering of the pump. Pump casing, pipe shaft column, discharge piping, and submerged materials, shall be rubber-coated a minimum of 6 mm 1/4 inch thick. Pump casing shall be split perpendicular to shaft. Provide renewable impeller wear rings locked against rotation.

Casing shall have replaceable rubber liner, minimum 10 mm 3/8 inch thick designed for long life under operating conditions specified. Casing shall be rubber covered. Pump impeller shall be enclosed type of soft natural rubber on steel skeleton. Pump shaft shall be provided with hardened (minimum 450 BHN) stainless-steel shaft sleeves designed to prevent water leakage between shaft and sleeve. Sleeve shall be adequately anchored to the shaft to prevent any rotation of the sleeve relative to the shaft. Shaft shall be keyed on the driven end for easy removal of the coupling half. Shaft shall be completely encased along its entire length by the impeller and shaft sleeves. Shaft shall have fillets for changes in diameter. Shaft shall be designed to carry torsional and axial thrust loads. Shaft shall be one-piece construction. Shaft support column shall be rubber covered. Upper bearing assembly shall be ball or tapered-roller type, mounted in an oil-filled or grease-filled housing. Include adequate seals to prevent leakage of lubricant to outside and dust entry to the inside. Bearings shall have 60,000-hour minimum B10 life under design head conditions. Provide with adequate lubrication system. Provide with dust and oiltight seals. Pump shall have no submerged bearings. Provide shaft seals as specified in paragraph entitled "Vertically Split-Case Rubber-Lined Pumps." Pump baseplate shall be of fabricated steel, of adequate size and thickness to prevent excessive vibration and deflection. Provide holes for mounting of the pump and necessary piping as required. Baseplate shall be rubber-coated on the bottom side. Provide with shims, bolts, and other devices required for proper alignment and anchorage. Anchor bolts required in foundation will be furnished by the Contractor. Materials of construction shall be as specified below.

Part Name	Material
Casing	Cast iron or steel, ASTM A48/A48M rubber covered with replaceable rubber liner
Impeller	Soft rubber on steel skeleton
Shaft	Heat-treated carbon, or stainless steel, ASTM A276, Type 410
Shaft Sleeve	Stainless Steel, 450 minimum Brinell hardness, or ceramic
Baseplate Steel	ASTM A36/A36M

2.10.1.5 Factory Test and Reports

Pumps shall be tested for static and dynamic balance of rotating assemblies, for normal functioning in conformance with the "Standards of the Hydraulic Institute," and for performance at design conditions. The pump casing shall be hydrostatically tested at 150 percent of shutoff head. After completion of shop tests, install new gaskets and tighten all bolts so that pumps are ready for operation and so that no field disassembly, cleaning, or flushing is required. Notify the Contracting Officer at least 30 days in advance of tests so that a representative can be present.

2.10.2 Valves and Piping

Piping, valves, and pumps in slurry service shall include provisions for automatic and manual flushing, complete drainage and cleanout. Pipe drains shall drain back into a tank. Control and isolating valves and controls

required for flushing operations shall be furnished. Furnish parallel piping systems to allow for flushing of one pipeline system with continued operation of the FGD system using the other. A description of provisions for flushing the piping systems shall be included as part of the system description. Slurry piping shall utilize flanged joints and long-radius (600 mm 24 inch minimum) bends. Piping shall be designed for the maximum operating and start-up pressure and temperature requirements of the service. Vent and bypass lines or other lines in intermittent service shall be sized for the available pressure drop. Bypass (recirculation) lines with control valves sized for the available pressure drop shall be provided on systems with varying demands as required to protect the pump. Piping for emergency service only shall be sized as required by the applicable code or based upon the available pressure drop. Piping systems shall be arranged to prevent plugging and settling out in lines and valves. Pipe hangers shall be corrosion-resistant as specified herein. Forces placed on equipment by piping shall not exceed the manufacturer's allowable levels. Piping materials and systems shall be compatible with the fluids handled. Fluid systems shall be designed so that circulation is has a low sound level and there is no water hammer and so that vibration from equipment is not transmitted through the piping systems. The fluid systems shall be designed and constructed to produce less than 85 dBA sound level, free field, at one meter 3 feet distance from any part of the system in accordance with ASA S12.54. Velocities maintained in slurry systems shall be not less than 1.22 meters 4 feet per second nor more than 3.35 meters 11 feet per second under all conditions in line including low and high flow. Piping systems shall have high-point vents and low-point drains. Valves shall be located no higher than 1 1/2 meters 5 feet above maintenance platforms and a minimum of 2.13 m 7 foot headroom shall be maintained over walkways. Provide expansion devices and appurtenances to allow for expansion of the piping system. Piping shall be arranged and routed to be readily accessible for maintenance. Field connections shall be located to allow access for disconnection as required for maintenance. On-off control valves shall be provided in the suction and discharge piping of pumps.

2.10.2.1 Valves

Air and water valves shall be as follows: Valves 50 mm 2 inchesand smaller shall be Class 200 bronze gate, globe or angle valves conforming to ASTM B61, valves larger than 50 mm 2 inchesshall be Class 125 cast-iron gate, globe, or angle valves conforming to ASTM A126. Slurry valves shall be Class 150 polyfluorotetraethylene (PTFE) sleeve plug valves, rubber-lined diaphragm valves with a minimum rating of Class 150, Class 150 semisteel rubber-lined eccentric plug valves, Class 150 knife gate valves or rubber sleeve pinch valves. Pinch valves or rubber-lined diaphragm valves shall be used to modulate slurry flow. The pinch valve elastomers shall be neoprene reinforced with polyester. Elastomer sleeve diameter-to-length ratio shall be 1.3 minimum. Pinch valve closure mechanism shall close the valve from opposite sides of the sleeve simultaneously, with complete valve closure at the centerline of the pipe, and shall be provided with positive opening feature. Valves shall be provided with lever or handwheel operators with adjustable position stop. As used in this specification, the term "control valve" refers to an assembly, consisting of a valve body and an actuator, which is used for on-off or modulating opening and closing of the valve, regulating fluid flow, or pressure in response to signal(s) from a control system. Control valve bodies shall be as specified. Provide control valves as required to enable the FGD system to be operated from the steam plant control room. Control valves shall have indicators showing position of valve. Control valves shall have manual override to ensure immediate local control. Manual override shall override coil without damage to

coil. Control valves shall be provided with isolating valves as necessary to allow for maintenance. Actuators shall be spring-and-cylinder double-acting cylinder or spring-and-diaphragm type actuators and shall have long-stroke design or special linkages, adapters as required for rotary-type valves. Actuators shall be sized as required for stable operation under maximum pressure drop conditions with 414 kPa (gage) 60 psig maximum air supply pressure available to actuator. Stable operation is defined as the ability of the actuator to position and hold the valve plug, elastomer sleeve or diaphragm accurately without pulsation, vibration, or sticking. Actuators shall be provided with stem travel indicator on yoke. Solenoid valves shall conform to the requirements as specified in paragraph entitled "Solenoid Valves." Provide with each open-closed control valve a limit switch assembly consisting of two DPDT switches, one to actuate in the open position and one to actuate in the closed position. Provide each modulating control valve with a position transmitter. Limit switches shall conform to the requirements of paragraph entitled "Limit Switches." Limit switches shall be furnished factory mounted to their respective control valves. Control valves shall be furnished with manual overrides on solenoid valves for local manual operation of the control valve.

2.10.2.2 Piping

Pipe furnished shall conform to the ASTM material specification specified and meet the dimension standards set forth in ASME B36.10M. Piping furnished shall be provided with the manufacturer's standard exterior surface preparation and coating as necessary to prevent rusting during shipping and storage. Random length pipe shipped to the jobsite shall be identified continuously along its length indicating schedule number and material. If this identification is in the form of a color code or colored stripe, copies of the color code shall be submitted for approval. Each piece of pipe shall be identifiable as to grade and schedule after erection. Water pipe shall be carbon steel, conforming to ASTM A53/A53M, Grade A or B. Pipe sizes 50 mm 2 inches and smaller shall be Schedule 80. Pipe sizes larger than 50 mm 2 inches shall be standard weight. Lime slurry piping shall be Schedule 80 carbon steel, ASTM A53/A53M, Revision B. Rubber hose or rubber-lined pipe may be used for lime slurry where approved by the Contracting Officer. Rubber hose and rubber-lined pipe shall be provided complete with flanges. Except for tubing as specified, air pipe shall be carbon steel, conforming to ASTM A53/A53M, Grade A or B. Pipe 50 mm 2 inches and smaller shall be Schedule 80. Pipe larger than 50 mm 2 inches shall be standard weight. Instrumentation and air tubing shall be seamless, fully annealed and suitable for bending. Steel tubing shall be 316 stainless steel conforming to ASTM A269, Grade TP 316. Copper tubing shall conform to ASTM B75M ASTM B75. Minimum wall thickness of tubing shall be as follows:

****
NOTE: Wall thickness selection depends on fluid, media, and pressure.
****

Material	Diameter (mm)	Wall Thickness (mm)	Fluid
Steel	6	0.889	
	10	1.245	
	15	1.651	
	16	2.108	
Copper	6	0.711	
	10	0.889	
	15	1.245	

Material	Diameter (inch)	Wall Thickness (inch)	Fluid
Steel	1/4	0.035	
	3/8	0.049	
	1/2	0.065	
	5/8	0.083	
Copper	1/4	0.028	
	3/8	0.035	
	1/2	0.049	

2.10.2.3 Fittings

Screwed fittings shall be Class 300 malleable iron conforming to ASME B16.3. Fittings shall be galvanized when used with galvanized pipe. Flanges shall conform to ASME B16.5. Steel pipe flanges shall be forged steel. Flanged fittings shall be cast steel. Steel flanges and fittings shall be of the same material and schedule as the pipe to which they connect. Flanges shall be provided with carbon steel bolts and nuts conforming to ASTM A307, Grade B. Bolts and nuts shall have hexagonal heads. Gaskets shall be heavy-duty Buna-N 1.59 mm 1/16 inch thick, full-faced, punched for bolts and pipe opening as required. Fittings shall conform to ASME B16.9 except that cast fittings are not acceptable. Butt-welded fittings shall be of the same material and schedule as the pipe to which they connect. Fittings shall be clean and free of all oxides, slag, and other impurities or foreign matter. Backing rings shall be split-ring type with knock-off spacer nubs.

2.10.2.4 Pipe Hangers

Pipe hanger assemblies, anchors and sway braces shall be designed by the hanger manufacturer and the Contractor in accordance with ASME B31.1, MSS SP-58, MSS SP-69 and as follows: (a) Make weight and moment balance calculations to determine the required supporting force on each hanger and

the reaction on equipment, (b) design supports so that the spacing does not exceed that given in Table 121.1.4, ASME B31.1 Power Piping Code, except in the center spans of straight runs where the spacing may be increased 20 percent, (c) design the first rigid hanger in a system so that the restraining action of the hanger produces a bending stress no greater than 1/4th of the allowable stress listed in Appendix A of the Power Piping Code, (d) design supports at concentrated load so as to prevent excessive bending moments in system, (e) design for Seismic Zone [_____] in accordance with Section 22 05 48.00 20 MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL, (f) design supports and hanger such that the resultant reactions imposed on the equipment connections due to the weight of the piping system does not exceed a resultant force of plus or minus 45.4 kg 100 lbs or a resultant moment of plus or minus 671 meters per kg 1,000 feet per pound, and (f) provide spring supports in accordance with the following:

Maximum Vertical Movement	MSS SP-69 Type
6.35 mm	51SS, 52SS, 53SS
12.70 mm	51S, 52S, 53S
25.40 mm	51LS, 52LS, 53LS
Over 25.40 mm	54, 55, 56

Maximum Vertical Movement	MSS SP-69 Type
1/4 inch	51SS, 52SS, 53SS
1/2 inch	51S, 52S, 53S
1 inch	51LS, 52LS, 53LS
Over 1 inch	54, 55, 56

Hanger assemblies shall use the following materials in construction:

a. Hanger rods shall be hot-rolled carbon steel cut to length and threaded in the factory. (Continuous threaded rods are not acceptable).

b. Pipe clamps shall be carbon steel.

c. Clevises, turnbuckles, and eye nuts shall be forged steel.

d. Eye rods shall be welded type.

e. Protection saddles shall be carbon steel.

f. Hanger rod components located outdoors shall be galvanized with the exception of lugs and clips welded directly to pipes or structural members.

Pipe hanger assemblies, anchors, and sway braces shall utilize only acceptable type of components as outline in MSS SP-58 and MSS SP-69. Upper supports shall utilize types 22, 28, 29, and 33. Intermediate supports shall utilize types 13, 14, 16, 17, 51, 52, 53, 54, 55, and 56. Lower

supports shall utilize types 2, 3, 4, 8, 24, 33, 35, 36, 37, 38, 39A, 39B, 40, 41, 44, 45, 46, 47, and steel plate lugs shop welded to the pipe.

2.10.2.5 Shipping and Handling

Materials for piping systems shall be prepared and marked for shipment and storage as specified. Each piece of piping fabrication shall be identified with a piece mark number which is repeated on each end of section and on each branch. Ship gaskets to the jobsite tagged with size, material, and pressure rating. Loose parts such as nuts, bolts, and gaskets shall be packaged for outdoor storage. Protect flanges with plywood or tempered hard fiberboard covers sealed and bolted to the flange with not less than four bolts. Protect threaded connections with thread protectors. Protect small connections with plastic inserts pressed into the connection and sealed with waterproof tape. Ship hangers to the jobsite with each hanger assembly individually bundled and tagged with the hanger assembly number. Coat-threaded connections with a suitable rust-preventative compound. Ship valves to the jobsite tagged with the appropriate valve number corresponding to the valve list. Ship valves with suitable covers to prevent entrance of foreign material into valve body. Protect valve threads, stems, and handwheels from damage.

2.10.3 Electric Motor Drives and Motor Control Center

Alternating current electric motors required to drive the equipment shall be continuous-duty type suitable for a steam plant environment where moderately abrasive conductive dusts and high humidity are present. Motors shall be self-ventilated. Motors shall be designed for full-voltage starting. Indoor motors shall be suitable for continuous operation at an ambient temperature of 50 degrees C 122 degrees F. Outdoor motors shall be suitable for continuous operation at any ambient temperature from minus 10 degrees C to plus 40 degrees C 14 degrees F to 104 degrees F. Motors shall have squirrel-cage rotors. The nameplate power rating of each motor at 1.0 service factor shall equal or exceed the power required to drive the connected equipment under the design conditions specified and within normal operating ranges. For each motor furnished, the nameplate power rating multiplied by the service factor shall equal or exceed the power required to drive the connected equipment under any operating condition. Motors shall be of high efficiency type.

2.10.3.1 Motors Rated 3/8 kW 1/2 Horsepower and Smaller

Motors shall be rated at 115 volts, single-phase, 60 hertz, and have a service factor of 1.0. The torque characteristics of each motor at voltages from 90 to 110 percent rated voltage shall be as required to accelerate the motor and driven equipment to full speed without damage to the motor or the driven equipment. Insulation shall be Class B or Class F, with Class B temperature rise in accordance with NEMA MG 1. Enclosures shall be fabricated of steel. Horizontal motors shall be mounted on a common baseplate with the driven equipment. Manual reset thermal overload protection shall be furnished integral to each motor. Enclosures shall be totally enclosed nonventilated.

2.10.3.2 Motors Rated 1/2 Through 149 kW 3/4 Through 199 H.P.

****

NOTE: The efficiency of each motor shall not be less than that indicated in the following table:

Efficiency						
Nameplate	3600 rpm		1800 rpm		1200 rpm	
Kilowatt	Nominal	Minimum	Nominal	Minimum	Nominal	Minimum
0.746	81.5	78.5	84.0	81.5	78.5	75.5
1.21	81.5	78.5	84.0	81.5	84.0	81.5
1.49	84.0	81.5	84.0	81.5	86.5	84.0
2.24	86.5	84.0	88.5	86.5	88.5	86.5
3.73	88.5	86.5	90.2	88.5	88.5	86.5
5.60	88.5	86.5	90.2	88.5	88.5	86.5
7.46	88.5	86.5	90.2	88.5	90.2	88.5
11.19	90.2	88.5	91.7	90.2	90.2	88.5
14.92	91.7	90.2	91.7	90.2	91.7	90.2
18.65	91.7	90.2	93.0	91.7	91.7	90.2
22.38	91.7	90.2	93.0	91.7	91.7	90.2
29.84	91.7	90.2	93.0	91.7	93.0	91.7
37.30	91.7	90.2	94.1	93.0	93.0	91.7
44.76	93.0	91.7	94.1	93.0	93.0	91.7
55.95	94.1	93.0	94.1	93.0	94.1	93.0
74.60	94.1	93.0	95.0	94.1	94.1	93.0
93.25	94.1	93.0	95.0	94.1	94.1	93.0
111.90	94.1	93.0	95.0	94.1	95.0	94.1

Efficiency						
Nameplate	3600 rpm		1800 rpm		1200 rpm	
Horsepower	Nominal	Minimum	Nominal	Minimum	Nominal	Minimum
1	81.5	78.5	84.0	81.5	78.5	75.5
1.5	81.5	78.5	84.0	81.5	84.0	81.5
2	84.0	81.5	84.0	81.5	86.5	84.0

Efficiency						
Nameplate	3600 rpm		1800 rpm		1200 rpm	
3	86.5	84.0	88.5	86.5	88.5	86.5
5	88.5	86.5	90.2	88.5	88.5	86.5
7.5	88.5	86.5	90.2	88.5	88.5	86.5
10	88.5	86.5	90.2	88.5	90.2	88.5
15	90.2	88.5	91.7	90.2	90.2	88.5
20	91.7	90.2	91.7	90.2	91.7	90.2
25	91.7	90.2	93.0	91.7	91.7	90.2
30	91.7	90.2	93.0	91.7	91.7	90.2
40	91.7	90.2	93.0	91.7	93.0	91.7
50	91.7	90.2	94.1	93.0	93.0	91.7
60	93.0	91.7	94.1	93.0	93.0	91.7
75	94.1	93.0	94.1	93.0	94.1	93.0
100	94.1	93.0	95.0	94.1	94.1	93.0
125	94.1	93.0	95.0	94.1	94.1	93.0
150	94.1	93.0	95.0	94.1	95.0	94.1

****

Motors shall be rated at 460 volts, 3 phase, 60 hertz, and have service factor of 1.15 for open dripproof enclosures, and a service factor of 1.0 for all other enclosure types. Enclosures shall be fabricated of cast iron or aluminum. Enclosures for indoor service other than in the lime slurry preparation area shall be open dripproof, fully guarded. Enclosures for the lime slurry preparation area, and for outdoor service shall be totally enclosed nonventilated or totally enclosed fan cooled. Bearings shall be antifriction type, and shall have an ABMA-L10 rating life of not less than 80,000 hours at rated speed, and under the thrust loadings encountered within normal operating ranges. The thrust loading corresponding to an ABMA-L10 rating life of 5,000 hours at rated speed shall not be exceeded under any operating condition of the motor or the driven equipment. Bearings shall be insulated when required to prevent bearing or shaft damage due to stray shaft currents. Each horizontal motor shall be mounted on a common baseplate with the driven equipment, or shall be furnished with separate sole plates and subsole plates to permit removal of the motor without disturbing the alignment of the driven equipment. Furnish space heaters for motors rated 19 kW 25 horsepower and above. Space heaters shall be rated 120 volts, single-phase, 60 hertz. The torque characteristics of each motor at voltages from 90 to 110 percent rated

voltage shall be as required to accelerate the motor and driven equipment to full speed without damage to the motor or the driven equipment. Insulation shall be Class B or Class F, with Class B temperature rise in accordance with NEMA MG 1. The motor "A" weighted sound level shall not exceed 84 dBA when measured to conform to IEEE 85 at a reference distance of one meter. Motors shall be of special high-efficiency and high-power factor design including the following design features: Low-loss lamination steel, increased stator and rotor length, increased winding cross section, high-efficiency cooling fan design, and optimized slot configuration and air gap. Information submitted with the compliance submittals shall include minimum guaranteed efficiency based on tests performed in accordance with IEEE 112, Method B, with accuracy improvement by segregated loss determination including stray load loss measurement. Information submitted shall include percent efficiency and percent power factor at full load, 3/4 load, and 1/2 load. Provide motor bearing thermocouples and motor winding resistance temperature detectors (RTDs) for motors 15 kW 20 horsepower and larger. Thermocouples and RTD's shall be as specified in paragraph entitled "Temperature Monitor."

2.10.3.3 Motors Rated 150 Kilowatt 200 Horsepower and Larger

Motors shall be rated 4,000 volts, 3-phase, 60 hertz, have a service factor of 1.0 and conform to ANSI C50.41. The torque characteristics of each motor at voltages from 85 to 110 percent rated voltage shall be as required to accelerate the motor and driven equipment to full speed without damage to the motor or the driven equipment. Insulation shall be Class B or Class F, with Class B temperature rise in accordance with ANSI C50.41. Insulation systems shall be mica based. Each motor shall be furnished with not less than two resistance temperature detectors per phase, embedded in the stator windings. Detectors shall be rated 10 ohms at 25 degrees C as specified in paragraph entitled "Temperature Monitor." The acceleration times for each motor at voltages within the starting voltage specified, when connected to the driven equipment, shall not exceed the allowable locked-rotor times at those voltages. In addition to the starting capabilities specified in ANSI C50.41, following one start with the motor initially at a temperature equal to the rated-load operating temperature, each motor shall be capable of making additional starts with a cooling period at standstill between starts not greater than 45 minutes. Enclosures shall be fabricated of cast iron or steel, and shall be furnished with corrosion-resistant hardware. Enclosures shall be weather-protected NEMA Type II. Horizontal motors shall be furnished with sleeve type bearings. Bearings, bearing brackets, and end shields shall be split type when available for the frame size and enclosure furnished. For motors, furnish oil rings; oil reservoirs; sight glasses located to be readily observable, and marked with the proper oil level when running and at standstill; and drain and fill piping to a location where each bearing and reservoir can be flushed, drained, and refilled. At least one bearing shall be insulated when required to prevent bearing or shaft damage due to stray shaft currents. Each horizontal motor shall be mounted on a common baseplate with the driven equipment, or shall be furnished with separate sole plates and subsole plates to permit removal of the motor without disturbing the alignment of the driven equipment. Thermostatically controlled heaters shall be furnished in each bearing oil reservoir of outdoor motors. Heaters rated 1,200 watts and less shall be rated 120 volts, single phase; heaters rated above 1,200 watts shall be rated 240 volts, single phase. One thermocouple type temperature detector shall be furnished for each sliding type bearing as specified in paragraph entitled "Slide Bearings." A vibration transducer mounting pad shall be furnished on the output shaft bearing housing of each motor connected to equipment specified with a bearing vibration system. Space heaters shall

be furnished on each motor. Space heaters rated 1,200 watts and less shall be rated 120 volts, single phase; space heaters rated above 1,200 watts shall be rated 240 volts, single phase. Each motor power lead terminal box shall be Type II as defined in ANSI C50.41. Each box shall be sized to enclose connections to synthetic-insulated shielded power cables including preformed stress cones. Removable molded insulating boots shall be furnished for factory and field connections in each box. Accessory leads including temperature detector leads, space heater leads, and current transformer secondary leads shall be wired to the accessory terminal box. The motor "A" weighted sound level shall not exceed 84 dBA when measured to conform to IEEE 85 at a reference distance of one meter.

2.10.3.4 Motor Control Centers

Contractor shall furnish motor control centers with starters and controls for 3 phase motors rated less than 150 kW 200 hp. Separate motor control centers shall be provided for each of the spray dry absorber-fabric filter baghouse units and the lime slurry preparation system. The lime system motor control center shall be located within the system enclosure. Motor control centers shall be totally enclosed dead-front type suitable for use on 480-volt, 3-phase, 4-wire, 60-hertz system. Motor control centers shall conform to NEMA ICS 6 and UL 845. Motor control centers shall consist of individual vertical self-supporting sections, nominally 508 mm wide, 508 mm deep, 2286 mm high 20 inches wide, 20 inches deep, and 90 inches high, bolted together on floor sills. Sections shall be divided into compartments for control equipment and arranged for future additions at the ends. Structures shall be rigid and sufficiently braced to prevent movement of control centers when inserting or withdrawing removable units. Compartment doors shall be hinged full length and equipped with quick captive screws and neoprene gasket on each compartment door. Guide rails shall be provided for alignment of plug-in units. Plug-in units and doors shall be accurately constructed and aligned to prevent binding. Control centers shall be arranged for front mounting of equipment and control units shall be plug-in type with wiring accessible from the front. Plug-in units shall be draw-out or tilt-out type with provisions for padlocking in the disconnected position. Disconnecting stabs shall be pressure type of silverplated high-strength copper alloy. Control center disconnecting devices shall be provided with external operating handles arranged for padlocking in the "off" position and the compartment doors shall be interlocked to permit opening only when the disconnect device is in the "off" position. Control center enclosure shall be NEMA 1 and wiring shall be NEMA Class II, Type B. Control center main horizontal buses shall be rated as required for the connected loads, but not less than 600 amperes, and vertical buses for each section shall be rated as required for connected load, but not less than 300 amperes, both at a continuous rating at 50 degrees C 122 degrees F rise. Buses shall withstand stresses of short-circuit currents of 42,000 amperes rms. A ground bus shall be provided at the bottom for the full length of the motor control centers. Furnish each vertical section with continuously energized space heaters as required to prevent condensation during construction. Space heaters shall be applied at one-half rated voltage. Space heaters in a shipping section shall be wired together and connected to a terminal block that is accessible before the motor control center is uncrated. Control center motor starters shall be circuit-breaker combination type and shall be rated at 460 volts, 3-phase, and shall be the NEMA size classifications required for motors furnished. Motor starter shall be magnetic, across-the-line, single speed, two speed or reversing as required. Each starter shall be provided with a control transformer rated 480/120 volts having a volt-ampere capacity to suit the control load including control devices,

but not less than 100 VA. A fuse shall be provided in the 120-volt control circuit for each starter. Control connections shall be as required. Each starter shall be equipped with three thermal overload relays. Short-circuit rating of combination starter shall be 42,000 amperes rms symmetrical. Starters shall be wired to the terminal block for a remote auxiliary contact to be provided by the Contractor. The auxiliary contact will be wired in series with the stop push button, selector switch or control device to open the control circuit to the starter contractor when the auxiliary contact is opened. Each motor control center shall be equipped with two NEMA Size 1, two NEMA Size 2, and one NEMA Size C complete, spare, full-voltage, nonreversing motor starters. Control center circuit breakers shall be rated 600 volts ac, manually operated, trip free from the handle, and with a molded case. Breakers shall be 3 pole unless otherwise specified. Breakers used in combination motor starters shall be adjustable instantaneous only, coordinated to provide short-circuit protection for both the motor circuit and the thermal overload relays in the magnetic starter. Breakers shall contain inverse-time thermal overload protection and instantaneous magnetic short-circuit protection. Combination motor starter circuit breakers shall have a symmetrical interrupting capacity at 480 volts not less than the motor control center short-circuit ratings. If current-limiting fuses are used to achieve the specified short-circuit rating, a positive acting anti-single-phase trip mechanism must be furnished. Each motor control center shall be equipped with two 100 A, 3-pole, and one 225A, 3-pole, spare feeder circuit breakers. Include external handle which clearly indicates when breaker is "on," "off," or "tripped." Handle shall be lockable in the "off" position. Control centers shall be ambient compensated to 50 degrees C 122 degrees F. Control centers that utilize frame sizes 225 ampere and larger shall be furnished with interchangeable trip units. Circuit breakers shall conform to NEMA AB 1 and shall meet the appropriate classification of FS W-C-375.

2.10.3.5 Factory Tests

<TESTPerform factory tests on each motor rated 460 volts and below in conformance with NEMA MG 1, and IEEE 112 or IEEE 114. Tests shall include:

a. No-load current and speed tests at normal voltage and frequency,

b. high potential test, and

c. standard factory tests.

Perform factory tests on each motor rated above 460 volts in accordance with ANSI C50.41 and IEEE 112. Tests shall include:

a. Measurement of winding resistance,

b. no-load test with readings of current, power, and nominal speed at rated voltage and frequency,

c. mechanical vibration test,

d. direction of rotation versus phase sequence test,

e. insulation resistance test, and

f. high-potential test.

2.11 DUCTWORK AND DRAFT EQUIPMENT

Provide self cleaning ductwork for the Flue Gas Cleaning System from the economizer outlet to the stack inlet as indicated, including fabric filter baghouse reverse gas ducts, if required, complete with necessary expansion joints, transitions, structural slide bearings, dampers, turning vanes, and support steel. Provide 100 mm 4 inch pipe coupling test ports upstream and downstream of each spray dryer absorber and upstream of each guillotine system isolation damper. Test ports in horizontal ductwork shall be located in the side of the ductwork and test ports shall be of sufficient length to extend 102 mm 4 inches beyond the insulation and lagging to be provided by the Contractor. Test ports shall be Schedule 40 316 stainless steel, pipe conforming to ASTM A167 with screw plugs. Coat each plug with antiseize lubricant suitable for service at the design temperature extremes. Exact locations and number and arrangement of ports at each location shall be determined by the Contractor following the model test. Except for the ductwork between the spray dryer absorber and the fabric filter baghouse, duct runs in which the Contractor intends to locate test ports shall be arranged to conform to at least the minimum requirements of U.S. EPA Regulation 40 CFR 60, Method 1, relative to the spacing between test port locations and flow disturbances in the upstream and downstream directions. Final location and arrangement is subject to approval of the Contracting Officer. Structural design temperature range for ductwork shall be [_____] to [_____] degrees C degrees F. Long ductwork sections shall contain hoppers, clean-out doors, and structural support due to dust drop out. Ductwork and support steel shall be designed such that no loads will be applied to the ductwork provided by the Contractor at the interface points. The expansion joints, bolts, nuts, backing bars and gasketing at interface connections shall be by the Contractor. Carbon steel ductwork, support steel, access ways and access doors shall be designed as specified and as noted on the drawings. External and internal walls and partitions of the ductwork shall be of fully sealed by continuous fillet or continuous complete penetration groove welds, as applicable. Provide control instruments and required penetrations as specified in paragraph entitled "Instrumentation and Controls." Expansion joints shall be provided at interface points of ductwork included in this contract and as required to ensure that no stresses in ductwork and supports are transmitted to equipment to be provided by the Contractor. Contracting Officer will supply exact location, sizing and bolt hole patterns for connections at the economizer outlet ductwork and chimney inlet. Furnish and deliver dampers as indicated and as required for operation of FGD system including, but not limited to, fabric filter baghouse module inlet and outlet dampers, fabric filter baghouse bypass isolation dampers, induced draft fan inlet control dampers, and guillotine system isolation system dampers. Furnish damper units complete with operators and accessories and field service, as specified. Dampers and louvers shall conform to AMCA 500-D, AMCA 801, and AMCA 802. Provide mechanical draft equipment required for proper operation of the flue gas cleaning systems and boilers including, but not limited to, induced draft fans. Fans shall be complete with accessories and auxiliaries specified. Provide fan inlet dampers as specified in paragraph entitled "Dampers." Ductwork submittals shall include general arrangement and outline information, foundation design information, structural fabrication information, internal arrangement and erection information, insulation and instrumentation information, and design calculations for stiffener requirements for internal pressure ratings. Drawings shall show details of ductwork connections, and layout and details as required for access platforms, ladders, and handrails, details of each expansion joint, details of slide bearing plates, and the expansion joint locations, the movements to be absorbed in each joint, construction details and

flange-to-flange dimensions.

2.11.1 Ductwork

****
NOTE: Dimension interface of ductwork and the chimney to reduce pressure drop. Use maximum dimensions.
****

Ductwork shall be constructed with a minimum thickness of 6 mm 1/4 inch. Ductwork shall be designed for a transient condition (80 percent of yield strength) at internal pressure of at least plus 4980 and minus 7470 Pa 20 and minus 30 inches WC except as specified otherwise. Joints and seams shall be welded gas-tight by continuous fillet or continuous complete penetration groove welds. Provide with access doors, as specified, to provide access to each run of duct including both sides of dampers and gas distribution devices. Ductwork shall be designed to withstand a fallout particulate weight of 976 kg/square meter 200 lbs/square feet. Provide 10 mm 3/8 inch thick-turning vanes for turns 45 degrees and greater and where indicated by the model study. Properly brace and support with pipes and angles. Bracing with rods is not permitted. Turning vanes are not required in fabric filter baghouse manifold inlet and outlet transitions to and from modules. Gas velocity of the main flue gas stream shall be as specified in paragraph entitled "Ductwork." Provide gasket material bolts and nuts for flanged connections. Gaskets shall be of ethylene propylene terpolymer (EPDM) material. Provide flanges and expansion joints at ends of scope to match equipment to be provided by the Contractor. Bolt hole tolerance in flanges to be connected at interface points and to dampers shall be 3/4 mm 1/32 inch between adjacent holes and 1 1/2 mm 1/16 inch between any two holes on a side in the flange pattern after fabrications of the complete ductwork section. After fabrication of the ductwork section, measurement shall be made between holes across diagonals and bracing shall be installed to maintain flange bolt tolerance. Provide connections for temperature and pressure measurements as specified and as required of the control of the FGD system. Instrument connections shall be 50 mm 2 inch Schedule 40 pipe with screw caps and shall extend 150 mm 6 inches beyond the insulation and lagging on the ductwork. Instrument connections shall be provided with rod-out caps or plugs. Maximum plan width inside dimension of the breeching at interface with the chimney shall be [_____].

2.11.1.1 Reverse Air Ductwork

Reverse air ductwork shall be constructed of sheet steel and all seams and connections shall be airtight. Means shall be provided to maintain the temperature in the reverse air ductwork above the dewpoint by circulation of clean flue gas.

2.11.2 Expansion Joints

****
NOTE: Dry and Wet Bulb Temperature and Duration:

Parameter	Season	Temperature (Degrees C)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

Parameter	Season	Temperature (Degrees F)	Frequency of Occurrence of Higher Temperatures
Dry Bulb	Dec-Feb	[_____]	[_____]
Dry Bulb and Mean Coincident Wet Bulb	Jun-Sep	[_____]	[_____]
Wet Bulb	Jun-Sep	[_____]	[_____]

****

Expansion joints shall be nonmetallic belt-type joints. Expansion joints shall be suitable for maximum expected or specified working pressures and for operation at design gas-flow velocities. Expansion joints shall include baffles able to withstand a fallout ash weight of 976 kg/sq m 200 lbs/sq ft and remain completely workable. Expansion joints shall be designed for temperature from [_____] to [_____] degrees C degrees F. Provide access to four sides of expansion joints, both interior and exterior to the ductwork. Each expansion joint shall include: minimum 80 by 80 by 6 mm 3 by 3 by 1/4 inch carbon steel angle flanges drilled for mounting to ductwork for joints where belt does not have molded flanges, a carbon steel backing bar, and internal baffle around full circumference of expansion joint; minimum of 3 mm 1/8 inch thick to prevent fly ash erosion and buildup in web of joint and not restrict the movement of the joint, and nuts and bolts required to attach the fabric to the flanges and the expansion joints to the ductwork. Bolt holes on maximum of 100 mm 4 inch centers. Belt materials shall be minimum 6 mm 1/4 inch thick, two-ply, aramid-or fiberglass-reinforced, solid fluoroelastomer polymer specially compounded for the intended service. Material shall be factory spliced to form endless belt without sewn joints. Bolt holes shall be factory punched.

2.11.3 Dampers

Dampers shall be designed for a Zone [_____] seismic risk area and a wind loading and additional loads as specified. The dampers shall be designed to be operated without manual assistance under temperatures and pressures specified and with normal accumulations of flue products. Dampers shall have provision for periodic lubrication with appropriate grease, if not permanently lubricated and sealed. Dampers shall be supplied with limit switches which shall give positive indication of the damper position (open/close). Dampers except guillotine dampers shall have pneumatic operators. Guillotine dampers shall be provided with the manufacturer's

standard motor operators as required for the service intended. Dampers shall fail in failsafe position upon loss of power or air. Fabric filter baghouse bypass dampers shall be a double tight seal damper to provide for essentially zero leakage at maximum fabric filter baghouse design differential pressure. Bypass dampers shall be provided with an air reservoir of sufficient capacity as to activate damper upon loss of plant air. Inlet and outlet dampers shall be a minimum of 99 percent gas tight. Fabric filter baghouse module inlet and outlet damper operators shall be located outside of the gas stream and shall be accessible for maintenance with the unit in operation. Induced draft fan inlet control dampers shall be louver dampers in accordance with induced draft fan manufacturer's recommendations. Guillotine isolation dampers at stack inlet breeching shall be provided with control interlocks to prevent dampers from closing when the associated induced draft fan is operating. Provide positive means of preventing accidental closure of guillotine dampers. These dampers will be used to isolate the equipment upstream for maintenance. They shall be equipped with an external, locally-mounted audible alarm to signal loss of seal air for personnel safety. Each damper frame shall be of a rigid structural design to eliminate distortion or warpage which may interfere with the damper operation. Frames shall be flanged for bolting to connecting ductwork. Frames shall be designed to support a fly ash load of 1464 kg/sq m 300 lbs/sq ft on the bottom of the frame. Design frames to support a 908 kg 2,000 pound concentrated load due to uneven fly ash distribution, at a point that causes maximum deflection of the frame. Frames shall be designed to support the seal air fan system, related controls, motors, and drive mechanisms, and the entire damper unit with only one flange bolted to the ductwork. Include lifting lugs to ensure proper handling of the damper during transportation and erection. Frames on louver dampers shall be of a length greater by one inch than the width of the louver blades. Control drive units shall be as specified and shall provide a direct position readout at the damper by means of a mechanical position indicator showing percent of damper opening on flow control dampers. Control drives other than poppet damper actuators shall be equipped with a permanently mounted handwheel that is disengaged under conditions of pneumatic or motor operation.

2.11.3.1 Seal Air Systems

Each guillotine damper shall be provided with a seal air system. Each seal air system shall include two full-capacity seal air fans, one operating and one standby. Each fan shall be capable of supplying two times the guaranteed cfm leakage rate through the dampers at design conditions. Fans shall be as specified. Each fan shall be capable of maintaining a pressure between the seal chamber and the gas stream of at least 747 Pa 3 inches W.C. at the design conditions. Provide zero leakage isolation valves at the discharge of each fan. Valves shall be mild steel gate or butterfly valves. Provide check valves at the discharge of each fan to prevent backflow through the idle fan. Check valves shall have a replaceable soft fluoroelastomer seat, and shall be designed to prevent "flutter" when in the open position. Provide a manual control damper or valve in the seal air duct to permit seal chamber pressure to be controlled. Control damper or valve shall be mild steel, and shall have an easily visible position indicator. Provide an automatic isolation valve in the seal air duct to permit seal chamber pressure to be controlled. Control damper or valve shall be mild steel, and shall have an easily visible position indicator. Provide an automatic isolation valve at the connection of the seal air duct to the seal air chamber. Valve shall be gate or butterfly type constructed of nickel-chromium alloy containing a minimum of 55 percent nickel, 20 percent chromium and 8 percent molybdenum and shall be suitable for

corrosive environments. Provide pneumatic piston operator on the valve to operate on 552 to 862 kPa (gage) 80 to 125 psig instrument air. Tube and mount a four-way dual-coil solenoid valve, with Class H coils rated for 120-VAC service. Provide two dual-pole-dual-throw limit switches, one to actuate in the open position, one to actuate in the closed position. Limit switch housing shall meet NEMA 4 requirements. Piston actuator shall remain in last position if air supply fails. Provide three 50 mm 2 inch pipe nipples with caps and rod-out on the seal chamber of the damper, preferably on top of the damper, for attachment of seal chamber pressure instrumentation. Provide necessary instrumentation to monitor operation of seal air system and initiate alarm as specified for maintenance personnel protection. Provide 50 mm 2 inch port with rod-out on seal chamber and 50 mm 2 inch port with rod-out on ductwork to test seal air pressure differential. Port on ductwork shall extend 150 mm 6 inchesbeyond stiffeners to clear insulation and lagging. Provide caps or plugs. Seal air systems, where possible, shall be mounted on the damper frame. Installation shall be such that the system is easily accessible and instrumentation can be easily observed. Install such that there is complete access to linkages, drive units, bearings, and stuffing boxes. Isolation valve and blower shall be mounted such that condensation occurring between the damper and the isolation valve flows into the ductwork. If installation on the damper frame is not possible, a platform shall be provided to support the equipment.

2.11.3.2 Louver Dampers

Damper blade/shaft assembly shall be designed not only for the maximum allowed stress, but to limit the deflection under the maximum conditions at which the damper is to seal to L/14.4 or 6 mm L/360 or 1/4 inch, (whichever is less)(L = blade length in mm inches). Blade shall be of a rigid structural design, capable of handling thermal stresses and warping due to differential temperatures and pressures, without affecting damper operation. Stub shafts shall be pinned or bolted to the through shaft or blade in such a manner that individual damper blades can be easily removed. Pins or bolting materials shall be of carbon steel, with a design such that the connections are self-locking. Shafts shall be sized to deliver the full operator torque to any one blade, without exceeding one-third of the shaft yield stress when operating at the worst-case design conditions. Provide dust-tight stuffing boxes sealed with fluoroplastic packing material to seal the shaft openings. Stuffing boxes shall be designed such that the packing can be adjusted or removed from the outside of the duct, without removing or disturbing the bearings or the linkage. Adjusting nuts, washers, and bolts shall be 316 stainless steel conforming to UNS S31600 (.03 to .08C) and shall incorporate a self-locking design, such that vibrations in the damper unit will not cause backing out of the bolts. Bearings shall be permanently lubricated, self-aligning type. Bearings shall be mounted outboard of the damper unit and any insulation and lagging, in such a manner that leaking packing will not cause the bearing to become contaminated with fly ash. Each bearing and bearing mount shall be designed to withstand three times the stress transmitted from the load on the blades plus the operator output torque. Linkage system shall be located outside of the damper unit. Linkage system shall be fully adjustable to compensate for thermal expansion of the frame. Parts with threaded connections for adjustment shall be carbon steel. Provide lock nuts on the adjustable linkage to positively hold the linkage after adjustment. Design shall be such that each individual blade can be adjusted. Clevis arms shall be pinned or bolted to the stub shaft. Arms shall be keyed to the shaft for easy removal. Clevis arm shall be carbon steel and linkage pins or bolts shall be 304 stainless steel conforming to

UNS S30400 (.03 to .08C). Pins or bolts shall incorporate a self-locking design, such that operation or vibration of the unit will not cause loosening of the connections. Linkage system, including connections, shall be designed to withstand three times the stress transmitted from the load on the blades plus the operator output torque. Linkage system shall have provisions for locking with a heavy-duty padlock in such a manner that the damper cannot be operated until the padlock is removed. Sealing strips shall conform to ASTM B443. Strips shall be bolted into place with bolts and nuts fabricated of the same alloy as the strips. Connection shall be self-locking to prevent loosening of the connection. Seal strips shall be of a suitable length to enable easy replacement in the event of damage or failure. Sealing strips are not required for induced draft fan dampers. Louver dampers shall be either parallel or opposed blade. Blades shall be air-foil type, of rigid structural design. Blade skin and through shaft shall be compatible material for expansion and contraction. Blade shall be connected to through shaft with self-locking bolts or pins. Louver dampers except the induced draft fan inlet control dampers and dampers in vertical ducts shall be designed for staged closing. Operation of the blade shall be such that blades close, except the bottom blade. When the upper blades have closed, then the bottom blade will close. Provide two operators on the linkage system, one to operate the top blades, and one to operate the bottom blade. Design of the linkage shall be such that the number of blades operated by each operator may be changed with relative ease. To prevent ash buildup at bottom of hopper, install purge air system.

2.11.3.3 Poppet Dampers

Poppet dampers shall be vertically operating, with pneumatic operators, adjustable speed and stroke, shaft packing glands, replaceable seal plates, and machined steel seating cylinder and guide shaft. The dampers shall be equipped so they can be mechanically locked in a closed position to protect service personnel. Poppet damper shafts shall be out of the dirty gas stream wherever possible. Shafts exposed to the flue gases shall be provided with shaft seals. Poppet dampers shall be a minimum of 99.5 percent gas tight.

2.11.3.4 Guillotine Dampers

Guillotine dampers shall be bottom-entering dampers in paragraph entitled "Dampers." Guillotine dampers shall have bonnets over the top frame if required to prevent flue gas leakage to the atmosphere. Bonnet assembly shall be of carbon steel and shall have easily removable side plates for inspection of the damper drive assembly. Bonnet shall be designed for continuous-seal air purge. Guillotine dampers shall have a removable plate for access to the bottom frame seal. Damper blade shall be fabricated of plate, and shall be as rigid as necessary to withstand the maximum differential pressures specified. Provide blade with sealing strips around the periphery of the blade and on the seating surfaces of the frame. Local seals on both the upstream and downstream sides of the blade. Sealing strips, seal strip bolting materials and backing strips shall be as specified for louver dampers. Blade shall be designed to include provisions for thermal expansion such that the blade will not bind. Bearings shall be permanently lubricated, self-aligning type. Design shall be such that thermal gradients and long periods of time between damper operation will not cause bearings to bind or seize. Damper drive shall be designed to lift the damper blade evenly on both sides. Each drive, tie rod, and bearing, shall be designed to withstand three times the load caused by the damper blade plus the operator output torque, at worst-case pressure and flow conditions. Upper frame shall be designed to support the

blade, drive mechanisms, and attachments. Frame shall not sway and cause binding of the blade when operating at worst-case flow and pressure conditions. Pressures and flows provided to the damper manufacturers shall be approved by the Contracting Officer in advance. Damper shall include a mechanical crank for manual operation.

2.11.4 Mechanical Draft Equipment

Mechanical draft equipment and appurtenances shall have an acceptable history of satisfactory reliable service in industrial steam plant use for a period of a least three years at comparable temperature, pressure, voltage, and design stress levels. Newly developed equipment with less than three years actual service may be considered from established manufacturers, only if it has been adequately tested, at an approved lab meeting AMCA standards, meets the requirements of this Contract, and is approved by the Contracting Officer. Prior to shipment, the manufacturer shall thoroughly inspect parts of the equipment furnished to ensure sound material and first class workmanship. Rivets shall be tight and welds shall be full thickness and without undercutting. Keys shall fit snugly and rotors shall be secured firmly to the shafts. Welding on rotors for fans shall be examined by magnetic particle inspection. Magnetic particle inspection shall be performed on the root pass and the finished surfaces of all welds. On full-penetration welds, the backside of the root base shall be examined by magnetic particle inspection before depositing weld from the backside. Welds shall be free from undercutting in excess of 0.40 mm 1/64 inch in depth and free of cracks and fissures in excess of 6 mm 1/4 inch in length. Inspection of the fans for compliance may be made by the Contracting Officer. Notify the Contracting Officer, in writing, at least 45 days prior to start of assembly and welding of fan rotors so that he may have a representative present to inspect fan rotors during fabrication, if desired. This inspection of the fan rotors will include an examination of the weld grooves preparations on the material being joined in the assembly of the fan wheels, witnessing the actual welding being performed on the fan wheels, a visitation to the manufacturer's nondestructive testing facility, witnessing the nondestructive testing being performed on welds and base material of the fan wheel, and verifying that subassemblies are fabricated properly and in accordance with the manufacturer's drawings and specifications. Fans shall be designed and constructed to ensure reliability with a minimum number of scheduled outages for repairs and maintenance. Fans shall be suitable for continuous operation at full or part load. The fans and their ducts, flow-regulating devices and dampers shall be coordinated to give an installation which will be capable of operation without excessive vibration, fan noise, or air or gas vibrations. This satisfactory performance shall be maintained throughout the entire load range of the fans including operation at minimum flow settings with cold air. Fans over 19 kW 25 hp shall be two-bearing design with rotor suspended between bearings with no overhung wheels.

2.11.4.1 Fan Housing

Provide split housing so the rotor is accessible and removable for normal maintenance without disconnecting the housing from the inlet or outlet ducts or foundation and without moving the motor. Shape the housing for maximum streamline flow from inlet to outlet. Construct from mild steel plate. Brace with structural steel welded to the housing and designed for sufficient strength to prevent warping and excessive vibration under operating conditions. Provide with gas-tight inspection doors. Provide with inlet and outlet connections of structural angle flanges for welding to similar flanges on the ductwork with bolts provided and used for

alignment only, or for connections to similar flanges on the ductwork by means of gaskets and bolts. Bolts shall be spaced not more than 65 mm 2 1/2 inches apart. Provide with a 50 mm 2 inch drain pipe connection welded to the lowest point of the fan scroll. Provide nipple and cap. Housing will be supported from a concrete base. Housing shall be designed so a minimum distance of 600 mm 24 inches will exist between the bottom of the housing and the foundation to permit application of insulation and access to the housing drain connection. Shop paint fan housings in accordance with the specifications for painting of the ductwork to which they connect.

2.11.4.2 Fan Rotors and Shafts

****

NOTE: Rotors shall be balanced statically and dynamically so that vibration displacement at the bearings measured on the shaft at full load and full speed with a clean rotor will not exceed the following.

Maximum Vibration	
Rotor Speed, rpm	**Displacement, mm**
Up to 600	**0.051**
600 to 900	**0.038**
Above 900	**0.025**

Maximum Vibration	
Rotor Speed, rpm	**Displacement, inches**
Up to 600	**0.0020**
600 to 900	**0.0015**
Above 900	**0.0010**

Weight adjustment for balancing shall be by either the addition or the removal of metal.

****

Fan rotors shall be designed and constructed to keep stresses from rotation or temperature differential at a safe and conservative level. Fan rotors shall be designed so the maximum calculated stress at any point on the rotor, under any normal condition such as continuous operation or starting acceleration, will not exceed 50 percent of the yield strength of the rotor material at the maximum operating temperature. Fan rotors shall have center plates and shroud plates of mild or alloy steel. Tie rods between plates or blades will not be permitted. Construct so that while the rotor is turning, the run-out of similar points on the rotor structure will not deviate from the median path by more than 0.375 percent of the wheel diameter. Rotors shall be designed and constructed so that the first critical speed of the rotor is not less than 33 percent above the normal operating speed for fans operating at temperatures up to 93 degrees C 200

degrees F and not less than 50 percent above the normal operating speed for fans operating at temperatures of 93 degrees C 200 degrees F and above. Fan shafts shall be forged and heat-treated steel, accurately machined, with ground and polished journal and thrust bearing surfaces. Shafts shall be provided with seals to minimize leakage where the shaft penetrates the housing.

2.11.4.3 Bearings

Bearings shall be suitable for continuous heavy-duty service and shall be self-aligning, sleeve-type journal bearings designed with adequate lubrication for coast down without an external oil supply. Install bearings in a horizontal split housing or pedestal of structural steel or cast iron. Pedestals shall allow removal of bearings without removing rotor and shall be suitable for shimming. Bearings shall be located external to the inlet boxes. Bearings on double-inlet fans shall be designed to withstand the thrust unbalance resulting from the shutoff of one inlet while the other inlet is open. Protect bearings from the weather on outdoor installations with a suitable rain hood and sun shield as recommended by the manufacturer. Each bearing shall have bearing temperature thermocouple as specified in paragraph entitled "Instrumentation and Controls." Bearing lubrication systems shall be specifically designed for air cooling except as noted below. Provide cooling air by inlet box suction. Inlet air filters shall be provided. Where the bearing surface rubbing speed exceeds 7.62 m/s 18,000 inches/minute bearings designed for water cooling shall be furnished. Each bearing shall be equipped with at least two machined oiling rings and an adequately sized integral lube oil reservoir with oil level gage. Reservoirs shall be equipped with immersion heaters designed to continuously maintain the lube oil in the bearing at starting temperature over the range of ambient temperature specified in paragraph entitled "Design Parameters." Immersion heaters shall be 120-volt AC single-phase and shall be complete with a thermostat located to accurately control lube oil temperature. Furnish bearing pedestals, mounting plates, and soleplates as required to mount the equipment on the concrete foundation. Contractor shall furnish the torque requirements of the foundation bolts for fans.

2.11.4.4 Motor Drive

Each fan shall be furnished with a single-speed motor drive. Each fan shall be equipped with a flexible coupling between the fan and motor drive. Coupling shall be rated at not less than 150 percent of the motor power at design fan speed. Design coupling to prevent any axial thrust from being transmitted to the driver under any normal operating condition.

2.11.4.5 Induced Draft Fan

Performance of the induced draft fan shall be as specified in paragraph entitled "Design Parameters." Induced draft fans shall be double inlet, double width. Provide one induced draft fan for each steam generator and its associated gas cleaning equipment as indicated. Each induced draft fan shall be equipped with dampers as specified in paragraph entitled "Mechanical Draft Equipment." Provide inlet control dampers for regulating the fan output. Inlet dampers shall be arranged for operation from one control drive at each fan. Control drive shall be as specified in paragraph entitled "Analog Control System." Provide control signal from combustion controls. Induced draft fans shall have housing constructed of 10 mm 3/8 inch minimum thick mild steel. Housing shall be provided with

wear-resistant liners of not less than 12.70 mm 1/2 inchthickness at all points of wear. Liners shall be easily replaceable. Interior bolt heads shall be protected from fly ash erosion. Fabricate housing of 19 mm 3/4 inch minimum thick, mild steel plate instead of separate liner plates, if desired. Induced draft fan rotors shall have radial blades with replaceable wearing surfaces over at least two-thirds of the blade width, at least equal to the thickness of the skin of the blade.

2.11.4.6 Reverse Air Fan

****
NOTE: Insert appropriate Section number in the blanks below.
****

The reverse air fans shall be heavy duty industrial type fans having single flanged inlets and outlets. Type of bearings and bearing lubrication shall be suitable for the temperatures encountered. Provide heat slingers. A quick-release gasketed inspection door shall be furnished on the housing. Fans shall be V-belt driven by a constant speed motor through adjustable speed sheaves. Mount motor on slide motor bases designed to adjust belt tension from a screw mechanism; furnish suitable belt guards. The fan shall be rated for flow, pressure, power, speed of rotation, and efficiency in accordance with AMCA 210 and the fan shall comply with AMCA 201 and the fan shall comply with AMCA 99. Motors shall be as specified in Section [_____] ELECTRICAL, for the service intended. Minimum reversing air flow shall be with 10 L/s per square meter 2 acfm per square foot of net cloth area under cleaning action.

2.11.5 Painting

Surfaces of ductwork and metal parts of expansion joints which will be exposed after installation of insulation and lagging shall be painted as specified in paragraph entitled "Ductwork and Draft Equipment." Areas that will not be exposed shall be painted as specified, except that a dry film thickness of 0.051 mm 2 mils shall be applied. Apply primer to steel surfaces, except the areas within 50 mm 2 inches adjacent to field welds. Surfaces that will be exposed to the flue gas flow need not be painted, but shall be protected during shipment and storage with a suitable rust-preventative coating. Damper frames, support steel and seal air ductwork not directly in the gas stream shall be shop-cleaned and painted as specified in paragraph entitled "Structural and Miscellaneous Steel." Damper operators, seal air valve operators, motors, seal air fans and limit switches shall be primed and painted per the equipment manufacturer's standard practice. Protect exposed machined surfaces with a suitable rust-preventative compound.

2.11.6 Factory Tests

Perform manufacturer's standard factory tests on mechanical draft equipment and material. Perform tests required by the applicable codes and these specifications. Notify the Contracting Officer in writing at least 45 days prior to factory tests so that he may have a representative witness the tests.

2.11.6.1 Damper Tests

Perform factory tests on dampers, except poppet dampers. Each damper which is provided with an integral frame shall be operated five times to test for

smooth and trouble-free operation, at both ambient and design pressures. Each damper will then be checked to assure that no damage has been sustained to the frame, blades, or seals. Each damper which is provided with an integral frame shall be tested in an airtight chamber at design temperature and pressure to determine the amount of gas leakage across the damper and through the frame. Provide instruments to determine the amount of leakage and the static pressure against the damper. Each damper equipped with a seal system shall be tested for air leakage across the damper with the seal air system operating at design temperature and at the design differential pressure across the damper. Each seal air unit shall be tested to assure that design flow, temperature and pressures are being met. These tests shall be run independently from the damper tests, and prior to the damper tests.

2.11.6.2 Mechanical Draft Equipment Tests

****

NOTE: Overspeed test is as follows. If the operating temperature of the fan is less than 93 degrees C 200 degrees F, the wheel shall be Spun at 10 percent above the maximum operating speed for a period of not less than three minutes. If the operating temperature of the fan is 93 degrees C 200 degrees F or more, the wheel shall be spun for a period of not less than three minutes at the speed calculated from the following formula.

$$\text{Test speed} = 1.10\ (\text{max oper spd}) \left(\frac{\text{(allowable stress at 38 C)}}{\text{(allowable stress at oper temp)}} \right)$$

$$\text{Test speed} = 1.10\ (\text{max oper spd}) \left(\frac{\text{(allowable stress at 100 F)}}{\text{(allowable stress at oper temp)}} \right)$$

There shall be no permanent deformation of any part of the wheel as a result of overspeeding. After the test, welds shall be examined for cracks by magnetic particle testing or dye check.

****

Perform manufacturer's standard factory tests on mechanical draft equipment and material. Perform tests required by the applicable codes and these specifications. Fan wheels with tip speeds exceeding 127 meter per second 25,000 feet per minute, and which are not identical to fan wheels in successful commercial operation, shall be given an overspeed test. Factory test shall include mechanical balancing of rotating parts.

2.12 INSTRUMENTATION AND CONTROLS

Furnish a control system to provide safe, reliable, and efficient operation of the Flue Gas Cleaning System through integrated control of system processes and equipment. The control system shall perform safe boiler

start-up and shutdown and shall respond to dynamic variations in boiler operating conditions including steam sootblowing while maintaining required emission levels. The control system shall include a vertical control and graphic system panelboard located in the Steam Plant control room and system cabinets located in the control equipment room. The Control system shall integrate local controls provided with the lime slurry preparation equipment, and other equipment, as specified, so that complete system operation can be remotely monitored and controlled from the Steam Plant control room. The Contractor shall provide instrumentation and control equipment, as specified and as required for a complete and operational system. Furnish instrumentation required to monitor the process variables. Furnish flow, pressure, and temperature instrumentation for each pump, to monitor operating conditions and indicated performance. Furnish flow, level, pressure, and temperature switches for alarm actuation in process lines, tanks, vessels, and heat exchangers. Furnish transmitters required to transmit the process variable to the control systems. Furnish instrumentation required to transmit the status of the process and equipment to control room panels. Furnish analyzers and sensors required to monitor and to control process reagents, flue gas influent and effluent, and waste products. Furnish supports, hardware, enclosures, and accessories required to mount, protect, and operate the instrumentation. Furnish instruments, meters, gages, switches, controllers, thermometers, thermocouples, transmitters, analyzers, panels, and gage boards as required. Furnish metal instrument identification tags on field devices. Furnish tubing, piping, and fittings required for a complete instrumentation and control system. Furnish electronic control systems to control and monitor continuous time-varying processes using either split architecture analog controllers or direct-digital control techniques to emulate analog controllers. Furnish electronic digital control systems to control and monitor sequential processes. Provide necessary control program software and hardware. Furnish control drives and control valve operators required for control of the FGD system including induced draft fan inlet damper control drives. Furnish control boards for at least the following areas or functions: FGD system control panelboard in Steam Plant control room, lime slurry preparation equipment, lime unloading, and at each spray dryer penthouse. Control panels in each area shall include the necessary control devices and instruments required to operate and monitor the equipment specified for control from that panel. Equipment which is specified to have both local control and control from the main system panelboard in the control room shall be provided with control mode selector switches at the main panelboard. Panelboards shall conform to UL 67. Analog loops shall be controlled from the main system panelboard only. Tag each field-mounted device and panel-mounted device using the following tag numbering scheme. Instruments shall be tagged according to contract number and type of device using standard device abbreviations. Tag numbers shall be prefixed with the number [_____] to signify this contract. Instruments furnished in multiples for multiple equipment shall have identical tag numbers suffixed by the letters A, B, C, etc., to correspond to the multiple equipment. Tag each device prior to shipment. Device tags shall be permanently attached (not with string or tape) to the stem or case of each device. Tags shall be fabricated of solid brass or aluminum with correct tag number stamped clearly on into the metal. Each tag shall be inscribed with a unique tag number assigned using the specified scheme. Submit drawings of mounting locations for devices to be mounted.

2.12.1 System Operation

****

NOTE: Failure Analysis. Provide a complete control

system failure analysis demonstrating and explaining the effects of various system component failure on the system. The failure analysis shall specifically identify the control system features which will be provided to minimize the effect of component failures and protect the equipment, especially the fabric filter bags.

****

Operation and control of the Flue Gas Cleaning System shall be accomplished by a full-time operator from the steam plant control room. The control system shall be designed to allow operation of FGD system in either of two modes; remote manual or semi-automatic. In the remote manual mode the various dampers, control valves, pumps and associated equipment will be opened or closed, started or stopped from individual switches or push buttons located on the main control panel. In the semi-automatic mode the FGD system components for each boiler will automatically placed in or taken out of service in the proper sequence when the start or stop push button is activated. In both modes sufficient interlocks shall be provided to assure that proper sequencing is followed and to allow equipment to be automatically tripped when required. The control system shall be designed to ensure that in the event of a power failure of FGD system equipment failure, the necessary corrective action to prevent damage to the equipment will automatically be initiated. Contractor shall provide a complete system failure analysis. Process variable indicators and alarms required for proper monitoring of system performance shall be located on the main control panel. Furnish necessary instrumentation to provide positive indication of operational status of equipment; such as, flow or pressure switches to verify operation of pumps and limit switches to indicate position of dampers and valves. Local controls shall be provided for valves, dampers, and motors. A complete system graphic display shall be provided.

2.12.1.1 Lime Slurry Preparation

Provide a control panel adjacent to the truck unloading fill pipe connection. Provide a NEMA 4 enclosure for panel. Panel shall include bin vent filter fan indicating light, low bin level indicator light, high bin level indicator light and audible alarm with alarm silencer button. When truck unloading tube is connected to the fill pipes, a limit switch mounted on the fill pipe shall be actuated. Limit switch actuation shall activate bin vent filter exhaust fan. Disconnection of truck pipe shall return limit switch to normal and operate bag cleaning mechanism for a preset period of time. Reaching high bin level during truck unloading shall sound alarm. Level switches for high and low feed bin level shall be provided, as specified in paragraph entitled "Instrumentation and Controls." Provide local and remote monitoring of feed bin levels. Provide signal from low and high bin level indicators as required for input to control of pneumatic lime conveying system from bulk lime storage silo. Silo, conveying system, and controls for bulk lime storage will be provided by the Contractor. Provide space for additional level monitors on FGD system panelboard for use with bulk storage silo. Primary control of the lime slurry preparation operation shall be from the local control panels as specified herein. Main FGD system control panelboard shall interface with local controls as specified paragraph entitled "Instrumentation and Controls." Once a feeder/slaker has been selected for operation from the local control panel, the lime slurry preparation equipment shall function automatically. A low level signal from the slurry tank level switch shall start water feed, lime feed, bin vibrator and other equipment as required including slaker

agitator and grit removal equipment. A high-level signal from the slurry tank shall stop line feed and bin vibrator immediately and provide continued operation of water feed, slaker agitator and grit removal equipment for adjustable time periods. Provide control panels at the time slurry preparation area enclosure preparation area enclosure and shall include complete controls for equipment in the slurry preparation system. In addition to selector switches or push buttons for all equipment, the local controls shall provide full instrumentation to annunciate any component failures and automatically trip equipment. Local annunciator shall be provided for component faults including high slaker temperature, slaker overflow, slaker fail-to-start grit remover zero speed, slurry agitator zero speed, and low-low slurry tank level. Any local alarm shall register at the main FGD system panelboard in steam plant. Flushing of the slurry pumps and piping systems shall be controlled from a panel at the slurry tank level in the lime system enclosure.

2.12.1.2 Spray Dryer Absorbers

The following paragraphs provide a typical functional description of the control of sulfur dioxide concentration and flue gas temperature leaving the spray dryer absorbers. It is recognized that individual differences between control schemes may exist to the extent that not all of the control details specified are applicable to a given system. The [proposal] [bid] shall clearly indicate such differences and shall include a detailed description of the control system features provided to attain the control objectives specified in these paragraphs. The degree of sulfur dioxide control achieved in the spray dryer absorber and fabric filter baghouse is directly related to the rate of lime feed to the atomizer. The lime slurry feed rate to the atomizer shall be regulated by a control valve which is modulated by a signal from the analog control system utilizing an input from an sulfur dioxide analyzer located at the fabric filter baghouse outlet. The control valve shall fail closed on loss of air, power, or control signal and the control system shall be provided with sufficient interlocks so that FGD system upsets cannot result in excessive liquid feed and subsequent moisture carryover to the fabric filter baghouse. The control system shall be designed to automatically control the sulfur dioxide concentration leaving the fabric filter baghouse at a level set by the operator from an operating station in the control room. Provide continuous indication of the inlet and outlet sulfur dioxide concentration, control valve status and slurry feed rate on the main control panelboard. The temperature of the flue gas leaving the absorber shall be controlled to an operator-adjustable setpoint by automatic regulation of water feed to the atomizer. The water feed rate to the atomizer shall be regulated by a control valve which is modulated by a signal from the analog control system utilizing an input from a temperature transmitter located at the spray dryer outlet. The control system shall provide a means of assuring that the outlet temperature remains above the moisture dewpoint with an adequate margin of safety as required to prevent condensation at any point downstream in the FGD system. A control signal will be available to indicate the initiation and termination of the steam sootblowing cycle. The temperature control system shall make use of this signal to automatically compensate for the additional moisture input with the flue gas. The water control valve shall fail closed on loss of air, power, or control signal. Absorber inlet and outlet temperature, water control valve status, and water feed rate shall be indicated at the main control panelboard. Each atomizer shall be provided with a local control panel mounted in the penthouse enclosure. Complete local controls, indicating lights and alarms shall be provided. Controls for the two-fluid nozzle atomizers shall be as follows: interlocks and automatic trips shall be provided to automatically

stop the atomizer due to low oil pressure, high oil temperature, high motor temperature or high vibration level. Remote indication of atomizer operating conditions and alarms shall be provided on the main control panelboard. Atomizer start switches shall be provided both locally and remote.

2.12.1.3 Baghouses

Primary control of the fabric filter baghouses shall be from the FGD system panelboard located in the steam plant control room. Design the control system for automatic control of each fabric filter baghouse as required to ensure stable and reliable operation. Monitor status and position of motors, dampers, valves, etc. at the main control board by a graphic presentation. Design for automatic or manual start-up and automatic verification of the operation of each component of the fabric filter baghouse in sequence as required for proper operation of the system. The automatic start-up sequence will be manually initiated. Design for automatic or manual shutdown and automatic verification of the shutdown of each component of the fabric filter baghouse in sequence as required for proper shutdown of the system. Design for automatic and safe shutdown of any malfunctioning part of the system without disrupting boiler operation capabilities. Any effect on the steam plant due to system control changes will be avoided or minimized. The cleaning cycle will be initiated by measurement of pressure drop across total fabric filter baghouse, by timer, or by manual switch. Initiation mode shall be switch selectable. A manual selector switch will allow manual operation of the cleaning function for any module for the purpose of extra cleaning of any module or in the event of automatic sequence failure. Off-line cleaning of pulse-jet fabric filter baghouse modules (normal) or on-line cleaning shall be available at the selection of the operator. The automatic timer and manual selector switch will be interlocked with an isolation switch located at the tube sheet access doors to ensure isolation of the module for maintenance. The automatic timer will bypass any module not in service. This bypass will be accomplished without timing through the cleaning cycle for the module just bypassed (no dead time). The cleaning timer will allow for adjustment of the frequency and duration of cleaning cycles to obtain optimum bag cleaning. The bypass mode selector for each fabric filter baghouse will be functional for either automatic control and for manual control. The system shall automatically bypass the fabric filter baghouse as required to prevent moisture carryover from spray dryer. Monitor status of process and equipment for abnormal operation, failure, trip, etc. and provide visual and audible alarms. Alarm indication shall include, but not be limited to, high temperature drop across the fabric filter baghouse, high-pressure drop across fabric filter baghouse, cleaning system malfunction, high ash level (with indication of which hopper is alarming) and low hopper temperature (with indication of which hopper is alarming).

Graphic display shall include at a minimum the following indicating lights (color of lens in parentheses):

a. Inlet damper--OPEN (green).

b. Inlet damper--CLOSED (red).

c. Outlet poppet--OPEN (green).

d. Outlet poppet--CLOSED (red).

e. Module--ACTIVE (green).

f. Module--INACTIVE (red).

g. High ash level (red)*.

h. High inlet gas temperature (red)*.

i. Low compressed air pressure (red)*.

j. High system differential pressure (red)*.

k. Power--ON (red).

l. SYSTEM START (green).

m. SYSTEM STOP (red).

n. Cleaning mode OFF-LINE selected (white).

o. Cleaning mode ON-LINE selected (white).

*These items shall activate an audible alarm.

Two position selector switches shall be provided for the following.

a. Power--ON/OFF.

b. Module--ACTIVE/INACTIVE.

c. Cleaning mode--OFF-LINE/ON-LINE.

Momentary contact push buttons shall be provided for the following.

a. System--START (green head).

b. System--STOP (red head).

c. Alarm--ACKNOWLEDGE.

Provide auxiliary devices required for the control functions indicated including the following.

a. Position indication switches on isolation valves.

b. Hopper level alarms.

c. Temperature indicator and thermocouple.

d. Pressure switch.

e. Audible alarm.

f. Differential pressure gage (baghouse module and panel board).

g. Fan current.

h. Fan inlet static pressure.

i. Fan outlet static pressure.

j. Opacity.

Provide suitable laminated plastic nameplates for devices on panel face. Temperature controller and differential pressure gage shall be mounted on face of panel. In addition, provide a two pen, 250 mm 10 inch diameter circular chart recorder to record inlet gas temperature and pressure drop across baghouse system for each module. Differential pressure gage for each module shall be indicating type with diaphragm magnetically coupled to pointer mechanism.

Units shall include a programmable controller which shall be completely solid state and shall be preprogrammed to control the following.

a. Pulse duration (pulse-jet only).

b. Pulse sequencing (pulse-jet only).

c. Cleaning cycle time.

d. Settling time.

e. Module isolation valve control.

The system shall sense differential pressure between inlet and outlet of each baghouse. When the differential pressure reaches the setpoint, controller shall initiate cleaning of all modules. In addition, an overriding timer shall be provided so that the bags can be cleaned on a preset interval independent of pressure differential. (Pulse interval and duration), cleaning cycle time, setting time and time for valve operation shall all be adjustable. Differential pressure setpoint shall also be adjustable.

2.12.2 Analog Control Systems

Furnish an analog control system complete with transmitters, flow-measuring elements, control modules, control system cabinets and panelboard, control operating stations, prefabricated plug-in cables, signal converters, control drives and accessories as required to allow control of the FGD system from the central steam plant control room. The control systems and instruments shall be electronic and be designed for continuous operation. The control system shall be of the "split architecture" design where computing and logic modules are mounted in system cabinets. Operating stations shall be mounted in the panelboard and connected to the system control module racks, mounted in the system cabinets, using prefabricated cables.

2.12.2.1 Electronic Control Modules

Analog computing and logic modules shall use proven solid-state electronic design. Circuits shall be constructed with high-quality, pretested components making maximum use of integrated circuits. Components shall be readily available from known suppliers. Analog computing and logic modules shall be designed for plug-in rack mounting in the system cabinets. Module pins and mating connectors shall be gold plated on nickel to withstand chemical attack by ambient atmospheric chemicals. Modules of the same type shall be interchangeable to facilitate maintenance and trouble-shooting by substitution. Pretest and age each module before installing in the module racks. Factory assemble, wire, and test the system using the operating

stations and actual plug-in cables for the system. Provide input and output test jacks on each module for tests. Controllers and analog computing circuits shall perform as follows unless specifically noted otherwise for a particular system or control loop: Provide calibrated, front-mounted controls on appropriate modules, to adjust proportional, integral and derivative action. Adjustments shall be possible while operating in automatic without causing undesirable upsets such as a proportional step. Prevent reset windup action and design to develop response to demand without the system first performing internal controller balancing. Provide means to automatically balance each loop that has a manual-automatic operating station so that bumpless transfer may be made from manual to automatic and from automatic to manual without any intermediate manual balancing. Where both master stations and individual final control element stations are employed in a loop, the master, as well as individual stations shall transfer bumplessly and without balancing, and be tied together, as appropriate. Bumpless transfer is effected if the output signal to the final control element does not vary more than 2 percent of the full-scale output signal range when transferring from automatic to manual and from manual to automatic. Provide for all interlocks and contact inputs and outputs and all digital logic functions necessary to control or interface the analog circuits throughout the system. Provide signal monitor modules to track analog signals where required to produce contact outputs for alarm or interlock with other logic when the signal exceeds a predetermined level. Signal monitor units shall be equipped with independently adjustable high and low set points. Provide suitable isolating devices such as relays or optical couplers to protect the control system from external outputs or inputs. Provide indicating lights on the modules to show the status of all logic, transfer relays, and signal monitors. Lights shall be visible without removing or withdrawing the modules from the racks.

2.12.2.2 Input and Output Signals

Input signals from field transmitters shall be 4-20 mA dc "two-wire." Provide output signals to panel recorders and indicators. Provide square root extraction for flow signals outputs to devices furnished. Output signals shall be 4-20 mA dc. Transmitters required to provide multiple outputs to recorders, and indicators as well as providing an input to the control system shall be buffered so that disconnecting, shorting or grounding of the input at the recorder or indicator shall not cause an upset or failure in the control system. Output control signals to final control elements shall be 4-20 mA dc. The final control elements shall be provided with the proper signal converter.

2.12.2.3 System Electrical Power and Power Supplies

The following power sources will be provided by the Government: Source "A" 120-V ac from station inverter. Source "B" 120-V ac from station service. The Contractor shall furnish fuses or circuit breakers for each source to protect against faults or overloads at the system modules. System computing and logic power, transmitter power, or other power used for control or indication, used either remotely or internally, shall originate from within the system. Such power users shall be properly fused or furnished with circuit breakers to protect power sources and supplies from overloads or faults. Power sources and power supplies shall be distributed into functional groups and protected from overloads or faults such that a power failure in one group does not cause power failure to the remainder of the control system. The system shall take appropriate control action and initiate an alarm contact upon partial power failure. Tripout of a circuit

breaker or opening of a fuse due to control equipment failure or wiring fault in a control loop shall disable the loop in which the failure occurred and place the final drive in the manual mode and initiate an alarm contact. Fuses, breakers, and fuse or breaker panels shall be readily accessible and clearly identified. Provide input filters for noise suppression, as required. Where internal dc power supply buses are utilized, furnish two full-capacity power supplies for each bus voltage and auctioneer their outputs to ensure no control upsets if one supply or its source fails. Power one supply from source "A" or "B" is distributed internally to individual circuit cards or individual transmitters or converters which have separate dc power supplies, provide an automatic transfer switch to switch to the backup source upon primary source failure. Furnish manual reset feature and provide an alarm contact on transfer. Provide circuit isolation and monitoring to permit removal of faulty supplies during operation.

2.12.2.4 Operating Stations

Operating stations will be remote mounted on the control panelboard in the central steam plant control room. Furnish operating station with an individual mounting rack to permit simple and quick removal from the panel. Wiring to the system cabinets shall be by a prefabricated plug-in cable. Operating stations shall contain dials, switches, lights, and indicators necessary to operate the system by either manual or automatic mode. Stations shall not contain computing or logic elements which are a part of the control loop except for operator-system interface. Station shall have the following features, as applicable, depending upon their purpose in the control system:

a. Manual-automatic selector switch or push buttons.

b. Dedicated indicating meters displaying only one variable, and marked in appropriate engineering units where applicable. Indicating lights displaying manual or automatic status of the control loop. Lights displaying status of the switch are not acceptable.

c. Set point dials calibrated and marked in appropriate engineering units.

d. Deviation meter.

e. Position meter indicating the actual final drive element position over its full range, and not the loading signal.

f. Raise and lower control for manual operation.

Manual, set point, or indicator stations which have specified functions shall have no extraneous or ineffectual indicators, switches, or lights. The station shall be tailored to its purpose. Tag operating stations with a unique number, as specified. Provide an engraved nameplate on each operating station identifying the service such as spray dryer outlet temperature.

2.12.2.5 Control Drive

Control drives shall be pneumatic type. The term "control drive" refers to a power actuator which is primarily used for positioning another device such as a damper, in response to signals from a control system. Select each control drive size as required to provide adequate capacity for the existing loads and conditions. Each control drive used for modulating

service shall positively position its controlled device accurately and without fluctuations with the existing load conditions and at any position. The time required for full-stroke travel in either direction shall be 15 seconds. Provide speed control to allow adjustment of full-stroke time from ten seconds to one minute. Provide couplings, adapters, linkages, clevises, ball joints, drive arms and damper arms required. Furnish control drives and handwheels, dual-pole-dual-throw limit switches for open and closed indication, on open-close drives, and 4-20 mA dc position outputs on modulating drives. Position shall be sensed electronically without the use of a slide wire. Provide control drives except the induced draft fan inlet damper drives with current-to-pneumatic positioners to accept a 4-20 mA dc control signal. The induced draft fan inlet damper drives shall be furnished with a pneumatic positioner to accept a 3-15 psi signal from a current-to-pneumatic signal converter furnished by the Contractor.

2.12.3 Digital Control Systems

Digital controls shall be relay logic, solid-state programmable logic. Baghouse sequence control shall be wired solid-state logic or solid-state programmable logic. Digital logic associated with analog process controls shall be as specified in paragraph entitled "Electronic Control Modules." Control circuits shall be 120 VAC maximum. Higher voltage power shall not be brought into a control system cabinet or control panelboard.

2.12.3.1 Wired Solid-State Logic

Components shall be highest quality industrial grade devices. Logic elements shall be integrated circuits. Components shall be subjected to a rigorous quality assurance inspection. Circuit cards shall be burned-in and tested in the completed system a minimum of 170 hours continuous operation. Logic elements shall be assembled on circuit cards to perform specific operational functions. Different types of circuit cards shall be minimized to reduce stocking of spares and to facilitate maintenance by card substitution. Logic cards shall be arranged in functional groupings for individual pumps or sequences. Failure of a single logic circuit or compartment shall not affect more than one pump or separate functional sequence. Power supplies shall be as specified for Analog Control Systems. System electronics shall be buffered and protected from external power sources by optical couplers or reed relays. Logic shall be documented by logic diagrams.

2.12.3.2 Solid-State Programmable Logic

Components shall be highest quality industrial grade devices. Components shall be subjected to a rigorous quality assurance inspection. Circuit cards shall be burned-in and tested in the completed system a minimum of 170 hours continuous operation. Small systems requiring a minimum of memory elements may use nonvolatile programmable memory. Larger systems shall use software programmable memory with nonvolatile memory for program and executive storage. Logic functions shall be performed by software engineer. Logic shall be documented by flow charts or word logic, and by program listings. Memory shall be static. Programming aids shall be provided to permit easy field reprogramming. Battery power back-up may be approved by the Contracting Officer. System electronics shall be buffered and protected from external power sources by optical couplers or reed relays. Software shall be factory tested and debugged including simulating inputs and outputs and checking resulting logic sequences.

2.12.4 Flue Gas Cleaning System Panelboard and System Cabinets

Provide one common vertical panelboard and system cabinet sections, as specified, to control the flue gas cleaning equipment for boilers. Panelboard dimensions shall be 0.762 m deep by 2.44 m wide by 2.44 m high 30 inches deep by 96 inches wide by 96 inches high. No process fluids or pneumatic signal lines shall be brought into any panelboard or system cabinet.

2.12.4.1 Construction

Construct of 3 mm 1/8 inch hot-rolled steel panels reinforced with angles and channels in the interior to form a single, rigid, freestanding unit in compliance with NEMA 12. Panelboards shall be completely enclosed floor-mounted units, except with bottom open. Panelboards shall be constructed with no bolt heads or fastenings visible from the exterior. Construct with 6 mm 1/4 inch radius corners. Edges shall be filled and ground to conform to a 6 mm 1/4 inch radius. Provide interior innerpanels for mounting auxiliary equipment and terminal blocks, as required. Make provisions for anchoring to floor or foundation. Provide hinged doors on the rear of the panelboard with key locks to allow access to equipment. Provide lifting eyes and shipping pallet on the panelboard to facilitate moving into the steam plant. Provide ventilation grills, exhaust fans, ductwork, and filters, as required. Provide cutouts and removable cover plates for items designated as future. Paint cover plates to match panels. Prime and paint panelboard as specified. System cabinets shall conform to the following requirements: Steel frame and sides, freestanding, and fully enclosed. Front and rear access doors with key locks to allow access to racks. Cabinets shall be maintained at positive pressure using a fan powered by a 120-volt, single-phase motor with a minimum power output of 0.09 kW 1/8 hp. Maintain cabinet pressure at least at 125 Pa 0.5 inch water gage. Provide ventilation louvers as required. Size ventilation system to ensure adequate heat dissipation and to maintain continuous operation without loss of function or cause reduced life. Pressurizing air shall be filtered with a 98.5 percent minimum efficiency for dust particles one micron or larger. Control cabinet shall be equipped with a safety key interlock (and shall be located as indicated). Assemble cabinets in sections in sizes convenient for handling and moving into the steam plant, but with lifting eyes and shipping pallet for each separate section. Design cabinets to allow sections to be installed side-by-side. Provide side openings at the bottom of the sections as required to permit interconnection of the sections by prefabricated cables without routing the cables outside of the cabinets. Provide work light and one 120 VAC, duplex, 3-wire-polarized-grounding type, specification grade, convenience outlet in each cabinet.

2.12.4.2 Finish

Smooth, fill, and apply one coat of primer and two coats of finish paint to exterior surfaces. Apply one coat of primer and one coat of white paint to interior surfaces. Contractor shall furnish finish paint of type and color specified by the Contracting Officer.

2.12.4.3 Nameplates

Fabricate nameplates from laminated white phenolic plastic with black engraved letters. Size of nameplates shall be 40 mm high and 150 mm long 1 1/2 inches high and 6 inches long for "Master" nameplates, with 10 mm 3/8 inch letters. Individual device nameplates shall be 20 mm high and 80 mm

long with 3 mm 3/4 inch high and 3 inches long with 1/8 inch broad letters. Engrave designations as required later by the Contracting Officer. Nameplates shall be attached by permanent adhesive or screws. Self-adhesive, embossed plastic label tape is not acceptable. Fabricated bezels shall be laminated phenolic plastic with beveled edges, brushed aluminum or as approved by the Contracting Officer.

2.12.4.4 Graphics

****
NOTE: Refer to paragraph entitled "SPRAY DRYER ABSORBERS."
****

Provide the FGD system panelboard with a graphic subpanel to pictorially describe the flue gas cleaning system process to the operator. Graphic shall include pipelines, pumps, fans, equipment, tanks, vessels, valves, and dampers that are part of the process, with indicating lights and control switches located adjacent to the corresponding graphic equipment symbols. The graphic shall include the flue gas flow path for each of the [_____] spray dryer absorber and fabric filter baghouse systems. The graphic subpanel shall be provided with switches, indicating lights and other devices as required to control and display the status of the equipment. Indications provided shall include at least the operating status of the equipment. Indications provided shall include at least the operating status (running or stopped) of each pump, fan and other driven equipment and the position (open and closed) of each valve and damper. Graphic laminated acrylic symbols on a base of solid acrylic sheeting or panels shall be constructed of laminated phenolic. Acrylic sheeting shall be supported by the metal panel surface continuously. Laminated phenolic may be used as a subpanel. Base sheet shall be 6 mm 1/4 inch thick for phenolic, 5 mm 3/16 inch for acrylic. Color will be selected later from manufacturer's standard colors. Provide smoothly finished openings accurately sized for indicating lights, switches, meters, and oversized openings in panel metal behind acrylic sheeting. Attach base sheet with mechanical fasteners which allow for expansion and contraction of the base. Finish the edge between graphic base sheet and panel surfaces with a brushed stainless-steel trim. Graphic symbols, flow lines, nameplates shall be:

a. Material: Laminated acrylic sheeting.

b. Thickness: Equipment symbols, flow arrows, and nameplates (10 mm (0.40 inch; flow lines: 0.51 mm 0.020 inch).

c. Color: Solid white core with colored satin finish overlay. Colors will be selected later from manufacturer's standard colors.

d. Engraving: Engrave through colored overlay to expose solid core. Cut laminate with beveled edges (except flow lines) to expose solid core on perimeter of all symbols, nameplates, etc.

e. Mounting: Attach to front face sheet by means of contact cement that may be loosened by a solvent that will not damage face sheet or symbols. Use of double-faced adhesive tape is not acceptable.

2.12.4.5 Wiring

Interconnecting wiring between the system cabinets and panelboard-mounted

operating stations or subpanels and between separate sections of the system cabinets shall be prefabricated cables with plug-in connectors at both ends. Cable connectors shall incorporate a mechanical restraint between the mating halves to assure that each connecting pin-pair maintains electrical contact and that the connector does not separate due to mechanical vibration or cable sag. The male connector shall be of a design which protects the pins from damage during cable pulling and aligns the two halves accurately during mating. The connector shall be approved by the Contracting Officer. Prefabricated cables shall be rated 600 volt, 90 degree C conductor temperature, 18-gage minimum size copper conductors, overall neoprene or polychlorosulphonate jacket, and shielding if required. Prefabricated cable length between the panelboard and system cabinets shall be [_____] meters feet. Provide field terminal blocks in the Flue Gas Cleaning System panelboard or system cabinets as appropriate for analog and digital connections of remote devices. Transmitters furnished by this contract will be wired to terminals in the system cabinets and powered by the Contractor's power supplies. Field terminal blocks shall be grouped and wired into the system according to the function or site of the input or output signals to simplify termination of multiconductor field cables. Wiring shall be insulated switchboard wire rated for 600 volt ac, 60 hertz, 90 degree C conditions. Size shall be No. 14 AWG or larger for 120-volt ac control and indicating circuits, No. 20 AWG for low voltage (28 volts or less) devices, and No. 10 AWG or larger for 120-volt ac main power supplies and tap circuits. Use heavy-duty terminal blocks rated at least 20 amperes, 600 volts with not less than 15 mm 1/2 inch spacing between terminals. Terminal blocks for main power supply circuits and control bus termination shall be rated at least 40 amperes. Terminals shall be sliding-link type to allow individual circuit isolation for testing without disconnecting field or cabinet wiring. Terminal shall be designed to receive ring-tongue cable connectors on the field side. Terminal blocks for current transformer circuits shall be 2 or 4 point, as required, short-circuiting type with one shorting screw for each terminal. Identify each terminal on all blocks by stamping or permanently marking the terminal designation on the marking strip. Self-adhesive embossed plastic label tape is not acceptable. Mount terminal blocks vertically in rows on interpanels within the panelboard and system cabinets with provisions for cleating external cables entering from the bottom. Location of the terminal blocks shall be subject to approval by the Contracting Officer. No terminal blocks shall be mounted at a height less than 300 mm 12 inches. Provide a quantity of terminals sufficient for both signal and power circuits required to implement the system plus 10 percent spare for future modifications. Provide grouping of the following terminals: (1) Analog, (2) Annunciator, (3) Control. Provide a ground bus running the full length of the panelboard and system cabinet sections with No. 4-250 MCM lugs for ground cable connection at each end. The internal copper ground bus shall be at least 25 by 6 mm 1 by 1/4 inch. Connect internal grounds required to the ground bus. Furnish one two-tube, 40-watt, 120-volt fluorescent light fixture with a protective metal grill for the panelboard. Furnish 120-VAC, duplex, 3-wire polarized-grounding type, specification grade, convenience outlets in the panelboard. Furnish single-pole and three-pole fuse blocks with fuses for each set of relaying and metering potential circuits. Provide 20A molded-case circuit breakers for connections from control buses to miscellaneous equipment installed in or served from the panelboard or system cabinet. Provide plug-in strips for connection of 120 VAC supplies to meters and recording equipment where required.

2.12.4.6 Power Supplies and Switches

Furnish a circuit breaker panelboard in the FGD system panelboard. Furnish

mechanically interlocked, main circuit breakers mounted in the panelboard for switching or primary and backup power services. Furnish quantity as required. Furnish molded-case circuit breaker for each tap from the control bus to serve items requiring separate AC circuits. Provide one AC alarm relay connected to each AC bus with two sets of contacts to close after 2-second delay on loss of AC. Provide a 120-volt AC control bus and a 120-volt utility bus. Provide 24 VAC or VDC power supplies for low voltage indicating lights, meters, and transmitters, as required. Control switches shall be heavy-duty oiltight momentary contact, spring return unless otherwise specified, with normally open and normally closed contacts of adequate quantity. Switch handle types, colors, and retaining rings will be as required. Metal nameplates shall be used for position marking, but plastic nameplates shall be used for identification, as specified, unless otherwise noted.

2.12.4.7 Lights and Indicators

Indicating light size shall be nominal 15 mm 1/2 inch diameter and rating shall be 120 volts ac. Lens shall be transparent, color to be indicated later by the Contracting Officer, unless otherwise specified. Indicators shall be of the high-accuracy D'Arsenvol type. Provide indicators in groups, as required, with mounting hardware and frame. Meter movement shall be suitable for 4-20 mA dc input signal. Scale markings and colors shall be as required. Scales shall be illuminated.

2.12.4.8 Counters and Meters

Six-digit pulse counters to interface with 4-20 mA dc input shall be provided, as required. Meters shall be semi-flush mounting, 70 mm 2.7 inches square. Accuracy shall be rated at plus or minus 2 percent. Meter movement shall be 0-5 ampere AC, 0-1 milliampere DC signal. Scales shall be as specified with overload red lines. Pushbuttons shall be heavy-duty oiltight construction. Contacts shall be momentary, one normally open and one normally closed, unless otherwise specified. Button type and color shall be specified later by the Contracting Officer.

2.12.4.9 Recorders

Multipoint printing strip chart size shall be 254 mm 10 inchesnominal width. Chart speed shall be 50 mm 2 inches per hour, nominal. Printing period shall be 5 seconds per point or multi-speed using numbered dots or plus signs with color selected later by the Contracting Officer. Provide engraved legend plate and rubber legend stamp. Provide a 12 month supply of charts and ink for each instrument. Recorders shall be designed for 120 volt AC power. Supply one complete set of manufacturer's tools and accessories. Provide internal fluorescent illumination. Furnish input circuitry for thermocouple, RTD, voltage and current input signals. Provide three separately adjustable alarm points with latching relay for wiring to the annunciator. Miniature pen strip chart size shall be 100 mm 4 inch nominal width. Chart speed shall be 25 mm one inch per hour. Provide indicating scale for each pen and scale legend markings. Provide a 12 month supply of charts and ink for each instrument miniature pen strip chart recorder.

2.12.4.10 Annunciators

****

NOTE: Alarm sequence shall be the following.

Status	Visual	Audible
Normal	Off	Off
Alert	Fast Flash	On
Acknowledge	On	Off
Return to Normal	Slow Flash	Off
Return before Acknowledge	Slow Flash	Off
Acknowledge (Reset)	Off	Off
Test	On	Off

****

Annunciator shall consist of remote logic rack and separate lamp box assemblies for control room applications, and integral logic, terminal blocks, and lamp box assemblies for local control panels. Mount the remote logic racks for the system panelboard annunciator in the system cabinets. Provide prefabricated display cables to connect the remote logic with lamp box assemblies mounted in the panelboard. Equipment shall be constructed of the highest quality solid-state electronics, factory-tested and burned in. Trouble contact circuitry shall meet IEEE C37.90.1 Surge Withstand Capability Test. Provide repeat contacts for each window wired to terminals. Equipment shall be powered from the Government's 120-volt AC station service source. Arrange power supplies, circuit breakers, and input terminal blocks in groups to permit servicing single sections of the annunciator system without disabling the entire system. Alarm windows shall be full 50 by 80 mm 2 by 3 inch nominal size. Cable connectors to lamp box assemblies shall be right-angle type to allow rear connection and cable routing from below. Terminal blocks in equipment cabinets shall be slide-link type. Provide terminal marking strips. Alarm audibles for the annunciator systems shall be electronic tone generators with variable pitch and volume controls.

2.12.5 Temperature Monitor

Temperature monitor shall scan thermocouple inputs, monitor critical process conditions, and record temperature in degrees C degrees F and point number upon alarm or operator demand. Scanning shall be continuous; recording shall be automatic for each alarm detected. Input point number, process value, and alarm condition shall be printed on a strip recorder. Front panel controls shall enable the operator to select scanning rate, continuous scanning, single point or group scanning, and print-on-alarm or print-on-demand. A digital display shall present point number and value for visual monitoring of any or all selected points. In addition to critical process temperatures such as spray dryer and fabric filter baghouse inlet and outlet temperatures, inputs shall include bearing thermocouples and motor RTDs (one per motor). Instrument calibration accuracy shall be one half degree C one degree F, or better, throughout the temperature range of 18 to 149 degrees C zero to 300 degrees F and one percent full scale for process variables. Calibration stability shall be within one half degree C one degree F for six months with no adjustment, and equivalent value for process variables. Scanning rate of 6 points per

second, continuous shall be used. Print speed shall be 6 lines per second. Provide five separate high-temperature alarm comparators with dual field adjustable set points wired for assignment to groups of inputs. Provide one isolated lock-in type alarm contact for each alarm set point for wiring to external annunciator, and wired for manual reset from a remote push button. Monitor output printer shall be numeric strip chart, nonimpact ribbonless, roll-type with take-up reel. Provide extra supply of paper for printing at least 10,000 lines. Provide for flush panel mounting with printer, indicators, and operator's controls accessible from the front. Alarm set-point modules, input modules, and auxiliary chassis shall be mounted behind panel or adjacent to operator's controls. Controller sensing element shall be stainless-steel armored bulb and capillary, 7.62 meter 25 feet in length. Controller shall include the following features:

a. Reset and rate as specified.

b. Set point, proportional ban, reset and rate adjustment.

c. Pressure gages for supply and control pressure.

d. Indicator for process temperature.

e. Supply air pressure regulator.

Provide thermowell sized for the bulb in accordance with the thermowell specification. Temperature switch elements shall be dry contact (mercury switch contacts not acceptable) single-pole-dual-throw, rated for at least 120 volt AC, 4 amp or 125 volt DC, 0.5-amp. Switch enclosure shall be NEMA 12. Sensing element shall be stainless-steel armored bulb and capillary, or direct-mounted bulb, as specified. Provide thermowell sized for the bulb in accordance with the paragraph entitled "Thermowells." Factory adjust each switch to the proper setting before shipment to the jobsite. Indicate the factory setting on the device tag.

2.12.5.1 Thermometers

Thermometers shall be dial type with an adjustable angle suitable for the service. Provide thermowell sized for each thermometer in accordance with the thermowell specification. Fluid-filled thermometers (mercury is not acceptable) shall have a nominal scale diameter of 125 mm 5 inches. Construction shall be stainless-steel case with molded glass cover, stainless-steel stem and bulb. Stem shall be straight, length as required to fit well. Bimetal thermometers shall have a scale diameter of 90 mm 3 1/2 inches. Case shall be hermetic. Case and stem shall be constructed of stainless steel. Bimetal stem shall be straight and of a length as required to fit the well.

2.12.5.2 Thermocouples

Pipe thermocouples shall be Type J, iron-constantan element, ungrounded, for pipeline mounting in a thermowell. Provide protective sheath, screw terminal head, and the thermowell sized for the service specified. Element shall be at least 20 gage wire, with 2 hole insulators, 304 stainless-steel sleeve, silver plug tip, spring loaded. Head shall be universal type with screwed cover and chain and terminal connector. Provide stainless-steel nipple as required for head to clear insulation by at least 50 mm 2 inches. Well shall be sized for each thermocouple in accordance with the thermowell specification. Duct thermocouples shall have Type J ungrounded element with 20 AWG iron-constantan wires 2 hole insulators and universal head as

specified for pipe thermocouples. Protecting tube shall be as specified under thermowells. Bearing thermocouples shall have Type J ungrounded element with 20 AWG iron-constantan wires and 25 mm one inch insulator cemented over measuring junction. Element shall be mounted in 5 mm 3/16 inch spun and welded copper tube, sealed at open end. Head shall be as specified for pipe thermocouples. Surface thermocouples shall have ungrounded Type K element (chromel-alumel) at least 20 AWG suitably protected from high temperatures using fiberglass insulating jacket.

2.12.5.3 Resistance Temperature Detectors (RTDs)

Detector shall be three lead resistance sensor with protective sheath and screw terminal head for pipeline mounting in a thermowell. Accuracy shall be plus or minus 1/2 degree C 1 degree F or plus or minus 0.5 percent of reading, whichever is greater. Element material and nominal resistance shall be 10 ohm copper. Head shall be universal type with screwed cover, chain, and terminal connector. Provide stainless-steel nipple as required for head to clear insulation by at least 50 mm 2 inches. Element length shall be as required for the insertion depth and insulation thickness specified. Provide thermowell sized for the element in accordance with the thermowell specification.

2.12.5.4 Thermowells

****

NOTE: General. Provide thermowell for each temperature sensing element (thermometer, thermocouple, remote bulb, etc.) unless otherwise noted.

Insertion:

Piping: 65 mm minimum, 150 mm 2 1/2 inch minimum, 6 inchmaximum unless otherwise noted.

Ductwork: At least 1/2 duct depth but not over 910 mm 36 inch unless otherwise noted.

Lagging extension neck: As required to keep well wrench flats clear of insulation.

Protection: Provide cardboard inserts in each well to prevent internal damage prior to installing thermometer in installed well.

Pipeline Wells:

Bore: Straight or tapered bore sized to fit sensor.

Material: 316 stainless steel unless otherwise noted.

Ratings: Submit pressure vs. temperature and velocity vs. insertion length ratings for each type of well furnished. Submit calculations (to verify that wells are safe for the specified conditions) for special wells for which ratings are not available.

Duct Protecting Tubes:

Type	Material (unless otherwise noted)
25 mm Schedule 80 pipe, closed end	Wrought iron
25 mm standard weight pipe, closed end	Type 446 stainless steel
Adapter: Furnish adjustable flange type collar with companion flange to provide airtight seal on a 50 mm pipe nipple fastened on the duct or casing. The adapter must completely support the tube; no intermediate supports will be provided.	

Type	Material (unless otherwise noted)
1 inch Schedule 80 pipe, closed end	Wrought iron
1 inch standard weight pipe, closed end	Type 446 stainless steel
Adapter: Furnish adjustable flange type collar with companion flange to provide airtight seal on a 2 inch pipe nipple fastened on the duct or casing. The adapter must completely support the tube; no intermediate supports will be provided.	

****

Provide a well for each temperature sensing element (thermometer, thermocouple, remote bulb) unless otherwise noted. Include specifications of insertion length, shipping protection, bore, material, and any necessary adapters.

2.12.6 Pressure Gages

Gage connections shall be bottom for flush, surface or line mounting. Furnish scale ranges to produce a reading 60 to 70 percent of full scale during normal operating conditions. Service legends shall be printed on the gage face by the manufacturer. Include adjustments for set point and proportional band of pressure controllers. Provide pressure gages indicating supply and control pressures. Provide cleanout push button for cleaning restricted feed orifice without dismantling. Case shall be dust-tight with air bleed hole. Pressure switch elements shall be dry contact (mercury switch contacts not acceptable) rated for at least 120-volt AC, 4 amperes or 125-volt DC, 0.5-amperes. Contacts shall be single-pole-dual-throw, or as specified. Switch enclosure shall be NEMA 12. Sensing element shall be type and material suitable for the service. Factory adjust each switch to the proper setting before shipment to jobsite. Indicate the factory setting on the device tag. Provide brass pulsation dampeners and liquid fill with high viscosity silicon oil for all gages used for steam, water, air, or liquid service. Diaphragm seal materials shall be 316 stainless-steel diaphragm and bottom housing with a carbon steel top housing. Provide tip bleed feature for bourdon tube in pressure sensing element. Provide pigtail siphons for pressure gages in steam service. Fabricate siphons from 6 mm 1/4 inch seamless carbon-steel pipe, ASTM A106/A106M Grade A, Schedule 40.

2.12.6.1 Panel Gages

Panel gages shall be provided with 150 mm 6 inch diameter face. Accuracy shall be 1/2 of one percent of scale range. Case shall be aluminum or high-impact polypropylene reinforced with glass fiber; solid front face; blowout back. Dial shall be white laminated plastic with black markings.

2.12.6.2 Header Gages

Header gage face shall be 113 mm 4 1/2 inch diameter. Accuracy shall be one percent of scale range. Bourdon tube shall be bronze, brazed. Movement shall be stainless-steel geared. Case shall be polished stainless-steel. Dial shall be fabricated of aluminum.

2.12.6.3 Differential Gages

Differential gage accuracy shall be 1/2 percent of scale range. Pressure unit shall be rupture-proof, stainless-steel bellows. Body shall be 316 stainless steel with 6894 kpa (gage) 1000 psig safe working pressure. Dial shall be 150 mm 6 inch diameter.

2.12.7 Level Elements

Level controllers shall be electrode probe type and shall feature remote electronic enclosure rated NEMA 4 with integral level indicator. Zero and span adjustments shall be noninteracting. Proportional band adjustment shall be provided. Electronic output as required. Power input: 115-volt AC. Prefabricate cable to connect probe to transmitter with quick disconnect connectors. Probe and electronic circuitry shall be designed to provide reliable level control unaffected by coating or material buildup on probe. Liquid level switch elements shall be dry contact (mercury switch contacts not acceptable), single-pole-dual-throw, rated for at least 120 volt AC, 4 amperes or 125-volt DC, 0.5-amperes, unless noted otherwise. Switch enclosure shall be NEMA 12 unless noted otherwise. The float actuated cage shall be external type with temperature and pressure rating equal to or greater than the design rating of the vessel to which it is attached. The float and trim materials shall be stainless steel. Float-type switches shall not be used for slurry tanks. Differential-pressure type shall be indicating type switch. Electrode probe types shall be provided with remote NEMA 4 electronic enclosure with integral level indicator, and noninteracting zero and span adjustments. Power input: 115-volt AC, single phase 60 hertz. Probe to transmitter prefabricated cable with quick disconnect connectors. Level indication shall be unaffected by material buildup on probe.

2.12.8 Flow Elements

Flanged orifice plates shall be 3 mm 1/8 inch thick, 304 stainless steel, sized for the service. Furnish a calculated calibration curve based upon design flow conditions plotting flow versus differential pressure. Insertion flow elements shall be Pitot-tube type using 304 stainless steel as material. Provide pipe connections. Application shall be for water only. Provide inline-magnetic type with liner material and thickness to match the piping. Accuracy shall be plus or minus one percent of rate. Power supply shall be 110 volt AC, 60 hertz. Furnish prefabricated cable from primary element to transmitter. Provide integral indication of flow. Flow switch elements shall be dry contact (mercury switch contacts not acceptable) single-pole-dual-throw rated for at least 120-volt AC, 4 amperes or 125-volt DC, 0.5-amperes. Switch enclosure shall be NEMA 12,

except as noted. Materials and pressure ratings shall be compatible with the service. Flow switch shall be paddle, plunger, differential-pressure, or ultrasonic type. Ultrasonic flow switches shall be provided with one flow setpoint, unless otherwise noted. Provide individual adjustment of setpoint and time response delay. Power input: 115-volt AC, single phase, 60 hertz. Provide NEMA 4 enclosure for electronics and encapsulated sensor probes. Use only when other types are not recommended for the service. Flow controllers shall include adjustments for set point, proportional band, rate, reset, and specific gravity. Provide pressure gages indicating supply and control pressures. Provide cleanout push button for cleaning restricted feed orifice without dismantling. Design shall utilize high-temperature diaphragms and gaskets, and shall provide dust-tight case, and cooling fins.

2.12.9 Density Elements and Transmitters

Shall be nuclear type and shall be accurate within 0.001-SGU maximum. Signal shall be linearized. Response of measurement system shall provide adequate response time when tied to mass flow. Power supply shall be 115-volt AC, single phase 60-hertz. Furnish prefabricated cable as required from primary element to transmitter.

2.12.10 Fly Ash Level Alarms

****

NOTE: Alarm sequence shall be the following.

Status	Visual	Audible
Normal	Off	Off
Alert	Fast Flash	On
Acknowledge	On	Off
Return to Normal	Slow Flash	Off
Return before Acknowledge	Slow Flash	Off
Acknowledge (Reset)	Off	Off
Test	On	Off

****

Each fabric filter baghouse hopper shall be provided with a fly ash level alarm utilizing nuclear type detectors. The detectors shall be single-point gamma source and detection units. The detectors shall be complete with separately mounted electronic units which shall include a local high level indicating light and relays for use with annunciation system specified in paragraph entitled "Annunciators." Relays shall be rated 10 amperes, 120 volts AC. Switch housings shall be dustproof and shall be mounted as one easily accessible location. Detector and source electronics shall be located at the hopper control panel. Detector shall be explosion proof and have waterjacketing. Alarm shall be able to withstand vibration and temperatures up to 260 degrees C 500 degrees F. The source shall have a lockable shutter mechanism operated by an external handle to totally isolate the beam when in the closed position. Electrical

wiring schematic shall be furnished. Electrical supply shall be 115 volts AC, single phase, 60 hertz. Alarm level shall be located at the 50 percent hopper capacity level. Each hopper shall have two sensors; one at the alarm level and one at the empty level. Level reproducibility shall be within one inch. Outdoor components shall operate between [_____] degrees C and 93 degrees C degrees F and 200 degrees F. Source for each hopper level sensor shall be Cesium 137. Source head shall be designed with a spring return off system in the event of remote cable actuator failure. Source shall be interlocked with hopper access doors to prevent entry into hopper unless source has been secured. Hopper access door key shall only be able to open one pair of hopper doors.

2.12.10.1 Hopper Level Signals

Hopper level signals based on hopper status indicator system shall report to a microprocessor through a coaxial cable system. Each hopper shall have two indicators, one for full and one for empty. A flashing light shall indicate a wall buildup. Loss of power for any period of time shall not require a recalibration. Enclosure for microprocessor shall be [NEMA 4] [12] and shall be located in [_____]. Each group of detector units for a single fabric filter baghouse shall be incorporated into the unit alarm system for its respective baghouse so that a high level in any hopper shall indicate as part of the unit alarm system.

2.12.11 Transmitters

Each transmitter shall be selected and adjusted for the service and operating conditions required and shall be designed to operate at the maximum condition expected. Transmitters shall be electronic, two-wire type with 4-20 mA current signal output powered by 24-volt DC source unless specified otherwise. Enclosures shall have NEMA 4 rating as a minimum. Devices shall be designed to operate continuously under the ambient conditions specified. Furnish condensing pots for flow and level transmitters when required by the conditions of the measured fluid. Furnish seal pots or diaphragm seals where required for the fluid being measured. Furnish transmitter mounting brackets suitable for either surface or piping mounting. Furnish any power supply, transformer, rectifier, or other device required to interface the equipment with the system. Magnetic flowmeter transmitters (signal converters) shall be compatible with the primary elements. Ultrasonic level transmitters shall be protected from process fluid corrosion by resistant coating or material. Temperature compensation shall be within accuracy requirements. Integral output indication shall be graduated in engineering units. Accuracy shall be at least plus or minus 2 percent of measured range. Provide with coaxial cable from each probe to each transmitter. Provide with recommended installation hardware for flange mounting. Transmitter shall use doppler effect to filter out moving fill material during measurement.

2.12.12 Limit Switches

Limit switches shall be provided with DPDT contacts. Limit switches shall be provided with housing conforming to NEMA 4 requirements.

2.12.13 Gage Glasses

Glass shall be 20 mm 3/4 inch borosilicate type class red line tubular. Length shall be a maximum of 915 mm 36 inches per section. Use multiple overlapping sections for more than 915 mm 36 inches length allowing one inch visible overlap between sections. Gage valves shall be offset with 20

mm 3/4 inch union tank connection. Provide four guard rods with holders. Drain valve shall be 15 mm 1/2 inch globe-type needle valve.

2.12.14 Solenoid Valves

Valve body shall be brass of 316 stainless-steel as required by the operating conditions. Coil shall be rated for continuous operation in ambient temperatures up to 50C. Voltage shall be 120 volts AC, single phase, 60 hertz. Provide design features as required that include 15 mm 1/2 inch threaded conduit hub, explosion-proof construction, metal-to-metal seats, and manual operation.

2.12.15 Sulfur Dioxide Analyzers

Analyzers shall have a history of successful application in coal-fired boiler flue gas analysis. Performance shall be unaffected by high moisture content and high grain loading. Analyzers shall meet or exceed the applicable requirements of U.S. EPA Regulation 40 CFR 60, Appendix B. Provide control units, calibration gas, signal cable, mounting flanges, accessories, and appurtenances required for integration of the analyzers into the process control system.

2.12.16 Factory Tests

Notify Contracting Officer, in writing, 45 days prior to factory tests. Conduct standard tests required by the applicable codes and standards.The Contracting Officer's representative may be present as an observer during functional factory testing to assure correct operation of circuits. Perform factory control systems tests with control system components and prefabricated cables connected together, except transmitters and control drive units. Provide an open loop test of each control system to check for circuit continuity. Provide a completely closed loop simulation for each analog control system to verify function and response, and to check direction of response. Provide a completely closed loop simulation for each digital control system to verify sequence operation, timing, and software integrity. Test control boards as follows: Supply control boards with 115-volt AC, 60 hertz, and operate each control switch and selector switch in all positions to verify that control circuits operate ash shown on the schematic diagrams. Simulate remote contacts and switches with jumpers at the appropriate external terminal blocks to verify proper circuit operation. Test annunciator systems to verify that annunciator points operate correctly by jumpering or operating alarm initiating device or jumpering external terminals for remote alarm inputs.

2.12.17 Nameplates

Provide plastic, engraved nameplates for remote mounted devices. Fabricate nameplates from laminated white phenolic plastic with black engraved letters. Size shall be 19 mm high and 80 mm long 3/4 inch high and 3 inches long. Attach nameplates with permanent adhesive or screws.

2.13 STRUCTURAL AND MISCELLANEOUS STEEL

Provide structural and miscellaneous steel required to frame and support the spray dryer absorbers, fabric filter baghouses, ductwork, lime slurry preparation system, and component parts and equipment. Provide steel supports, access platforms, grating walkways and stairs for access to spray dryer absorbers, fabric filter baghouses, and other equipment, as specified in paragraph entitled "Access." Structural-steel supports shall be

designed to support equipment from the top of concrete foundations set at elevation [_____] (150 mm 6 inches abovegrade). All concrete foundations, anchor bolts and grouting will be provided by the Contractor. The Contractor shall allow 50 mm 2 inches for grout, so that the bottom of the baseplates provided under this contract shall be at elevation [_____]. Provide steel girts, purlins, braces and framing required for enclosures. Compliance submittals shall include general arrangement and outline information, foundation design information, structural fabrication information, and erection information. Unless otherwise specified, all structural steel shall conform to ASTM A36/A36M, as designated in the AISC 360, Part I. High-strength structural steel as listed in AISC may be used if it conform to the appropriate ASTM specification and subject to approval of the Contracting Officer. Structural steel includes columns, beams, trusses, baseplates, girts, secondary bracings, purlins, girders and hangers of structural steel. Miscellaneous steel includes steel other than structural steel such as edge plates, handrails, stairs, grating, ladders, and plate. Structural and miscellaneous steel shall be designed to resist not less than the minimum loadings. Design, fabrication, and erection of structural steel shall conform to the AISC 360 Manual of Steel Construction. Structural components shall be designed for wind loads with a minimum wind velocity of [_____] km/s mph. Design for seismic loads in accordance with Section 22 05 48.00 20 MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL. The entire structure along with components shall be designed in accordance with earthquake regulations for structures located in Zone [_____]. The site periods shall be between 0.8 and 1.2 seconds, whichever results in the highest lateral force. The term "W" as used in the calculations for seismic loading shall be interpreted as the normal operating weight of the unit including dead loads. Platform live loads may be excluded. The structural components shall be designed for a snow loading of [_____] kg per square meter pounds per square foot. The structural components shall be designed for dust loading of 98 kg per square meter 20 pounds per square foot. The structural components shall be designed for dust loading where appropriate based on 1600 kg per cubic meter 100 pounds per cubic foot minimum. Use a higher load where applicable. Walkways, platforms, and stairs shall be designed for live loads of 488 kg per square meter 100 pounds per square footplus concentrated equipment loads. Stair live load shall be 610 kg per square meter 125 pounds per square foot and shall be designed to carry the live load or a moving concentrated load of 454 kg 1000 pounds, whichever is greater. Roof purlins shall be spaced so that the metal roof deck span will not exceed 2.13 meters 7 foot. Design for a roof dead load of 98 kg per square meter 20 pounds per square foot and a live load of 148 kg per square meter 30 pounds per square foot.

2.13.1 Girts and Opening Frames

Provide girts for support of metal-wall panels with maximum spacing of 2.13 meters 7 foot center-to-center and supported on the outside face of the columns. Girts shall have a girt line or outside edge distance of 560 mm 1 foot 10 inches from the supporting column centerline. Lowest girt on spray dryer absorbers, fabric filter baghouses, and lime slurry preparation system enclosure to be located abovegrade (Elevation [_____]) with support at base of wall by Contractor. Provide closed ends or miter-cut girts at corners. Provide structural subframing for doors and ventilators located more than [_____] above grade. Contractor will provide doors, door frames, and ventilators and will also provide necessary structural subframing from these items up to [_____] above grade.

2.13.2 Slide Bearings

Provide structural slide bearings for spray dryer absorbers, ductwork, and fabric filter baghouse to ensure correct alignment, prevent equipment damage, ensure that stresses in the ductwork, fabric filter baghouse duct, and supports are not excessive, and to allow efficient system operation at conditions. Provide ductwork and fabric filter baghouse supports, except at totally laterally restrained points, with structural slide bearings. Construct slide bearings with slide bars or other methods to prevent possible accumulation of ash, dirt, and other materials on the bearing area. Slide bearings shall have fluoroplastic self-lubricating bearing elements.

2.13.3 Miscellaneous Steel

Handrail shall be 40 mm 1 1/2 inch round black standard weight pipe conforming to ASTM A53/A53M Type E or S, Grade B, with two horizontal pipe runs at 584 mm and 1067 mm1 foot 11 inches and 3 feet 6 inches above top of walking grating. Handrail, accessories, and kickplates shall be hot-dipped galvanized after fabrication in accordance with ASTM A123/A123M. Kickplates shall be 6 mm 1/4 inch thick steel plate. Steel floor grating shall be one-piece, resistance-welded steel construction without notching of bearing or crossbars before welding. Main bars shall be 5 mm 3/16 inch thick, spaced not more than 30 mm 1 3/16 inches on centers. Serrate main bars for outdoor use. Crossbars shall be spaced at four inches on centers and shall be one of the following shapes: hexagon with 8 mm 5/16 inch diameter of inscribed circle; rectangular 13 by 5 mm 1/2 by 3/16 inch; square 6 mm 1/4 inch with spiral twist; round 8.33 mm 21/64 inch diameter. Grating materials shall be of welding quality and conform to the following standards: (1) Crossbar - ASTM A108 - Grade 1010. (2) Main Bars - ASTM A108 - Grade 1015. Grating finish shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M. Stairs shall be open-riser type with grating treads and grating landings conforming to "Steel Floor Grating" an with main bars 25 by 5 mm 1 by 3/16 inch(Serrate main bars for outdoor use). Stair treads and landings shall be hot-dip galvanized after fabrication in accordance with ASTM A123/A123M. Stairs shall be supported with carrier plates 65 by 5 mm 2 1/2 by 3/16 inch by tread width tack welded to all bearing bars and with 5 mm 3/16 inch fillet welds (one side only) to the front two and the rear bearing bars, or supported with 35 by 22 by 3 mm 1 3/8 by 7/8 by 1/8 inch minimum size angle welded to the front and rear bearing bar (one side only). Provide subframing so grating span on landings does not exceed 1067 mm 3 feet 6 inches. Provide nosing on all treads and at the head of all stairs. Raised pattern floor plate shall be 6 mm 1/4 inch minimum thickness with surface deformation of the four-way type. Hot-dip galvanize raised pattern floor plate and straighten warped plate after galvanizing so that warpage does not exceed one inch for every 3 meters 10 feet in any direction.

2.13.4 Fabrication

Shop fabrication and assembly of steel structures shall be done in conformance with AISC Specifications, Codes, and Standards. Field welding shall be shielded metal arc or submerged arc. Shop welding shall be shielded-metal arc, submerged arc, flux-core arc, or gas metal arc. Welding shall be done in conformance with the requirements of the AWS D1.1/D1.1M and AISC Specifications. Field welds shall be shown on erection drawings in conformance to the applicable standards. Shop connections shall be welded, riveted, or bolted with high-strength bolts at the Contractor's option and as allowed by the seismic code. Unless restricted by

consideration of clearance or seismic design criteria, field connections shall be shown as bolted friction type using ASTM A325M ASTM A325 or ASTM A490M ASTM A490 bolts and shall be designed to conform to AISC specification for "Structural Joints Using ASTM A325M ASTM A325 or ASTM A490M ASTM A490Bolts." Form and weld handrails and do not exceed 1.83 meters 6 feet from center-to-center of posts. Grind welds smooth and even with the surface of the pipe, remove weld splatter. Carefully form transitions at corners where change of direction or elevation occurs as required to provide continuous handrail. Clear columns or other vertical or horizontal projections by at least 80 mm 3 inches. Furnish plates and additional items as required for fastening to supporting members. Extend kickplates 100 mm 4 inches above top of grating and install at the edge of uncovered openings and at the edge of walkways and platforms. Kickplates shall be constructed to allow water run-off. Shop fabrication shall be as complete as possible and within standard industry practice. Large pieces shall be left unassembled only to the extent necessary for shipment.

2.13.4.1 Grating

Fabricate grating main bars vertical within a tolerance of 2.5 mm per 25 mm 0.1 inch per inch of depth with the longitudinal bow before fastening to supports shall be less than 1/200 of the length and the traverse bow before fastening to supports shall be less than 10.41 mm in one meter 3/8 inch in 3 feet. Crossbars shall not deviate from a straight line perpendicular to the main bars by more than 5.21 mm in one meter 3/16 inch in 3 feet. Crossbars shall match crossbars of adjacent sections to form a continuous pattern of straight lines. Grating panels shall be cut to size and piece marked. Panel width and length tolerances shall be plus or minus 6 mm 1/4 inch. Provide openings in grating as required for installation of piping and equipment furnished under this Contract. Band openings 100 mm 4 inches and larger with a metal bar same size as main bearing bar. Weld to each bearing bar with 4.76 mm 3/16 inch fillet weld 19 mm 3/4 inch long. Tack weld to crossbars. Trim band open end of grating at head of ladder, manway opening, hinged sections, and grating panels with four crossbars or less. Grating shall be removable. Fasten raised pattern floor plate in place with countersunk stainless-steel screw at each corner of each piece or plug weld where permanent fastening is required. Screws shall be flathead, 6 mm 1/4 inch, national coarse thread stainless steel, and shall be countersunk.

2.13.4.2 Stairs

Construction of stringers of channel sections shall be adequate to carry the specified design loads without excessive deflection. Construct cross brace stringers to provide lateral stability where the horizontal run exceeds 3.66 meters 12 feet. Provide struts and hangers where required to suit specified live load with minimum size as specified. Bolt tread to stringers with a minimum of two 9.53 mm 3/8 inch, national coarse thread, stainless steel bolts.

2.13.5 Access

Provide access walkways across top of ductwork from boiler enclosures to spray dryer absorbers as indicated. Extend walkways to fabric filter baghouses as indicated. Stair access and platforms shall be supplied to fabric filter baghouse hopper accessories. Provide stair access and walkways for access to the tube sheet level of the fabric filter baghouses with connecting walkways. Internal and external access walkways, lights, and platforms shall be provided to access doors, inspection or maintenance points, and other areas where access is required for operation, inspection,

testing, and maintenance. Walkways and platforms at each level shall be interconnected by walkways at the same level. Walkways including roof, shall be connected by stairs. Caged ladders shall be provided at each level for secondary egress. Provide stair access and platforms to lime system equipment levels. Access shall be provided for dust valves, manholes, poke holes, hopper vibrators, conveyors, expansion joints, dampers, portion of the ductwork subject to dust accumulation, gas sampling points and all parts of equipment requiring routine maintenance, repair or replacement. Handholds shall be provided inside and outside directly above each access door. Access doors, and mechanical and electrical components shall be accessible from a walkway or platform. Complete layout of access system shall be subject to approval of the Contracting Officer.Provide supporting steel, grating, handrails, and kickplates electrical lights and outlets for walkways, stairs and platforms. Arrangement, design, and fabrication of access systems shall conform to OSHA regulations. Headroom shall be 2.13 meters 7 foot clear. Provide adequate allowance for installation of piping, conduit, electrical outlets, and lighting fixtures. Design exterior walkways and platforms which will be located above ductwork or other areas requiring insulation and lagging to allow a minimum of 150 mm 6 inches clearance between lagging and bottom of walkway structural steel assuming that insulation and lagging will be placed on top of ductwork stiffeners. Stairs, walkways, platforms, and ladders and their vertical support steel shall be located a minimum dimension of 0.91 m 3 foot from the outside column row centerline of structures for which the Contractor will be supplying and installing metal wall panel. Walkways width shall be 0.91 m 3 foot, minimum. Include handrail and kickplates around platforms. Design access stairs, as specified. Access stairs width shall be 0.91 m 3 foot, minimum. Include handrail along both sides, top rail to be 762 to 813 mm 2 foot 6 inches to 2 foot 8 inches above edge of tread. Stairs shall be open-riser type. Stair treads shall be as specified. Stairs shall have a minimum of 229 mm 9 inch tread and a maximum of 203 mm 8 inches rise. Minimum width of ladders shall be 457 mm 1 foot 6 inches. Rung diameter shall be 19 mm 3/4 inch. Rungs shall be spaced at 300 mm 12 inch on centers. Side rails shall be a minimum of 9.53 by 63.50 mm 3/8 by 2 1/2 inch. Exterior ladders and cages shall be hot-dip galvanized after fabrication in conformance with ASTM A123/A123M. Provide gas-tight and liquid-tight access doors to facilitate entry to parts of the flue gas cleaning system. Access doors shall be 610 mm 24 inch minimum diameter and the quick opening type. Access doors shall have ethylene propylene terpolymer (EPDM) gaskets. Provide access doors with hinges to support door when open. Provide access doors with external latches and tightening devices which allow for gasket shrinkage without loss of gas-tight seal. Provide safety chains on access doors to allow door to be cracked open slightly before opening completely. Provide a means of padlocking access doors in the open position. Provide inside and outside handholds directly above each access door.

2.13.6 Personnel Access Requirements

2.13.6.1 Class 1

Regularly attended areas shall have access operating platforms which are fully accessible by stairs. No ladder or ships ladders for access will be permitted. Areas included: Lubricated equipment, bearings, instruments, valve operators, damper operators, damper linkages and drives, test ports, instrument connections, and equipment requiring access during operation and for normal day-by-day inspection and maintenance. Platforms at same elevation on each side of equipment or building shall have a walkway connecting the two sides.

2.13.6.2 Class 2

Maintenance access areas such as expansion joints, duct access doors, safety valves, valve packing, and other areas requiring access every two years or more, shall have access platforms of adequate size to permit two people to work, 1.12 meter 12 square feet minimum, with access ladders and maintenance access walkways for reaching the platforms in accordance with the following: Maintenance access walkways shall be not less than 610 mm 2 foot in width. Ladders shall be as specified in paragraph entitled "Access." Headroom shall be 2.13 meters 7 footclear except 2 meters 6 foot 6 inches will be allowed in tight locations. Provide adequate allowance for installation of Government's piping, conduit, and lighting fixtures. Provide at least two avenues of escape from safety valves or other hazardous equipment.

2.13.6.3 Class 3

Maintenance access areas, where access is only required for painting, reinsulation, or replacement of components which have a service life of 10 years or more, shall be met by providing facilities to enable the erection of patent scaffolding, temporary ladders, platforms and safety nets to safely perform the work involved.

2.13.6.4 Maintenance Access Requirements

Provide rotating machinery and mechanical equipment components weighing in excess of 91 kg 200 pounds with monorails and eyebolts to permit the equipment to be removed and lowered to grade in a single lift.

2.13.7 Painting

The steel surfaces must be dry and clean in accordance with the following requirements. Remove grease, oils, and contaminants as outlined in SSPC SP 1. Remove weld spatter and grind burrs on cut edges and rough welds smooth. Blast-clean surfaces after fabrication, in accordance with SSPC SP 6/NACE No.3 and profile depth from 0.038 to 0.064 mm 1.5 to 2.5 mils. Apply first coat before any rust bloom forms. Apply one coat, dry film thickness of 0.076 mm three mils, of any of the organic zinc-rich primers meeting the requirements of SSPC PS 12.01, with a minimum of 82 percent zinc in the dry film. Apply primer in accordance with manufacturer's recommendations. Apply primer to steel surfaces except the areas within 50 mm 2 inches adjacent to field welds and surfaces specified to be hot-dip galvanized.

PART 3 EXECUTION

3.1 INSPECTION

As equipment is delivered to the jobsite, it shall receive a preliminary inspection by Contractor Quality Control Representative and the Contracting Officer. The inspection will be continued during the installation after installation, and during testing. The right is reserved to inspect equipment at the plant of the manufacturer, during or after manufacture, and to require reasonable witness tests before shipments are made. Government and Contractor Quality Control Representatives shall be allowed unrestricted access to manufacturing and fabrication facilities. Any equipment rejected shall be either corrected or replaced before installation. The Contractor shall provide field representatives for

technical direction of the erection, startup, and testing of the FGD system by the Contractor and for training of the Government's operating personnel.

3.1.1 Contractor Construction Representatives

The Contractor shall furnish experienced, competent, contractor construction representatives including travel and living expenses, to advise and consult the Contractor regarding erection procedures and quality standards for the equipment furnished. These inspection services shall be furnished from receipt of materials at the jobsite until the equipment and material furnished under this contract is ready for operation by the Government. The contractor construction Representative shall be responsible for the inventory and inspection of equipment and material furnished under this contract at delivery to determine if the equipment and material meets the requirements of the specifications for the Contractor's purpose of recovering, at the Contractor's option, the cost of new equipment and materials or the cost of corrections or modifications to the equipment, and materials from the Contractor's, subcontractors, or suppliers.

3.1.2 Contractor Construction Representative Areas of Work

The contractor construction representative shall advise and consult with the Contractor regarding the proper removal of equipment from rail cars, trucks, and other means of shipment, and the movement of material to and from storage facilities. Contractor shall advise Contracting Officer regarding the need for various classes of storage facilities. The Contractor shall advise the Contracting Officer regarding the protection of equipment while in storage. Contractor shall review the status of stored equipment and advise the Contracting Officer of any condition not in conformance with the Contractor's storage requirements. Contractor shall review the storage facilities to ensure the following:

a. Protection of motors, electrical equipment, and machinery of all kinds against corrosion, moisture deterioration including temporary wiring of motors space heaters while in storage, mechanical injury, and accumulation of dirt or other foreign matter.

b. Protection of exposed machined surfaces and unpainted iron and steel as necessary with suitable rust-preventive compounds.

c. Protection of bearings and similar items with grease packing or oil lubrication.

d. Handling and storing of steel plate, breeching sections, dampers, expansion joints, and similar items, in a manner to prevent deformation.

e. Blocking equipment and material stored outdoors, at least 6 inches above the ground and arranging for natural drainage with equipment drain connection open, but protected.

Contractor Construction Representative shall advise and consult with the Contractor regarding the erection of structural and miscellaneous steel, installation, and retightening of valves, welding of piping, installation of instruments and controls, installation of insulation and lagging, erection of bracing and scaffolding, grouting, retouching paint surfaces, protection of equipment from freezing, and alignment of equipment.

3.1.3 Field Service Engineer Representatives

Contractor shall include in his bid the cost of the services of competent, qualified field service engineers from the manufacturers of purchased equipment. Field service engineers shall provide consulting and advising services required for placing equipment into successful operation. Field service engineers shall be provided for the spray dryer, fabric filter baghouse, hopper heaters, fly ash level detectors, induced draft fans, pumps, dampers, control valves, air pollution monitors, FGD system panelboard, and analog control systems. Field service engineers shall perform an inspection prior to startup to verify that the unit is installed in conformance with the manufacturer's recommendations. A written report of the inspection, performed by the field service engineer, shall be submitted to the Contracting Officer stating his findings including the acceptability of the FGD system for field performance tests within 15 calendar days after his inspection. Field service engineer shall be on call for 30 days after start-up.

3.2 INSULATION INSTALLATION

3.2.1 General

Insulation shall be applied with interruptions to permit access doors, inspection doors, flanges, and other special features to be opened or removed for inspection or maintenance without disturbing the insulation. Boxouts around code stamping symbols and nameplates shall be provided. Double thickness insulation shall be installed with the joints of the two layers staggered. Cracks, voids, and depressions in layers of insulation shall be filled with suitable insulating cements before application of another layer of insulation as required to allow for thermal expansion movements which might cause cracks or tears in the insulation. Insulation shall be installed between stiffeners or over stiffeners in such a manner that stiffeners are completely insulated. Additional insulation or casing spacers shall be installed between stiffeners so that a uniform level surface is achieved. The intent of this insulating procedure is to prevent a direct metal path between inside the dry FGD system and ambient air. Insulation shall be securely wired and laced in place using No. 14 dead soft type 302 stainless steel wire, conforming to ASTM A580/A580M.

3.2.2 Block and Mineral Fiberboard Insulation Installation

Block and mineral fiberboard insulation shall be held in place with insulation lugs spaced on not greater than 300 by 450 mm 12 by 18 inch center. The lugs shall be stud type welded in place. Blocks shall be reinforced on the exterior face with expanded metal, if necessary, to prevent sagging or cutting of the insulation by the lacing wire. Block and mineral fiberboard insulation of the specified thickness shall be securely wired in place over the entire surface by means of wire threaded through the lugs both ways, pulled tight with the ends of the wire loops twisted together with pliers, bent over, and carefully pressed into the surface of the insulation.

3.2.3 Mineral Fiber Blanket Insulation Installation

Mineral fiber blanket insulation shall be held in place with speed washers and impaling pins spaced on centers not exceeding 300 mm 12 inches. Mineral fiber blanket insulation shall be provided with expanded metal reinforcement on the outer surface and wire mesh or expanded metal on the inner surface. Sections of the blankets shall be tightly butted and jammed

together, and securely tied for maximum sealing at joints. The blanket shall be secured at joints to prevent peeling or bulging away from blanket edges. Care shall be taken in applying speed washers so that the designed thickness of insulation is not reduced when washers are installed.

3.2.4 Protection From Insulation Materials

Equipment and structures shall be adequately protected from damage from insulation materials. After completion of the work, equipment and structures shall be cleaned, repaired, and restored to their original state. Casings which become corroded, discolored, or otherwise damaged shall be repaired by replacement of casing or other means acceptable to the Contracting Officer.

3.3 CASING INSTALLATION

3.3.1 Structural Steel Grid System

Casing shall be installed on aluminized structural steel grid system of subgirts designed, furnished, and installed by the Contractor. The subgirts shall be of sufficient size, gage, and depth to provide adequate support and a smooth exterior surface and shall be welded to the equipment and structural support surfaces. Subgirts shall be of sufficient depth to provide for application of the full thickness of insulation over the stiffeners, access doors, flanges, ribs, and other surfaces having uneven contours to provide a smooth finished surface. Subgirts on vertical and bottom surfaces shall be at a maximum spacing of 1220 mm four feeton centers. Subgirts on roof surfaces shall be at a maximum spacing of 600 mm two feet on centers. The walking surfaces shall be such as to transmit an external 114 kg 250 pound walking load from the casing to the structural steel grid system without compression of the insulation material.

3.3.2 Access Openings

Access doors and other penetrations through the insulation shall have insulation fitted closely to the fittings and shall be neatly framed and flashed to make weathertight and to create a pleasing appearance. Hinged or lift-off doors designed for convenient opening or removal shall be provided with nameplates, code stampings, and nonprojecting connections at all access openings. Access openings shall be pitched for water runoff and have flashing at door head as shown in SMACNA 1793.

3.3.3 Weatherproofing

Install casing with proper overlap to make the installation weathertight. The casing shall be carefully fabricated and fitted to ensure a neat appearance. Provide closures, flashings, and seals. The open ends of fluted sections shall be provided with tightfitting closure pieces. Flashing shall be suitably formed and installed so that water cannot enter and wet the insulation. The flashing shall be designed and installed to readily drain any water that might enter. Joints or openings in casing which cannot be effectively sealed from entry of moisture by flashings or laps shall be weatherproofed by application of an aluminum-pigmented sealer manufactured for this type of service.

3.3.4 Convection Stops

Furnish and install convection stops on vertical surfaces over 3.70 meters 12 feet tall. The maximum interval between convection stops shall be 3.70

meters 12 feet. The convection stops shall consist of steel channels or Z girts.

3.3.5 Casing Attachment

Attach aluminum casing to the steel structural members by means of No. 14 stainless steel series 300 self-tapping screws on 300 mm 12 inch centers. Fasten vertical laps and flashing by means of 10 mm 3/4 inch No. 14 stainless steel series 300 sheet metal screws on 300 mm 12 inch centers. Exposed screws shall have aluminum or stainless steel backed neoprene washers preassembled to screws. Installation shall be such that the insulation is not compressed below nominal thickness.

3.4 FIELD INSPECTIONS AND TESTS

3.4.1 General

Field testing of the equipment provided under this contract shall include the tests specified herein. Field testing will be performed by the Contractor and observed by the Contractor's field representatives as indicated in Section 01 45 00.00 10 01 45 00.00 20 01 45 00.00 40 QUALITY CONTROL. If the equipment fails to perform as required by this specification during any of these tests due to any deficiency in the Contractor's work, the cost of any repairs and any retesting required as a result of such deficiency shall be borne by the Contractor.

3.4.2 Hydrostatic Tests

After erection, piping systems shall be given a hydrostatic test 50 percent in excess of the design working pressure in accordance with the ASME BPVC Boiler and Pressure Vessel Codes (Sections I, II, V, VIII, and IX) and the applicable portions of ASME B31.1. Hydrostatic tests shall be conducted before any piping systems are encased by jacketing or insulation. Contractor shall provide cold water for the tests and suitable disposal facilities for wastewater after tests are complete. Contracting Officer has option to provide or not provide cold water or disposal facilities. Contractor shall furnish necessary equipment and materials required for testing including pumps, gages, temporary blank-off plates, gaskets, anchors, and bracing required to conduct tests. Contractor shall furnish and install an accurate pressure recorder and continuously record the pressure during the complete hydrostatic test. Contractor will furnish and install adequate relief valves to limit the maximum pressure that can be developed during the hydrostatic test to the specified test pressure. Tanks will by hydrostatically tested with clear water by filling to not less than 150 mm six inches from the tank top. Welds at tank bottom will be tested using a bubble technique, as specified in ASTM E515.

3.4.3 Smoke Tests

Spray dryer absorber vessels, fabric filter baghouse modules and breeching will be given a smoke test with smoke bombs producing a larger volume than available in the FGD system. The purpose of this test is to detect leaks due to shop and field welding and at expansion joints around seals. Test will be made by sealing gas inlets, outlets, and other openings. Pressure will be produced with a special pressure fan or with compressed air. Testing equipment and materials will be provided by the Contractor. Perform testing prior to the placement of insulation and lagging. Leaks found during the test will be repaired and the equipment will be retested until complete system is acceptable. Conduct tests at a pressure of 1245 Pa 5

inches W.C. Measure pressure with a suitable water manometer. High-intensity white smoke bombs shall be used to provide the means for leak detection. Contractor shall provide equipment and materials required for the tests including fans, compressor, blank-off plates, gaskets, and smoke bombs. Notify the Contracting Officer 48 hours in advance prior to conducting any smoke tests. Tests will be witnessed by the Government's Field Representative.

3.4.4 Acceptance Tests

****
NOTE: Method 17 of 40 CFR 60 may be used as an alternative to Method 5. Specify that testing shall include sootblowing where applicable in certain states. If necessary provide for steam venting. Test with fuel close to design parameters. Operate boiler close to design parameters.
****

****
NOTE: Since most Navy facilities are not base loaded determine turn down capabilities of system.
****

After a period of initial operation, a performance test will be conducted on the [entire steam plant] [dry FGD system]. Conduct tests to determine if, according to the Contracting Officer, equipment and systems provided under this contract appear to be operating in a reliable and satisfactory manner. Tests will be conducted to determine if the equipment is performing as specified. Conduct final acceptance tests for gas cleaning performance in accordance with the test procedures outlined in U.S. EPA regulation 40 CFR 60. Performance testing for the fabric filter baghouses shall conform to methods 1, 3, 5, 6, 7, and 9. [For the purpose of determining fabric filter baghouse performance, the term "particulate" shall not include material collected in the impingers of the Method 5 sampling train.] Performance simultaneously testing for sulfur dioxide removal efficiency will be based on testing upstream of the spray dryer sulfur dioxide absorber and downstream of the fabric filter baghouse utilizing Method 6. Three contiguous one-hour runs shall constitute one test. Tests shall be conducted on the flue gas cleaning equipment for each of the units. Conduct tests at both 50 and 100 percent of rated boiler capacity. The operating temperature limits specified will be maintained during the acceptance tests. [Sootblowers will [not] be operated during the performance test for sulfur dioxide removal or fabric filter baghouse performance]. Perform field performance tests by an independent testing organization approved by the Contracting Officer. The Contractor shall give written notice to the Contracting Officer, at least 45 calendar days before scheduled test date, stating that equipment is being scheduled for test. Perform a trial run of 30 days minimum before actual test to ensure that associated systems required for the test are ready. Contractor and the manufacturer's field service engineer shall witness the test. Tests shall be performed at design conditions herein specified. Conduct the efficiency tests after the gas cleaning system has been in continuous service for at least 45 days.

3.4.5 System Stoichiometry Tests

Contractor shall conduct system stoichometry tests for the flue gas cleaning systems. Measure system stoichiometry as the ratio of moles of

sorbent entering the spray absorber per mole of sulfur dioxide entering the spray absorber. Sulfur dioxide entering the spray absorber shall be determined by Method 6 of 40 CFR 60, Appendix A. Sorbent entering the spray absorber shall be calculated from the lime slurry feed rate and the calcium hydroxide content of the lime slurry as determined by ASTM C25. Conduct separate tests for each spray absorber. Tests shall be performed at both 50 and 100 percent of rated boiler capacity. Contractor shall consult with the Contracting Officer and with the Government's operators to coordinate schedules and operating conditions for the tests.

3.4.6 System Power Consumption Tests

Contractor shall measure the total power consumption of the flue gas cleaning system with boiler unit in operation at 100 percent of rated capacity. Power consumption shall be determined through the use of watt-hour meters provided by the Contractor for the purpose. Watt-hour meters shall be used at the power supply inputs to the motor control center for the lime slurry preparation equipment, the motor control center for the spray absorber-baghouse combination in operation, and the operating induced draft fan motor. The watt-hour meters used shall be accurate to within 1.0 percent. Coordinate test schedule and operating requirements with the Contracting Officer and the Government's operators.

3.4.7 Test Failures

In case any of the equipment furnished under this contract fails to operate as required, or in case of failure to meet any of the provided for in this contract, the Government shall have the right to operate the equipment until such defects have been remedied, and guarantees complied with as specified in paragraph entitled "Quality Assurance," without cost to the Government. Failure to meet guarantees for which a schedule of compensatory damages has been specified may be resolved, at the Government's Option, by deduction of compensatory damages from the final payment. Removal of rejected equipment shall be scheduled at the convenience and discretion of the Government. In the event that serious defects necessitate the rejection of equipment, the Government will have the right to operate the equipment until such time as new equipment is provided to replace the rejected equipment.

3.5 PAINTING

Provide field painting of those surfaces of the following equipment not in contact with the flue gas stream; cyclones, fabric filter baghouse, fans, dry scrubber, and ductwork. Field painting shall meet the requirements specified in Section 09 90 00 PAINTS AND COATINGS. Other equipment provided in this section shall be painted; either field-painted with systems conforming to the requirements specified in Section 09 90 00 PAINTS AND COATINGS or painted with factory or shop painting systems conforming to the requirements specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS.

3.5.1 Galvanic Corrosion Prevention

To prevent galvanic corrosion, care shall be used to prevent permanent contact of aluminum casing with copper, copper alloy, tin, lead, nickel alloy including Monel Metal. Where it is necessary to attach the casing to carbon steel or low alloy steel, the steel shall first be prime painted with zinc chromate, and then painted with aluminum paint suitable for surface temperatures encountered. The use of lead base paint is not

acceptable.

3.6 SCHEDULE

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

Products	Inch-Pound	Metric
a. [_____]	[_____]	[_____]

-- End of Section --