Pakistan
Water and Power Development Authority

Lakhra Coal Mine and Power Generation Feasibility Study

Power Plant Feasibility
Volume IV

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Prepared by

Gilbert/Commonwealth International, Inc.

LAKHRA COAL MINE AND POWER GENERATION FEASIBILITY STUDY

POWER PLANT FEASIBILITY

VOLUME IV

Submitted to

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

and

PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

By

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LAKHRA POWER FEASIBILITY STUDY

MATERIAL SPECIFICATIONS

Chemicals:	Polyelectrolytes Aluminum Sulfate Chlorine Caustic Soda Sulfuric Acid Anhydrous Ammonia Lime Hydrazine Solution Trisodium Phosphate

No. 2 Fuel Oil

No. 6 Fuel Oil

Limestone

POLYELECTROLYTES
SPECIFICATION

TRADE NAME:	Polyelectrolytes	
SYNONYMS:		
FORMULA:	Various	Formula Wt. Varies
PROPERTIES:	All are high polymer substances primarily synthetic. Various types of polymers may be required with varying properties.	
	Raw Water Treatment	- Anionic, Cationic
	Wastewater Settling	- Anionic, Cationic
	Recirculating Water System	- Cationic, Non-Ionic, Anionic
GRADE AND PURITY:		
USE:	Raw Water Treatment Recirculation Water	
ESTIMATED QUANTITIES:	Not Known - Jar Tests and Operating Experience Required	
PACKING AND SHIPPING:	U.S. D.O.T. Regulations	
REMARKS:	Polyelectrolytes shall be tested and recommended by a Vendor. Dosages, feed equipment, handling and storage to be determined based on recommendations. Polyelectrolytes used in potable water treatment shall be those approved by U.S. Public Health Service.	

ALUMINUM SULFATE
SPECIFICATION

TRADE NAME:	Alum
SYNONYMS:	Aluminum Sulfate
FORMULA:	$Al_2(SO_4)_3.14H_2O$ Formula Wt. 546.1
PROPERTIES:	Hydrated aluminum sulfate or "alum" is an opaque white solid. Standard commercial grade corresponds to $Al_2SO_4.XH_2O$ where X is approximately equal to 14.
GRADE AND PURITY:	Commercial grade, not less than 17.0% Al_2O_3 for solid and not less than 8% Al_2O_3 for liquid alum. No soluble organic impurities. Solid alum shall be ground of a size so that no less than 90% shall pass through a No. 10 U.S. Standard sieve and 100% shall pass through a No. 4 U.S. Standard sieve. Liquid alum shall be reasonably clear. Soluble iron content shall not exceed 0.75% on the basis of 17% Al_2O_3. Insoluble matter shall not exceed 0.5% in powder and 0.2% in liquid. Alum shall be at least 99.5% pure. Limitations on other impurities are calculated on the basis of $Al_2SO_4.14H_2O$.

Arsenic	30 mg/kg
Cadmium	7 mg/kg
Chromium	30 mg/kg
Lead	30 mg/kg
Mercury	1 mg/kg
Selenium	7 mg/kg
Silver	30 mg/kg

USE:	Coagulation of Raw Water
ESTIMATED QUANTITIES PER UNIT:	410-465 Metric Tons (450-515 tons)/Year
PACKING AND SHIPPING:	Solid packing in lined 40 kg (88 lb.) bags. Liquid in barrels. Containers to be suitable and in compliance with U.S. D.O.T. Regulations. Each container shall carry clear identification.
REMARKS:	Reference Methods ASTM-E-11 ASTM-117H Standard Methods for the Examination of Water and Wastewater

LPS/2/B2157/D2

CHLORINE
SPECIFICATION

TRADE NAME:	Chlorine
SYNONYMS:	
FORMULA:	Cl_2 Formula Wt. 71.0
PROPERTIES:	A greenish yellow gas that liquifies under modest pressure to form an amber colored liquid. It is highly corrosive and has a pungent noxious odor. Solubility in water is 0.72 g/100 ml @ 20°C (68°F). At atmospheric pressure liquid chlorine boils @ -35°C (-31°F) and freezes at about -100°C (-148°F). At room temperature, the vapor pressure is about 600 kPa (87 psi) but @ 37.8°C (100°F) the vapor pressure increases to 1000 kPa (145 psi). Chlorine is 2.5 times as dense as air. One volume of liquid yields 460 volumes of gas.
GRADE AND PURITY:	Chlorine shall contain no soluble mineral or organic substances, shall be 99.8 percent pure. Limitations on impurities:

Moisture	150 mg/kg
Heavy metals	30 mg/kg
Lead	10 mg/kg
Mercury	1 mg/kg
Arsenic	3 mg/kg
Carbon tetrachloride	150 mg/kg
Trihalomethane	300 mg/kg
Total Residue	150 mg/kg

USE:	Biocide-disinfection of: raw water, recirculating cooling water, sanitary effluent and potable water.
ESTIMATED QUANTITIES PER UNIT:	105-140 metric tons (115-150 tons)/year
PACKING AND SHIPPING:	One (1) ton cylinders in accordance with U.S.D.O.T. Requirements. Each container shall carry precautionary information and clear identification.
REMARKS:	Reference test methods ASTM-E-412-70 ASTM-E-410-70

CAUSTIC SODA
SPECIFICATION

TRADE NAME:	Caustic Soda
SYNONYMS:	Sodium Hydroxide, Sodium Hydrate, Lye, White Caustic
FORMULA:	$NaOH$ Formula Wt. 40
PROPERTIES:	Anhydrous Caustic Soda has a white color and a micro-crystalline structure. It attracts moisture and absorbs it from atmosphere. 50 percent solution has an alkali equivalent of 38.74 percent and specific gravity of 1.53 @ 15.6°C (60°F). Sodium Hydroxide is not combustible but reacts with many substances, attacks many metals. Reacts violently with generation of heat when mixed with water.
GRADE AND PURITY:	50 percent solution, commercial grade with less than 2 mg/kg of Mercury. No soluble or organic impurities. Minimum 99.5 percent $NaOH$.
USE:	Demineralizer regenerant and pH adjustment.
ESTIMATED QUANTITIES PER UNIT:	465-525 metric tons (510-580 tons)/year
PACKING AND SHIPPING:	Bulk delivery. The Vendor shall pack the chemical in suitable containers in compliance with U.S. D.O.T. Regulations. Each container shall carry precautionary information and clear identification.
REMARKS:	Sampling shall be in accordance with AWWA-501-75. Analysis are to be performed according to "Standard Methods for the Examination of Water and Wastewater", American Public Health Association, Washington, D.C.

SULFURIC ACID
SPECIFICATION

TRADE NAME:	Sulfuric Acid
SYNONYMS:	Oil of Vitriol, Battery Acid
FORMULA:	H_2SO_4 Formula Wt. 98.0
PROPERTIES:	Highly corrosive, dense oily liquid, colorless to dark brown. Soluble in water, very reactive. Spr. gr. of pure acid = 1.85, 66° Be - sp. gr.= 1.84
GRADE AND PURITY:	Commercial grade 66° Be (93.2%) - No soluble or organic impurities. Acid shall be at least 99.5% pure. Limitations on impurities:

Non Volatile Matter	250 mg/kg
Selenium	20 mg/kg
Arsenic	20 mg/kg
Lead	20 mg/kg

USE:	Demineralizer regenerant, recirculation water pH control, and wastewater treatment
ESTIMATED QUANTITIES PER UNIT:	700-815 metric tons (770-900 tons)/year
PACKING AND SHIPPING:	Bulk delivery. Chemical to be packed and shipped in suitable containers in compliance with U.S. D.O.T. Regulations. Each container shall carry precautionary information and clear identification.
REMARKS:	Use great caution in mixing with water.
	Reference Methods ASTM E-223, D1193.

ANHYDROUS AMMONIA
SPECIFICATION

TRADE NAME:	Ammonia, Anhydrous
SYNONYMS:	
FORMULA:	NH_3 Formula Wt. 17.0
PROPERTIES:	Colorless, liquified gas. Corrosive and has a pungent odor. Can form explosive mixtures in air. Lighter than air. Vapor pressure at 20°C (68°F), 8.5 atmosphere sp. gr. at 0°C (32°F) = 0.77. Very soluble in water.
GRADE AND PURITY:	Commercial grade, 99.9% pure. Limitations on impurities:

Total Heavy Metals	- 30 mg/kg
Oil	- 50 mg/kg
Moisture	- 200 mg/kg
Mercury	- 1 mg/kg
Arsenic	- 3 mg/kg
Lead	- 10 mg/kg
Non Volatile Residue	- 50 mg/kg

USE:	Boiler feedwater additive.
ESTIMATED QUANTITIES PER UNIT:	2.5 - 3.5 metric tons (2.5-3.8 tons)/year
PACKING AND SHIPPING:	Suitable cylinders in compliance with U.S. D.O.T. Regulations. Each container shall carry precautionary information and clear identification.
REMARKS:	Reference Methods, ASTM-D96.

LIME
SPECIFICATION

TRADE NAME:	Lime
SYNONYMS:	Quick Lime, Calcium Oxide
FORMULA:	CaO Formula Wt. 56.
PROPERTIES:	Essentially calcium oxide which results from calcination of limestone sp. gr. 3.2-3.4. Hydrated lime sp. gr. 2.3-2.4. Lime is white or grayish white sometimes with a tint due to iron impurity. Solubility is 1g/840 ml at 25°C (77°F).
GRADE AND PURITY:	Commercial. No soluble mineral or organic substances. Lime shall be freshly burnt and contain no more than 5% insoluble material. It shall be substantially free of carbonate solids and silicons residue. Material shall be crushed and screened so that none will be retained in 19 mm sieve and not more than 5% shall pass a No. 100 U.S. standard sieve. Minimum acceptable CaO = 80%. Limitations on other impurities:

Arsenic	10 mg/kg
Cadmium	2 mg/kg
Chromium	10 mg/kg
Lead	10 mg/kg
Selenium	2 mg/kg
Silver	10 mg/kg

USE:	Raw Water Treatment Wastewater Treatment
ESTIMATED QUANTITIES:	Varying
PACKING AND SHIPPING:	Bulk Shipment
REMARKS:	Reference Test Methods ASTM C-41-47 ASTM C-110-76a ASTM C-25

HYDRAZINE SOLUTION
SPECIFICATION

TRADE NAME:	Hydrazine
SYNONYMS:	Hydrazine Base, Diamine
FORMULA:	H_2NNH_2 Formula Wt. 32.0
PROPERTIES:	Colorless, hygroscopic. Miscible with water. Strong reducing agent and diacidic but weak base.
GRADE AND PURITY:	Clear, water white aqueous solution containing minimum 22% hydrazine. Limitations on impurities:

1. Chemical shall be free of sediment.
2. Hydrazine solution shall contain not less than 21% or more than 24% by weight of hydrazine.
3. Chloride content shall be less than 300 mg/kg.
4. Dissolved matter shall be less than 300 mg/kg.
5. Sp. gr. range 1.011-1.015.

USE:	Boiler Feed Water Treatment
ESTIMATED QUANTITIES PER UNIT:	1600 Kg (3500 lb)/year
PACKING AND SHIPPING:	Carboys. Packaging and shipping in compliance with U.S. D.O.T. Regulations. Each container shall carry precautionary information and clear identification.
REMARKS:	Reference Test Methods ASTM D941-55 ASTM D1069-58

TRISODIUM PHOSPHATE
SPECIFICATION

TRADE NAME:	Trisodium Phosphate
SYNONYMS:	Tertiary Sodium Phosphate, Sodium Phosphate TRIBASIC
FORMULA:	$Na_3PO_4 \cdot 12\ H_2O$
PROPERTIES:	Colorless crystals; soluble in water, sp. gr. 1.62, loss 12 molecules of water at 100°C.
GRADE AND PURITY:	Technical grade, chemical shall contain no more than 0.1 percent insoluble material and shall be 99.9 percent pure. 1 percent solution shall have a pH of 11.8 - 12.0. Chemical shall be free from impurities.
USE:	Boiler Feedwater
ESTIMATED QUANTITY PER UNIT:	470 Kg - 580 Kg (1025-1280 lb)/year.
PACKING AND SHIPPING:	Chemical shall be packaged in bags and barrels. Each container shall carry precautionary information and clear identification.
REMARKS:	Reference Methods ASTM E-70

NO. 2 FUEL OIL SPECIFICATION

Use: ignition oil for warming the steam generator prior to introduction of coal. Primary fuel for auxiliary boiler and emergency diesel generator. Fuel shall meet the requirements of ASTM Standard D396, Specifications for Fuel Oils.

RANGE OF CONSTITUENTS

	Minimum	Maximum
Weight, percent		
Sulfur	0	.7
Hydrogen	11.8	13.9
Carbon	86.1	88.2
Nitrogen	Nil	0.1
Oxygen	-	-
Ash	0	Trace
Carbon Residue	0	Trace
GRAVITY		
Deg API	-	30
Specific	-	.8762
kg/l (lb/gal)	-	.874 (7.296)
POUR POINT, ^{o}C (^{o}F)	-	-7 (20)
VISCOSITY		
Saybolt viscosity, sec universal at 38^{o}C (100^{o}F)	32.6	37.93
Kinematic viscosity, centistokes at 38^{o}C (100^{o}F)	2.0	3.6
WATER AND SEDIMENT, VOL. %	0	.10
FLASH POINT ^{o}C (^{o}F)	38 (100)	-
HEATING VALUE		
kJ/kg (Btu per lb), gross	44,587 (19,170)	-

NO. 6 FUEL OIL SPECIFICATION

Use: To be used either as fuel for supplemental firing in the steam generator or as alternate fuel to Lakhra coal for the steam generator. Fuel shall meet the requirements of ASTM Standard D396, Specifications for Fuel Oils.

RANGE OF CONSTITUENTS

	Minimum	Maximum
Weight, percent		
Sulfur	.7	3.5
Hydrogen	9.5	12.0
Carbon	86.5	90.2
Nitrogen	-	-
Oxygen	-	-
Ash	-	0.08
Carbon Residue	-	12.0
GRAVITY		
Deg API	22	12
Specific gravity	.9218	.9861
kg/l (lb/gal)	.920 (7.676)	984 (8.212)
POUR POINT, ^{o}C (^{o}F)	-	18.3 (65)
VISCOSITY		
Saybolt viscosity, sec universal at 38^{o}C (100^{o}F)	900	9000
Fural at 50^{o}C (122^{o}F)	45	300
WATER AND SEDIMENT, VOL. %	-	2.0
FLASH POINT ^{o}C (^{o}F)	65 (150)	-
HEATING VALUE		
kJ/kg (Btu per lb), gross	42,703 (18,360)	-

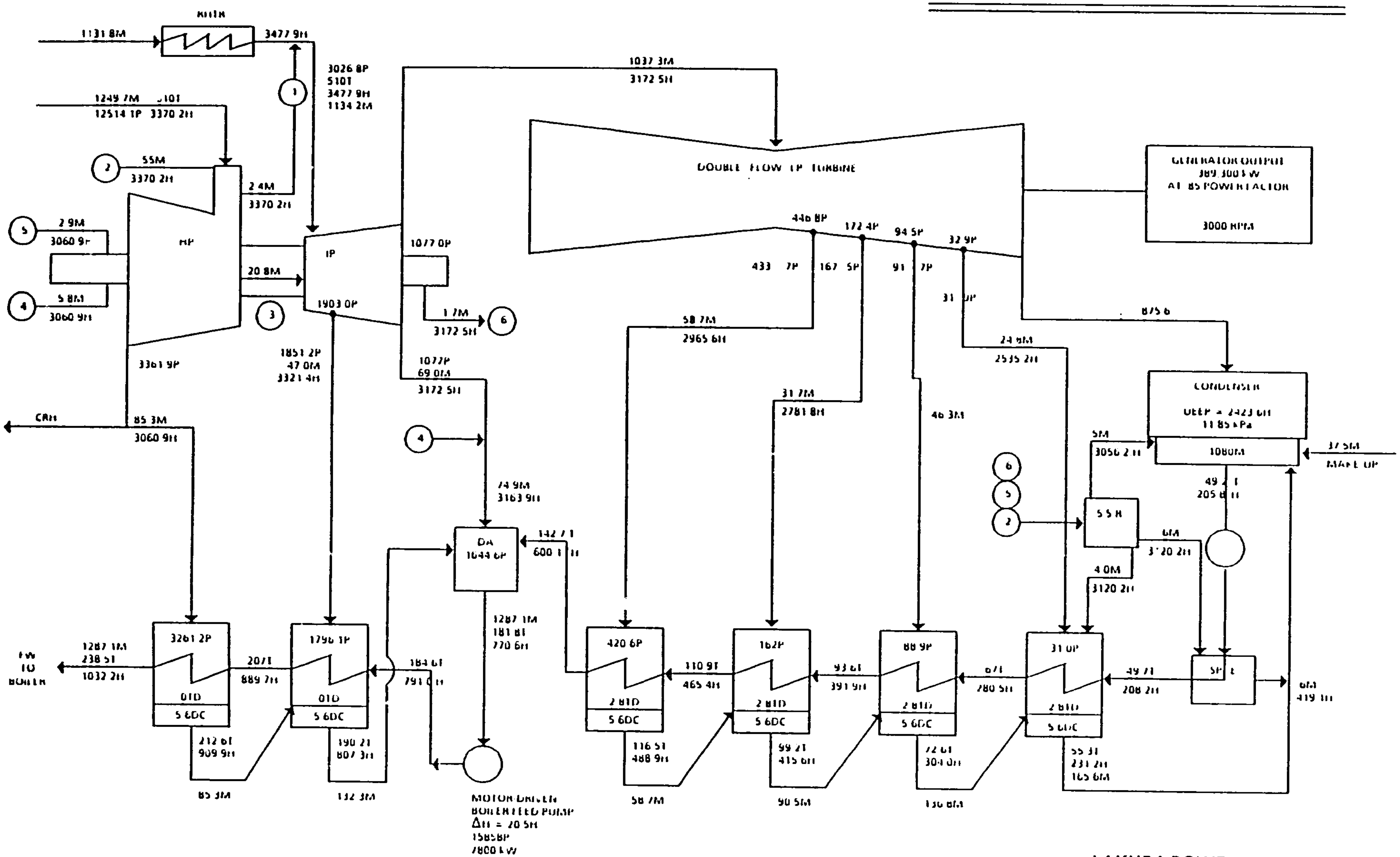
LPS/2B2872/D5

LAKHRA POWER FEASIBILITY STUDY

MECHANICAL DIAGRAMS

No.	Title
M-1	Water Balance
M-2	Water Treatment
M-3	Fire Protection
M-4	Compressed Air
M-5	Auxiliary Steam
M-6	Material Balance
HB-1 (SI)	Turbine Heat Balance (11.85 kPa, 3% M.U.)
HB-2 (SI)	Turbine Heat Balance (8.47 kPa, 0.5% M.U.)
HB-1 (English)	Turbine Heat Balance (3.5"HgA, 3% M.U.)
HB-2 (English)	Turbine Heat Balance (2.5"HgA, 0.5% M.U.)

GUARANTEED – 11.85 kPa, 3% MU, TC2F



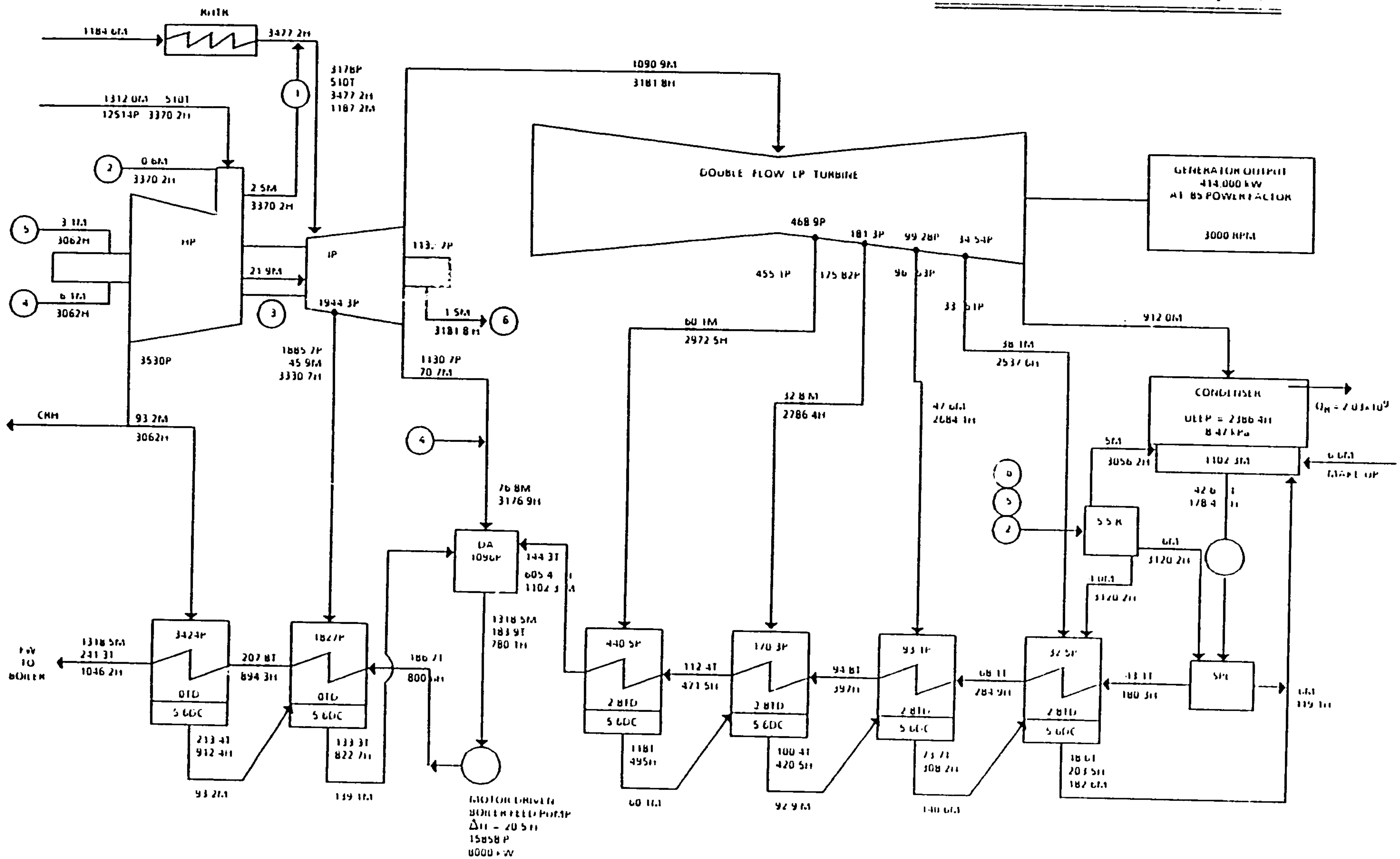
GROSS HEAT RATE = 8717 kj/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – °C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-1

B1619-4/GF#72

VWO – NP – 8.47 kPa, 0.5% MU, TC2F



GROSS HEAT RATE = 8554 kj/kWh
(Heat Rate May Vary Depending
on T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – °C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-2

81619-2/GF#72

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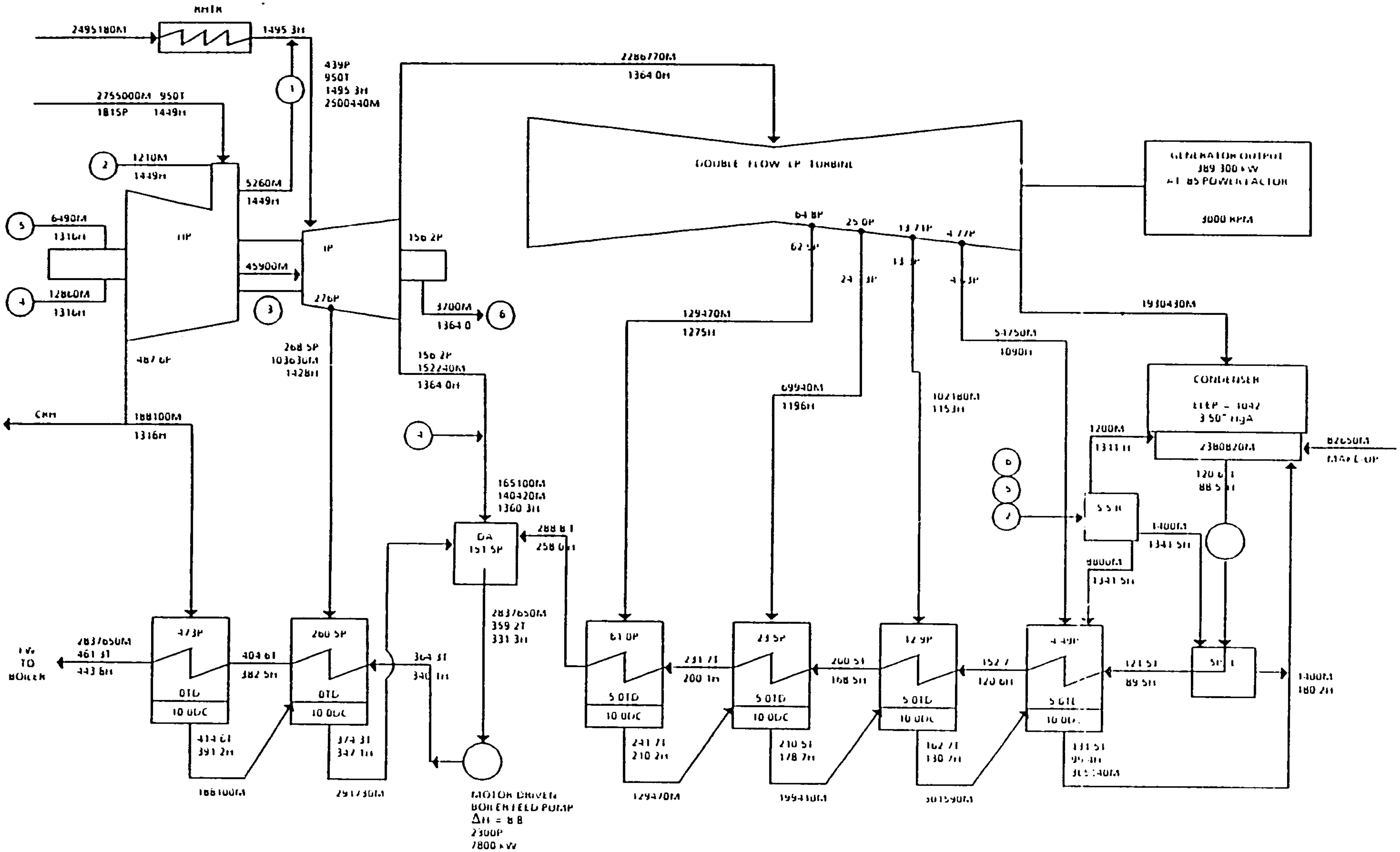
GUARANTEED – 3.5" HgA, 3% MU, TC2F



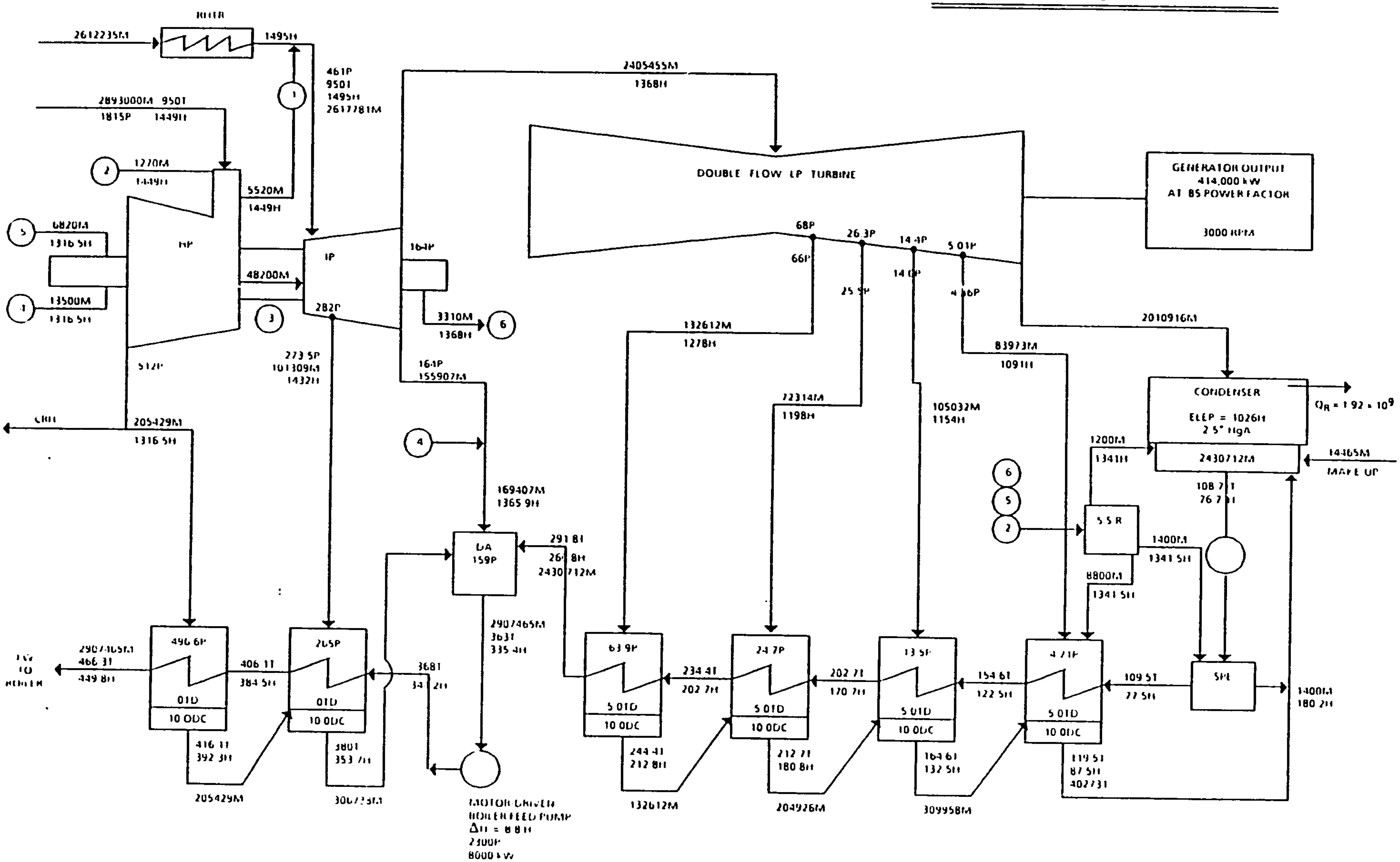
GROSS HEAT RATE = 8263 Btu/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – °F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
ENGLISH UNITS
G/C II 11/12/85 HB-1

B1619 3/GF #72

VWO – NP – 2.5" HgA, 0.5% MU, TC2F



GROSS HEAT RATE = 8108 Btu/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – °F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
ENGLISH UNITS
G/C II 11/12/85 HB-2

1619 1/GF #72

LIMESTONE SPECIFICATION

PROPERTIES:	A sedimentary rock composed principally of calcium carbonate (the mineral calcite) or double carbonate of calcium and magnesium (the mineral dolomite) or mixture of the two
GRADE AND PURITY:	H_2O maximum 0.20% $MgCO_3$ minimum 0.50% $CaCO_3$ minimum 90% Inerts maximum 8.5% Total neutralizing value minimum 95%
USE:	As reagent in flue gas desulfurization system
GRADATION:	19mm x 0 (3/4" x 0)
BOND WORK INDEX:	7 to 12
ESTIMATED QUANTITIES PER UNIT:	41 tonnes/hour (46 tons/hour)
PACKING AND SHIPPING:	Bulk delivery by rail
REMARKS:	Samples for testing to determine the characteristic chemical and physical properties shall be representative of the limestone to be used and shall be selected per ASTM D-75

LAKHRA POWER FEASIBILITY STUDY

SPECIFICATION M-1

BOILER ISLAND

SPECIFICATION M-1

BOILER ISLAND

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LAKHRA POWER FEASIBILITY STUDY
SPECIFICATION M-1
BOILER ISLAND

1.0 DESCRIPTION OF WORK

The work to be performed includes designing, fabricating, furnishing of materials and components, packaging and delivering to the jobsite two boiler islands to serve two nominal 350 MW net nominal reheat, condensing turbine generator units for the Water and Power Development Authority of Pakistan (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

The work shall include, but not necessarily be limited to the following items:

a. Steam drum.

b. Furnace and waterwalls.

c. Superheater.

d. Reheater.

e. Economizer.

f. Pulverizers, classifiers, feeders, primary air fans, coal piping, and burners.

g. Light oil ignition system.

h. Breeching connecting the economizer outlet to the air heaters, air ducts connecting the air heaters to the burner windbox and coal pulverizers, tempering air ducts to the coal pulverizers, control dampers, shutoff dampers, and expansion joints.

i. Casing, frames, and structures.

j. Hanger rods, springs, bearing plates, bolts, and nuts for attachment to the building structural steel.

k. Regenerative air heaters.

l. Necessary openings for soot blowers with wall boxes.

m. Thermocouples and temperature probes.

n. Boiler trim and safety valves.

o. Piping for vents and drains.

p. Steam soot blowing equipment including controls.

q. Test connections, draft gauge connections, thermocouple connections, pressure gauge connections, and all other connections which will be located in the boiler casing, breechings, ductwork, piping, or other components being furnished by the Vendor.

r. All electric motors shall be furnished in accordance with the requirements of Attachment 8.

s. The services of technical representatives to direct installation and startup and to train operating plant personnel.

t. Burner control and flame safety systems.

u. Centrifugal forced draft fans including inlet vane control mechanisms, outlet isolation dampers, inlet boxes, inlet cones, inlet screens, inlet silencers, flexible couplings and including the necessary lubricating oil pumping stations.

v. Modified radial tip centrifugal induced draft fans including inlet vane control mechanisms, outlet isolation dampers, inlet boxes, inlet cones, inlet screens, inlet silencers, flexible couplings and including the necessary lubricating oil pumping stations.

w. Electric motors.

x. Structural steel including coal silos, structural columns, cross-members and bracing for the steam generator and accessories, air ducts, gas breechings, stairs, ladders, platforms, handrails, etc.

y. Bottom ash handling system including clinker grinders, jet pumps, shutoff gates, bottom ash hoppers, and controls.

3.0 WORK NOT INCLUDED

The following items are not included in the requirements of this Specification and will be accomplished by Others:

a. All concrete foundations and embedded foundation bolts.

b. Chimney.

c. Fly ash handling system.

d. Piping from the second shut-off valves.

e. Finish painting.

f. Ignition oil pumping system.

g. Switchgear, motor starters unless otherwise specified, wiring unless otherwise specified, motor control centers, and distribution panels.

h. Fuel, water, electric power, air, nitrogen and chemicals for drying out, boiling out, chemical cleaning, washing, testing, preliminary operation, and performance testing.

i. Erection of all equipment.

j. Combustion, feedwater and steam temperature control system.

k. Finish painting.

l. Connecting steam, water, oil, air, chemical, feed and other piping.

m. Water treatment equipment.

n. Bottom ash pumps and piping.

4.0 APPLICABLE CODES, STANDARDS, AND REGULATORY REQUIREMENTS

4.1 Design, materials, manufacture, installation, examination, testing, inspection, and documentation shall conform to the applicable portions of the following specifications, codes, and standards, including case rulings, interpretations, and addenda as applicable and in force at the time of issue of this Specification:

a. Acoustical Society of America (ASA) 5-____ (ANSI 1.23-____.

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b. Air Moving and Conditioning Association (AMCA) 300-___, "Test Code for Sound Rating Air Moving Devices."

c. American National Standards Institute (ANSI):

   1. S1.2, "Method for the Physical Measurement of Sound."

   2. S1.13, "Method for Measurement of Sound Pressure Level."

d. American Society of Mechanical Engineers (ASME):

   1. Power Test Code 19.3

   2. ASME Boiler and Pressure Vessel Code, Sections I, II, V, and IX.

e. American Society for Testing and Materials (ASTM):

   1. Annual Book of ASTM Standards, Part 31, "Water."

   2. D 1428-64, "Test for Sodium and Potassium in Water and Water-Formed Deposits by Flame Photometry."

f. Institute of Electrical and Electronics Engineers (IEEE), 85-_____, "Airborne Sound Measurements on Rating Electronic Machinery."

g. Insulated Power Cable Engineers Association (IPCEA).

h. Instrument Society of America (ISA).

i. National Electric Manufacturers Association (NEMA): ICS 2-216.

j. National Fire Protection Association (NFPA).

k. Pipe Fabrication Institute Standards.

5.0 SUPPLEMENTAL DATA

The documents listed on the contents page as attachments are applicable to the Work, to the extent specified herein.

6.0 VENDOR DATA

6.1 The Vendor shall furnish data in accordance with the following requirements:

a. Setting drawings, plans and elevations (showing Owner's piping connections, the soot blowers, wall blowers, observation doors, access doors, pull spaces).

b. Pulverizer arrangements and foundation requirements.

c. Fans and outlines of parts of equipment furnished.

d. Burner and igniter details.

e. Arrangement of air ducts and flues.

f. Attemperator locations and details.

g. Attemperator piping and control diagram.

h. Layout coal piping and air ducts to burners.

i. Electrical outline and general arrangement.

j. Outline showing Owner's electrical connections to Vendor's thermocouple terminal blocks and junction boxes.

k. Detail electrical connections diagrams showing locations, size, and marking of all Owner's connections.

l. List of all auxiliary motors furnished, including name-plate data and outline drawings.

m. Outline showing location of all drum and tube metal thermo-couples.

n. Detail drawing of motor-operated valves furnished.

o. Detail drawings of safety valves furnished.

p. Lagging assembly and details of openings, doors, rein-forcements, air seals, etc.

q. List of specific engineering standards.

r. Welding specifications, including welding material, repair, heat treating, and nondestructive examination.

s. Superheater and reheater tube materials, dimensions and sizes.

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t. Holdout steel requirements.

u. Drum raising scheme.

6.2 The Vendor data furnished in accordance with paragraph 6.1 above shall include the following: (Data which are representative rather than exact shall be identified as such.)

a. Drawings

1. Plan view, side, and front elevations of equipment furnished. These drawings shall show locations of headers, drums, column spacings, terminals for Owner's piping dimensions, soot blower locations, and allowable forces and moments at the Owner's piping connections.

2. A cross-section drawing of the unit showing the gas temperatures and velocities m/sec (ft/sec) for each duct, breeching, and tube bank at a steam flow of 1312 tonnes/hr (2,893,000 lb/h) VWO and at 1249.7 tonnes/hr (2,755,000 lb/hr) 95 percent VWO. Expected maximum steam and tube wall temperatures shall also be shown for points throughout the superheater and reheater sections. Average tube wall temperatures shall be stated, along with tube material sizes and wall thickness.

3. Typical details of attachment of soot blower wall, boxes, and inspection, access, and lancing doors.

4. Clear indication of all steelwork furnished.

5. Typical lagging construction and installation details for insulation and lagging.

6. Startup diagrams which shall show the following quantities plotted versus time from ignition of first lighter to full load:

(a) Lighter fuel input.

(b) Main fuel input.

(c) Drum pressure.

(d) Feedwater flow.

(e) Steam flow through superheater.

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(f) Steam flow to turbine.

(g) Steam flow to drains or turbine bypass.

(h) Primary superheater outlet temperature.

(i) Superheater attemperator spray flow.

(j) Secondary superheater outlet temperature.

(k) Steam flow through reheater.

(l) Reheater attemperator spray flow.

(m) Reheater outlet temperature.

Note: The required startup diagrams shall be for a cold start, a warm start after an overnight shutdown, and a warm start after a weekend shutdown. The Vendor shall assume no delay for cycle water cleanup. Conditions for overnight and weekend shutdowns shall be specified so that the fastest warm startup rates may be achieved.

b. Curves:

1. Curves showing the expected spraywater quantity plotted against reheater outlet steam flow and the differential pressure across the desuperheater spraywater nozzle plotted against spraywater flow.

2. Curves showing the expected spraywater quantity plotted against superheater outlet steam flow and the differential pressure across the desuperheater spraywater nozzle plotted against spraywater flow.

3. Fan curves, speed torque curves, and descriptive information for all fans quoted.

c. Lists:

1. List of all valves furnished.

2. List of all motors supplied.

d. A detailed statement of the criteria that will govern the rate of loading of the boiler. The Vendor shall explicitly state the maximum permissible metal temperatures and fluid pressures, their rates of increase and differentials that will govern the permissible rate of loading, and the maximum load of the boiler. The Vendor shall include specific reference to thermocouples and their location on the boiler which will be used to establish boiler loading schedules with reference to the loading criteria specified.

e. A statement and guarantee of the grinding capacity of each pulverizer at a fineness of 70 percent through a 200-mesh screen and at least 99 percent through a 50-mesh screen.

f. The furnace pressure differential and other basis used for design of the waterwall buckstays and casing.

g. The steam pressure drop through the superheater at a steam flow of 1312 tonnes/hr (2,893,000 lb/hr).

h. The steam pressure drop through the reheater at a steam flow of 1184.9 tonnes/hr (2,612,235 lb/hr).

i. A description by ASME specification and grade of the materials to be used for the superheater and reheater elements.

j. A description of the materials used for the superheater supports or hangers. Where possible, the Vendor shall identify the material to be used by ASME specification and grade or by another recognized standard.

k. A description of the method that is used to calculate the furnace projected area, as well as the furnace envelope limits used to define and calculate furnace volume (see paragraph 7.4, c).

l. The arrangement of pulverizers and burners to provide for balanced firing at all loads.

m. The minimum load at which the pulverizers can be placed in operation, the rating in kJ/hr (Btu/hr) of the ignition torches, and the quantity of oil required to place the boiler in operation from a cold start. (See paragraph 7.13, d.)

n. Acoustical information required:

   1. Sound power level values for the equipment being quoted. These sound power level values shall represent equipment acoustic information is not to be

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guaranteed; rather, it is requested for the purpose of plant acoustic design studies. An acceptable alternate data presentation shall be sound level, or sound pressure level, in each octave band measured one meter (3 ft 6 inches) from major surfaces of the equipment.

2. Octave band acoustic data for the equipment in the sound attenuated condition, if sound attenuating equipment is applied.

o. The Vendor shall specify the number of personnel and the time allotted for the following:

1. To train plant operating personnel in accordance with paragraph 2.0,s.

2. To provide startup assistance in accordance with paragraph 2.0,s.

p. A description of quality control exercised during manufacture and list of all nondestructive tests, inspections, and factory tests.

q. The Vendor shall furnish procedures and instructions for all field installation and all required startup tests. Instruction books for the equipment being furnished shall be provided and shall include a list of recommended spare parts.

6.3 QA/AC REQUIREMENTS

a. The Vendor and his subvendor(s) shall have in effect in their shops at all times an inspection, testing, and documentation program that will ensure that the equipment furnished under this Specification meets, in all respects, the requirements specified herein.

b. The Vendor shall submit a copy of his quality control program to the Owner. The Vendor's quality assurance program is subject to approval by the Owner.

6.4 PERFORMANCE TEST REPORTS AND CERTIFICATIONS

Certified copies of results of the tests specified in article 13.0 shall be submitted to the Owner prior to acceptance of the Work.

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6.5 MATERIAL TEST REPORTS AND CERTIFICATIONS

a. Certified copies of all mill test reports and results of nondestructive weld tests for the structural steel furnished shall be submitted to the Owner.

b. Certified materials test reports shall be obtained for all materials used in ASME Boiler and Pressure Vessel Code, Section I construction, except for material specifically exempted by PS-11.3 of the ASME Boiler and Pressure Vessel Code, Section III.

6.6 SPECIAL TOOLS AND SPARE PARTS

Special Tools:

a. The technical representative, as required in paragraph 2.0,s during installation and startup of the equipment, shall furnish all special installation test instruments and tools.

b. The Vendor shall furnish all special tools, gauges, yokes and eye bolts, and cleaners required for assembling the steam generating equipment and for handling various parts. One complete set of box or special wrenches, cleaners, and tools required for maintenance, all new and in first-class condition, shall be supplied. Identification of all tools by name and number shall be provided, and the number shall appear on drawings and in the instructions to indicate the application of the tools furnished and to permit ordering replacements.

c. The Vendor shall supply with his proposal, pricing for 1 and 5 year supplies of spare parts.

7.0 <u>DESIGN REQUIREMENTS</u>

7.1 The steam generator shall be designed for the following:

a. Balanced draft firing.

b. Capacity:

The steam generator shall be capable of continuous operation and meeting the following load conditions corresponding to turbine operation at valves wide open with all feedwater heaters in service:

SHO Pressure kPa (psig)	13,100	(1,900)
SHO Temperature C (F)	513	(955)
Main Steam Flow tonnes/hr (pph)	1,312	(2,893,000)

VA·

Final Feed Temperature C (F)	241.3	(466.3)
Reheat Inlet Pressure kPa (psia)	3,460	(502)
Reheat Inlet Temperature C (F)	332	(630)
Reheat Pressure Drop kPa (psi)	180	(26)
Reheat Outlet Temperature C (F)	513	(955)
Reheat Steam Flow tonnes/hr (pph)	1,184.6	(2,612,233)

c. The steam generator and accessories shall be capable of operating on automatic control at all loads from 20 percent of rated capacity to maximum capability. The steam generator shall have the capability of either full pressure or variable pressure operation.

d. 10,000 cycles during a 30-year life.

e. Ambient conditions:

Summer Design Dry Bulb Temperature (1 percent)*	41.7°C (107°F)
Summer Design Wet Bulb Temperature (1 percent)*	28.3°C (83°F)
Maximum Summer Temperature	46.8°C (116.2°F)
Minimum Winter Temperature	5.7°C (42.3°F)
Sand Storm Wind Velocity (typical)	44.5 m/sec (105.6 MPH)

*Percentage of the time temperature would be above this number.

f. The steam generator shall be designed for outdoor installation.

g. The NOx emission rate shall be limited to 260 nanograms per joule (.60 pounds per million Btu) heat input for all loads. Only low NOx burners shall be used to attain this limit, gas reinjection and overfire air are not acceptable.

7.2 FUEL

a. The steam generator shall be capable of producing continuously and reliably the capacity stated in pararaph 7.1 when burning #6 furnace oil or Lakhra coals having the following analyses:

TABLE 2
COAL AND MINERAL ANALYSES

SHORT PROXIMATE

Daily Basis	Typical	Range
GCV-(Dry) Btu/lb	7500	6300 - 8700
Ash-(Dry) %	36.0	26.0 - 46.0
Sulfur-(Dry) %	7.4	6.5 - 9.5
H_2O %	32.0	25 - 45
Monthly Basis		
GCV-(Dry) Btu/lb	7500	6900 - 8100
Ash-(Dry) %	36.0	30.0 - 42.0
Sulfur-(Dry) %	7.4	6.8 - 8.3
H_2O %	32.0	28.0 - 40.0

PROXIMATE ANALYSIS
(Dry Basis)

	Typical	Range
Ash (%)	36.00	26.17 - 41.87
VM (%)	34.60	32.15 - 39.58
FC (%)	29.40	23.68 - 35.82
Total	100.00	- - -
Sulfur (%)	7.26	6.02 - 9.85
GCV-(Btu/lb)	7500	6060 - 8950
Equilb. Moisture (%)	38.91	33.77 - 50.06

ASH FUSION TEMPERATURE

Reducing (^{o}F)		
Initial	2094	2001 - 2443
Softening	2124	2005 - 2453
Hemisphere	2157	2012 - 2463
Final	2263	2046 - 2508
Oxydizing (^{o}F)		
Initial	2443	2254 - 2593
Softening	2474	2302 - 2621
Hemisphere	2503	2333 - 2631
Final	2543	2395 - 2640

TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

PROXIMATE ANALYSIS
(Dry Basis)

	Typical	Range		
Forms of Sulfur				
Total	7.71	6.02	-	9.85
Pyritic	4.14	2.89	-	5.51
Sulfate	0.60	0.31	-	1.56
Organic	2.97	1.43	-	3.86

ULTIMATE ANALYSIS

	Typical (% As Fired)	Range (% Dry Basis)			
H_2O	32.00	-	-		-
Ash	24.48	36.00	26.17	-	41.87
H_2	2.12	3.12	2.76	-	3.66
C	29.12	42.82	35.61	-	50.75
N_2	0.55	0.81	0.66	-	1.08
S	4.94	7.26	6.02	-	9.85
O_2	6.79	9.99	9.69	-	12.84
TOTAL	100.00	100.00	-		-
GCV-(Btu/lb)	5100	7500	6300	-	8700
Chlorine	-	0.14	0.10	-	0.19
Water Soluble					
Chlorine	-	0.11	0.04	-	0.16
Potassium Oxide	-	0.018	0.011	-	0.024
Sodium Oxide	-	0.253	0.092	-	0.917
Total Alkalies	-	0.231	0.104	-	0.363

TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

MINERAL ANALYSIS
(% Ignited Basis)

	Typical		Range		
SiO_2	39.60	-	32.34	-	47.68
Al_2O_3	20.17	-	12.12	-	26.30
TiO_2	2.02	-	1.33	-	3.16
CaO	3.70	-	2.11	-	8.39
K_2O	0.61	-	0.45	-	0.76
MgO	1.60	-	0.79	-	2.54
Na_2O	0.72	-	0.32	-	1.02
Fe_2O_3	24.64	-	17.02	-	33.60
P_2O_5	0.75	-	0.56	-	0.93
SO_3	5.63	-	2.20	-	10.55
Undetermined	0.56	-	-	-	-
Phosphorus % Dry Basis	0.105	-	0.076	-	0.143
Slag Viscosity (T250)°F	-	-	2200	-	2530

OTHER DATA

	Typical		Range		
Base/Acid	0.51	-	0.35	-	0.79
Slagging Index	Severe	-	Severe	-	Severe
Fouling Index	Medium	-	Low	-	High

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TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

b. Basic predicted performance and performance guarantees shall be based on burning the specified typical lignite above at 32.0 percent moisture as received at the coal scales and pulverizers. Pulverizer capacity shall take into account the daily swings of moisture and ash noted in the short proximate specified above.

c. The base fuel will be Pakistan Lakhra lignitic coals as typified by the above analyses. The coals will range from low to high fouling and always exhibit high slagging. The above data are given for the guidance of tenderers; it is anticipated that the coals will be within the range specified above.

d. Typical "worst" coals for design purposes are listed as follows:

TYPICAL HIGH ASH UNWASHED COALS

PROXIMATE ANALYSIS
(% Dry Basis)

Sample	W-C2	W-C1	E-C2
Ash	41.87	41.00	39.89
VM	32.69	35.32	32.15
FC	25.44	23.67	27.96
Sulfur	8.46	7.65	6.48
GCV-Btu/lb	6060	6592	6850
Equilb. Moisture %	36.93	33.77	41.75

ASH FUSION TEMPERATURES

Reducing (F)				
Initial	2140		2108	2104
Softening	2162		2152	2155
Hemisphere	2197		2208	2372
Final	2492		2312	2490
Oxydizing (F)				
Initial	2462		2382	2502
Softening	2497		2451	2543
Hemisphere	2515		2483	2558
Final	2545		2521	2585

TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

ULTIMATE ANALYSIS
(% As Received)

Sample	W-C2	W-C1	E-C2
H_2O	25.00	32.00	35.00
Ash	31.40	27.88	25.93
H_2	2.07	1.94	1.89
C	26.71	25.94	25.52
N_2	0.56	0.45	0.48
S	6.35	5.20	4.21
O_2	7.91	6.59	6.97
GCV-(Btu/lb)	4545	4483	4453

MINERAL ANALYSIS
(% Ignited Basis)

	Typical	Range		
SiO_2	45.06	47.68	-	47.57
Al_2O_3	20.98	19.62	-	21.91
TiO_2	2.16	1.88	-	2.48
CaO	3.88	3.06	-	2.13
K_2O	0.76	0.58	-	0.65
MgO	0.79	2.54	-	1.15
Na_2O	0.48	0.32	-	0.70
Fe_2O_3	19.11	17.79	-	19.92
P_2O_5	0.66	0.59	-	0.82
SO_3	4.98	5.28	-	2.20
Undetermined	1.14	0.66	-	0.47

TYPICAL LOW ASH UNWASHED COALS
PROXIMATE ANALYSIS
(% Dry Basis)

Sample	E-B1	C-A2	W-A2
Ash	27.83	27.68	27.77
VM	36.94	38.18	39.15
FC	35.23	34.14	33.09
Sulfur	7.36	8.46	8.26
GCV-(Btu/lb)	8821	8826	8534

TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

ASH FUSION TEMPERATURE

Reducing (^oF)			
Initial	2047	2001	- 2065
Softening	2076	2005	- 2076
Hemisphere	2132	2012	- 2079
Final	2195	2046	- 2133
Oxydizing (^oF)			
Initial	2445	2488	- 2268
Softening	2473	2510	- 2321
Hemisphere	2491	2527	- 2391
Final	2538	2550	- 2503

ULTIMATE ANALYSIS

H_2O	45.00	45.00	45.00
Ash	15.31	15.22	15.27
H_2	2.01	1.84	1.91
C	27.21	26.83	26.81
N_2	0.50	0.52	0.44
S	4.05	4.65	4.54
O_2	5.92	5.94	6.03
GCV-(Btu/lb)	4582	4854	4694

MINERAL ANALYSIS

SiO_2	32.34	36.44	37.31
Al_2O_3	19.22	17.61	20.06
TiO_2	1.54	1.68	2.21
CaO	4.28	3.92	3.52
K_2O	0.65	0.58	0.54
MgO	1.82	1.33	2.10
Na_2O	0.94	0.81	0.74
Fe_2O_3	31.02	31.88	25.53
P_2O_5	0.90	0.93	0.64
SO_3	7.20	4.35	6.10
Undetermined	0.09	0.47	1.25

TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

TYPICAL LOW ASH FUSION TEMPERATURE UNWASHED COALS
PROXIMATE ANALYSIS
(% Dry Basis)

Sample	W-A1	E-A1	C-A3
Ash	29.42	27.26	31.87
VM	39.58	39.28	36.29
FC	31.00	33.46	31.84
Sulfur	8.85	7.45	8.03
GCV (Btu/lb)	8292	8882	6326

ASH FUSION TEMPERATURES

Reducing (F)			
Initial	2017	2046	2012
Softening	2035	2076	2045
Hemisphere	2051	2103	2072
Final	2132	2230	2189
Oxydizing (F)			
Initial	2306	2441	2421
Softening	2398	2488	2470
Hemisphere	2486	2501	2500
Final	2525	2537	2541

ULTIMATE ANALYSIS

H_2O	32.00	32.00	32.00
Ash	20.01	18.54	21.67
H_2	2.39	2.43	2.01
C	32.10	34.51	31.27
N_2	0.59	0.63	0.86
S	6.02	5.07	5.46
O_2	6.89	6.82	6.95
GCV-(Btu/lb)	5639	6040	5600

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TABLE 2
COAL AND MINERAL ANALYSES
(Continued)

MINERAL ANALYSIS

SiO_2	38.01	40.97	37.05
Al_2O_3	20.84	18.87	20.84
TiO_2	2.07	1.69	2.77
CaO	2.89	3.63	3.07
K_2O	0.57	0.57	0.63
MgO	1.70	1.27	1.16
Na_2O	0.58	0.69	0.78
Fe_2O_3	26.11	25.16	27.55
P_2O_5	0.76	0.87	0.88
SO_3	5.18	6.25	5.13
Undetermined	1.29	0.03	0.14

Nominally the coal will be sized to pass through a 63mm square mesh. It is anticipated that 20 percent to 40 percent of this coal will pass through a 3.35mm square mesh and that approximately 90 percent will pass through a 31.5mm square mesh.

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TABLE 3
NO. 6 FUEL OIL SPECIFICATION

Use: To be used either as fuel for supplemental firing in the steam generator or as alternate fuel to Lakhra coal for the steam generator. Fuel shall meet the requirements of ASTM Standard D396, Specifications for Fuel Oils.

RANGE OF CONSTITUENTS

	Minimum	Maximum
Weight, percent		
Sulfur	.7	3.5
Hydrogen	9.5	12.0
Carbon	86.5	90.2
Nitrogen	-	-
Oxygen	-	-
Ash	-	0.08
Carbon Residue	-	12.0
GRAVITY		
Deg API	22	12
Specific gravity	.9218	.9861
kg/l (lb/gal)	.920 (7.676)	984 (8.212)
POUR POINT, °C (°F)	-	18.3 (65)
VISCOSITY		
Saybolt viscosity, sec universal at 38°C (100°F)	900	9000
Furol at 50°C (122°F)	45	300
WATER AND SEDIMENT, VOL. %	-	2.0
FLASH POINT °C (°F)	65 (150)	-
HEATING VALUE		
kJ/kg (Btu per lb), gross	42,703 (18,360)	-

7.3 DRUM

a. The boiler drum shall be welded construction. Suitable manholes with hinged manhole covers, gaskets, grabs, and bolts shall be furnished for both ends of the drum. Lifting lugs or some other suitable means for lifting the drum into place shall be provided.

b. Suitable U-bolts or U-plates for suspending the boiler drum shall be furnished for transmitting the load to the structural steel. All hangers for suspending other parts of the boiler unit shall be furnished by the Vendor.

c. The internal surfaces of the drum shall be shot blasted, cleaned free of mill scale, rust, corrosion products, dirt, grease, moisture, or other loose or foreign material. Grease or heavy oil shall be removed with a nonvolatile solvent. All nozzles shall be temporarily covered during shipment and erection.

d. Drum surfaces shall not be exposed to the furnace gases at any point.

e. The steam drum shall be equipped with cyclonic separators and steam scrubbers or equivalent separating devices to prevent carryover of solids or water droplets. The Vendor shall guarantee that the purity of the steam leaving the boiler at rated pressure and load and with the boiler water concentrations stated below shall be such that the total entrained solids shall not exceed one quarter of one part per million (1/4 p/m):

Total solids	p/m	15
Total alkalinity ($CaCO_3$)	p/m	50
Suspended solids	p/m	5
Chloroform extractable material	p/m	0
Silica	p/m	0.25
Phosphate as PO_4	p/m	10
Chloride ion concentration	p/m	6
Boiler water	pH	10.5

f. Sampling and determination of boiler water conditions shall be in accordance with Part 31 of the Annual Book of ASTM Standards.

g. An approximate measure of the total solids in the steam will be determined by the Owner by the Sodium Spectrophotometric Method B of ASTM D1428.

h. All piping within the drum, including feedwater, steam and water sampling, and chemical feed piping, shall be furnished by the VENDOR.

7.4 FURNACE AND WATERWALLS

a. The furnace shall be completely water cooled on all four sides and the bottom, and shall be of welded wall construction. The furnace roof may be either steam or water cooled.

b. The furnace shall be the dry bottom ash type design. Provision shall be made to sufficiently cool the ash so that the unit will be free of ash hopper clinkers. The opening in the hopper throat above the ashpit shall be not less than 900 mm (36 inches) in the clear. The slope of the inclined tubes in the hopper bottom shall not be less than 55° to the horizontal and 60° is preferred where center wall tubes pass through the hopper slope. Furnace hopper tubes shall be adequately protected to minimize sudden temperature changes due to ash sluicing and quenching water.

c. The furnace shall be designed so that the temperature of the gases leaving the furnace will be kept as low as is consistent with the heat requirement of the superheater and reheater, and in no case shall the temperature of the gases entering the convection pass at the capacity stated in paragraph 7.1,b exceed the ash softening temperature of the fuel burned. The furnace exit gas temperature shall not exceed 1093°C (2000°F) at the furnace exit plane. The furnace exit shall be defined as that point of a vertical plane beginning at the nose of the upper furnace arch, regardless of tube spacing beyond that arch.

d. The furnace shall be designed for a net heat release rate of not greater than 625,000 kJ/hr/m^2 (55,000 Btu/hr/ft^2) for the effective projected radiant surface. The net heat release shall be calculated on the basis of the gross calorific value of the fuel, corrected by subtracting radiation loss, unburned combustible loss, latent heat of water in the fuel, and water formed by burning of hydrogen in the fuel, and adding the sensible heat in both the fuel and the combustion air above 38°C 38°C (100°F). The net heat release rate per square foot of furnace plan area shall not exceed 14,750,000 kJ/hr/m^2 (1,300,000 Btu/hr/ft^2). The furnace design parameters noted above shall be based on burning the worst coal (high fouling, severe slagging, high moisture, high sulfur, high ash) at 30 percent excess air for combustion.

e. The furnace exit gas velocity and convection pass gas velocity shall not exceed 13.7 mps (45 fps) when firing the worst coal (high ash, high moisture, high fouling, severe slagging, low ash fusion temperature) at 30 percent excess air in the furnace.

f. The maximum heat release per burner zone area shall not exceed 2,570,000 kJ/h (225,000 Btu/h). Burner zone area being the area of a cube that is 3m (10 ft) above top burner row and 3m (10 ft) below bottom burner row (or to a lower bend if less than 3m (10 ft).

g. The Vendor shall guarantee adequate waterwall circulation for all steaming rates from 0 to 110 percent of the maximum capacity stated in paragraph 7.1,b.

h. The Vendor shall furnish any piping, equipment, and controls which are necessary to assure adequate flow through the waterwalls and which are not part of the normal boiler feedwater system.

i. The transverse clear spaces from face-to-face of convection tubes or radiant platens shall be as follows:

Temperature Range ^{o}C (^{o}F)	mm (in)
1,090 - 1,315 (2,000 - 2,400)	1,524 (60)
955 - 1,089 (1,750 - 1,999)	300 (12)
790 - 954 (1,450 - 1,749)	150 (6)
400 - 789 (750 - 1,449)	75 (3)

All heating surfaces shall be bare tube and in line, no staggered tube arrays are acceptable.

7.5 CASING

a. The Vendor shall furnish a gastight enclosure for the entire steam generator from the lower furnace hopper to the economizer exit. The integrity of the enclosure is to be determined within 1 year after commercial operation. The Vendor shall at his own expense, repair and modify the casing to satisfy this requirement. In areas where welded wall construction is used, no skin casing is required, but skin casing of 12-gauge steel plate shall be used for all closures and behind all wide spaced tubes where tile or refractory is used.

b. The Vendor shall furnish all necessary test instrument connections and other equipment as required to perform an air pressure test on the setting and ductwork. The test pressure and procedure for this test shall be specified by the Vendor.

c. The Vendor shall furnish frames around all openings in the steam generator designed to allow for expansion between the welded wall or inner skin casing and an outer aluminum lagging which shall be supplied by the Vendor. The frames shall be terminated at the lagging line and in such a manner as to provide a fastening area for the aluminum lagging.

d. The boiler roof throughout the penthouse area shall be designed and constructed to be gastight. The Vendor shall furnish two suitable fans with motors and differential pressure controls to pressurize the penthouse specifically for the purpose of keeping fly ash out of this area. Each fan and motor shall be capable of providing the required flow and pressure over the range of ambient conditions from 5°C (41°F) to 50°C (122°F).

e. The Vendor shall furnish his standard pressurized boiler penthouse. Doors shall be provided in both sides of the penthouse for personnel access and ventilation during maintenance.

f. Sufficient thimbles shall be provided in the boiler roof extending through the penthouse for cable supports used to install scaffolding for maintenance and inspection.

g. The Vendor shall furnish all seals at hangers, pipes, and other penetrations through the steam generator casing or roof. The seals shall be designed to allow for expansion.

h. Suitable openings shall be provided for installing television equipment to observe burner ignition and flame patterns.

i. The location, number, and type of furnace inspection and access doors shall be subject to approval by the Owner. Four quick-opening access doors (two in ash hopper throat and two high in furnace) shall be large enough for passage of a maintenance scaffold. All burners, soot blowers, probes, and areas that are subject to slag buildup shall be accessible for inspection from an inspection port usable for inservice inspection.

j. The Vendor shall provide all necessary connections and valves for drains, vents, pressure relief, and sampling. All valves, except the safety valves, shall be tandem.

k. Provisions shall be made on the lower headers of all drainable sections for permanent double 200mm (8 inch) valves with spool acid cleaning connections. All valves to be supplied by the Vendor shall be selected to avoid damage from strong alkalies and inhibited acids used for cleaning purposes.

l. The furnace and water walls shall be designed to withstand pressures of ± 6.5 kPa (± 26 in H_2O water column) at 67 percent of yield without causing permanent deflections of any parts.

m. Furnace division walls that extend into the burner area will be considered uncleanable and evaluated unfavorably. The Bidder is advised to omit furnace division walls from his design as well as any radiant platen heating surfaces.

7.6 SUPERHEATER

a. The superheater shall be located within the boiler setting, except that all headers shall be located outside of the high-temperature gas-swept space.

b. The superheater outlet temperature shall be controlled by any of the following methods:

1. Spray type desuperheaters.

2. Tilting burners or bias firing certain rows of burners.

3. Differential firing.

4. Suitable alloy control dampers.

5. A combination of these methods as recommended by the Vendor.

c. Bypass dampers, if used, shall be heat-resistant construction, shall be located in a zone where the gas temperature will not exceed 370°C (700°F), shall be free moving, and shall in no case require more than a total of 2,712 J (2,000 ft-lb) torque for the entire damper under all conditions or operations.

d. The superheater shall have provisions so that the outlet temperature can be controlled at 513°C (955°F) over a range of loads from 787 to 1,312 tonnes/hr (1,736,000 to 2,893,000 lb/hr) (60 percent to 100 percent of design capacity). The Vendor shall guarantee that the steam temperature from the superheater can be limited at all loads to the maximum of 513°C (955°F) by means of the regulating device(s) provided, with fairly heavy slag accumulations on the waterwalls.

e. The Vendor shall provide one superheater outlet connection suitable for the Owner's main steam piping. The superheater outlet shall be terminated outside of the boiler lagging surface and shall include vent, drain, and safety valve nozzle connections in accessible locations.

f. The Vendor shall state the maximum allowable forces and moments that can be imposed on the outlet connections by the main steam piping. It is desired that the design flexibility of the Owner's main steam piping be determined by the allowable stresses stated in the ASME Boiler and Pressure Vessel Code rather than by limits on terminal reactions imposed by the Vendor.

g. The superheater elements may be either seamless tubing or welded tubing.

h. Superheater welds exposed to hot gases shall be butt welds.

i. Elements in each section of the superheater shall be uniformly spaced. If vacant lanes are required, they shall be designed to eliminate gas bypassing. Elements shall be spaced wide enough apart to prevent plugging with ash as per paragraph 7.4, c. If the Vendor deems these spaces too narrow he may exceed the specified spacing and so state in his tender.

j. Superheater elements in the high-temperature section of the superheater shall be arranged so that the hot discharge ends of the elements are protected from the entering gases by at least one loop of the cooler tubes of the high-temperature superheater elements in front of them.

k. Banks of superheater elements shall be spaced for convenient element replacement; i.e., the sum of the two spaces adjacent to a bank shall be at least equal to the depth of the bank, but the clear face-to-face distance between element banks shall not be less than (later) for vertical elements nor (later) for horizontal elements to provide for the use of long-retractable soot blowers.

l. The superheater supports or hangers exposed to the hot gases within the setting shall be provided by the Vendor. The Vendor shall furnish all necessary U-bolts or rods required for supporting the superheater headers from the structural steel. Girders or beams from which U-bolts or rods are supported shall be furnished.

m. Spacers preferably shall be water-cooled tubes of the boiler circulation system.

n. Adequate provision shall be made in the design and installation of all superheater tube supports, hangers, and spacers for differential expansion of the various components.

o. The Vendor shall furnish all necessary pipes or tubes connecting the boiler drum with the superheater and any intermediate piping between superheater headers, including piping and sleeves for spray type superheat control.

7.7 REHEATER

a. The reheater shall be designed for a maximum steam working pressure of not less than 4,482 kPa (650 psig).

b. The reheater outlet temperature shall be controlled by any of the following methods:

   1. Spray type desuperheaters.

   2. Tilting burners or firing certain rows of burners.

   3. Differential firing.

   4. Suitable alloy control dampers.

   5. A combination of these methods as recommended by the Vendor.

c. If spray type desuperheaters are used for reheat temperature control, the design shall be such as to allow reheat temperature control without the need for spray during normal operating conditions. The Vendor shall install spray nozzles, liners, and spacers into a section of pipe which will be shipped by the Owner to the Vendor for shop installation.

d. Bypass dampers, if used, shall be heat-resistant construction, shall be located in a zone where the gas temperature will not exceed 370°C (700°F), shall be free moving, and shall in no case require more than a total of 2,712J

(2,000 ft-lbs) torque for the entire damper under all conditions or operations.

e. The reheater shall have a characteristic curve so that the outlet steam temperature can be controlled at 513°C (9,550°F) over a range of loads from 711 to 1,185 tonnes/hr (1,565,000 to 2,612,235 lb/hr) of steam.

f. The Vendor shall provide butt welded type reheater inlet and reheater outlet connections suitable for the Owner's reheat piping. A single outlet header connection is preferred. Both the inlet and outlet header connections shall terminate a sufficient distance outside the boiler lagging surface to allow vent, drain, instrument, and safety valve nozzle connections and piping in accessible locations. If two outlet headers are provided, the Vendor shall guarantee his equipment to be capable of producing 0°C (0°F) differential at the steam outlets over the control range.

g. The Vendor shall state the maximum allowable forces and moments that may be imposed on the outlet connections by the reheat piping. It is desired that the design flexibility of the Owner's reheat steam piping be determined by the allowable stresses as stated in the ASME Boiler and Pressure Vessel Code, rather than by limits on terminal reactions imposed by the Vendor.

h. The Vendor shall design the reheater so that closing one turbine intercept valve or reheater stop valve will not damage the reheater due to flow blockage in part of the reheater.

i. Baffles or dampers and their supports shall be furnished by the Vendor.

j. The Vendor shall furnish reheater supports on the same basis as specified for the superheater, paragraph 7.6.

k. The Vendor shall describe the materials used and state the temperature that the elements are designed to withstand for each section of the reheater.

l. Elements in all sections of the reheater shall be uniformly spaced. If vacant lanes are required, they shall be designed to eliminate gas bypassing. Elements shall be spaced wide enough apart to prevent plugging with ash.

m. Banks of reheater elements shall be spaced in accordance with the design philosophy used for the superheater, paragraph 7.6.

n. The Vendor shall provide blanks for hydrostatic testing of the reheater.

o. The reheater shall have a pressure drop of not more than 180 kPa (26 psi) at turbine valves wide open condition of 1,185 tonnes/hr (2,612,255 lb/hr).

7.8 ECONOMIZER

a. The economizer may be the single or twin type as required to meet pressure drop conditions and space conditions for removal of the elements.

b. The economizer shall be drainable, located below the water level of the boiler drum, and shall be arranged for upflow of water and downflow of flue gas throughout.

c. The economizer elements shall be the inline type and fabricated of bare tubing. The minimum clear tube space shall not be less than 76mm (3 inches). The maximum gas velocity or clear space between tubes shall not exceed 13.7 m/sec (45 ft/sec) at 30 percent excess air at maximum continuous rating.

d. Banks of economizer elements shall be spaced for convenient element replacement, i.e., the sum of the two spaces adjacent to a bank shall be at least equal to the depth of the bank but the clear face-to-face distance between element banks shall not be less than 76 mm (3 inches), and where soot blowers are to be installed, a free, clear space of at least one-half of the upper or lower bank, whichever is greater, shall be provided between the banks for access and inspection.

e. The Vendor shall furnish all necessary feed pipes or tubes connecting the economizer with the boiler. The feed pipe to the boiler drum shall be through thermal sleeves so that excessive thermal stresses will not be set up in the drum or nozzle.

f. The economizer inlet piping supplied by the Vendor shall terminate at one connection point located outside the boiler lagging surface and include vent and drain valve connections and piping in accessible locations.

g. The design flexibility of the Owner's feedwater piping will be determined by the allowable stresses stated in the ASME Boiler and Pressure Vessel Code, rather than by limits on terminal reactions imposed by the Vendor.

h. A steaming economizer is not allowed. Temperature of water leaving economizer shall be at least 17°C (30°F) below saturation temperature in the steam drum temperature at all loads.

7.9 HEADERS

a. The Vendor shall supply all necessary headers for waterwalls, superheaters, reheaters, and economizer, complete with shop welded nozzles.

b. All headers shall be thoroughly cleaned and free of scale by shotblasting on the inside.

c. A minimum number of header handholes to facilitate cleaning and inspection of the headers is preferred. The handholes shall be readily accessible and shall be of the seal welded design.

7.10 NOZZLES AND CONNECTIONS

a. The Vendor shall furnish and install all necessary nozzles, located to suit the Owner, including the following:

1. Safety valve nozzles required in accessible locations at the ends of drums and on the superheater headers and reheater headers.

2. Feedwater inlet nozzle.

3. Drum level transmitter nozzles, four 25mm (1-inch) on one end of the drum, used in feedwater control.

4. Drum level indicator nozzles, two 25mm (1-inch), on one end of the drum.

5. Drum level gauge nozzles, four 25mm (1-inch), two on each end of drum.

6. Blowoff and drain nozzles having sufficient capacity so that the entire unit can be drained in 1/2 hour with an initial pressure in the boiler of 690 kPa (100 psig).

7. Vent connections on drum, two 40mm (1-1/2-inch), one on each end of the drum shell.

8. Pressure gauge connection with gauge and syphon on the drum.

9. Continuous blowdown connection, one 40mm (1-1/2-inch), on each end of drum.

10. Boiler water sampling connections, two 25mm (1-inch), one on each end of drum shall be taken off continuous blowdown connections.

11. Pressure gauge connection nozzles, two 25mm (1-inch), on superheater outlet.

12. Pressure gauge connection nozzles, two 25mm (1-inch), one on each reheater outlet.

13. Pressure gauge connection nozzles, two 25mm (1-inch), on each reheater inlet.

14. Pressure gauge connection nozzle, one 25mm (1-inch), on drum shell.

15. Chemical feed connections, one 25mm (1-inch), on drum with internal sleeve similar to feedwater inlet nozzle sleeves, one 25mm (1-inch), on economizer inlet nozzle.

16. Steam sampling connections, four 25mm (1-inch), uniformly spaced along the drum.

17. Suitable chemical cleaning connections required for the steam generator configuration offered.

b. All nozzles shall be the long body type so that they will extend through the boiler lagging. Ends of nozzles 50mm (2 inches) and smaller shall have plain ends for socket welding. Nozzles larger than 50mm (2 inches) shall have beveled ends for butt welding.

7.11 SUPPORTING STEEL

a. The Vendor shall furnish all necessary hangers, U-bolts, rods, waterwall buckstays, stiffeners, and other framing required for supporting the waterwall tubes, headers, and casing from the structural steel. All such steel work shall be designed stiff enough to resist ordinary pulsations in the furnace and furnace implosions as described in paragraph 7.5.

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b. Boiler columns and top support steel shall be furnished.

c. The building structure will be designed for the seismic requirements specified in the Uniform Building Code for a Zone 1 earthquake. The Vendor is not required to design the boiler to withstand seismic forces, but the buckstay/building ties shall be designed to withstand them.

1. The seismic forces in the buckstay/building ties shall be computed for each of the two major horizontal axes of the boiler. Only the ties parallel to an axis shall be assumed to act.

2. The seismic force in each tie shall be computed by the following formula:

$$V = 0.05\ W$$

when V = total horizontal seismic force in tie

W = maximum vertical weight of the portion of boiler which is tributary to each tie (i.e., reaction on each tie if boiler is assumed to be lying on its side and supported only by the ties).

3. The vertical location of ties shall be judiciously selected, as far as practicable, to minimize seismic effects on the building structure. This can be achieved by locating ties so that larger tie forces occur at lower elevations.

7.12 FUEL BURNING EQUIPMENT

a. The Vendor shall furnish fuel conditioning and burning equipment including oil burners and piping, atomizing steam connections, pulverizers, pulverizers lube oil system, primary air fans, classifiers, coal feeders, burners, and burner supports, burner windboxes, and coal piping from silo to feeder including motor-operated coal valves, feeder to pulverizer, and pulverizer to burners. Seal air fans and associated piping shall also be provided if necessary.

b. Not less than seven pulverizers shall be provided. The pulverizers shall have a guaranteed capability such that any six of the seven pulverizers will be capable of carrying full load on the worst coal with a 15 percent design margin for worn pulverizers on line and the seventh pulverizer out of service for maintenance. If the Vendor's design does not require a "wear margin" he shall guarantee design

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of coal output at the end of a 30,000 hour run before roller, race, or grinding table elements replacement is required. Substantial documentation from users who experienced no drop in capacity over 30,000 hrs shall be included with the proposal.

c. The Vendor shall supply cold primary air fans as recommended for the pulverizers offered. The fans shall shall be driven separately from the pulverizers.

d. The Vendor shall furnish Stock Equipment Company gravimetric type coal feeders or approved equal. The coal feeders shall be mounted on the operating floor. The feeder shall be complete with illuminated observation windows at feeder inlet and outlet, a stainless steel, steeply sloped discharge spout, and all accessories as recommended by the Vendor for satisfactory operation.

e. The coal feeders shall be furnished with individual control cabinets. The cabinets shall be completely wired to accept the Owner's 400-volt, 50-hertz supply.

f. The fuel burning system shall be capable of maintaining continuous stable operation on automatic control at all steam generator loads of 20 percent of the steam generator rating and above without the use of supplementary fuel.

g. The pulverizers, coal burners, and oil burners shall be arranged to provide for balanced firing at all loads.

h. The coal chutes shall be type 316 ELC stainless steel, 6mm (1/4-inch) thick stainless steel and shall extend from the feeder inlet gate to the silo outlet and shall be provided with poke holes. A Stock Equipment Company or approved equal nuclear coal flow detector system shall be included and mounted on each coal chute. Flanges may be carbon steel.

i. A motor-operated slide gate shall be provided at the silo outlet between the silo discharge and the feeder inlet.

j. The coal pipe between the feeder discharge spout and the pulverizer inlet shall be 6mm (1/4-inch) wall, type 316 ELC stainless steel.

k. Each coal transport pipe shall include a valve between the classifier and the burner. The valve shall be accessible for operation and maintenance. The valve shall be designed to minimize pressure loss and coal hideout areas while being suitable for the normal operating atmosphere.

The valves shall be remotely operated and interlocked with the fuel safety system. The transport piping shall be carbon steel. Piping layout and hanger design shall provide for future installation of ceramic lined piping at all bends. The Vendor shall state the pipe material and thickness and expected wear life.

l. The Vendor shall also furnish duplex pumping, heating and straining sets for the oil burners to take oil from oil tanks by others.

7.13 IGNITION SYSTEM

a. The Vendor shall furnish complete ignition equipment for all burners. The equipment shall include ignition electrodes, high-tension cables, pneumatic cylinders, a transformer, signal lights, limit switches, and pilot flame scanners. Ignition fuel will be No. 2 fuel oil.

b. The ignition system shall be designed for local and remote operation and shall meet the requirements of the Owner's insurance carriers and the NFPA.

c. All equipment for the ignition system shall be suitable for continuous operation in 60°C (140°F) ambient temperature. No visible emissions shall be produced during cold startup with precipitators out of service.

d. The ignition system shall be designed to use a minimum quantity of fuel oil for starting and have a total capacity to support a 7 to 10 percent firing rate.

e. The Vendor shall provide all piping and valves necessary for oil supply and return, control air, and service air. Piping systems shall be manifolded so that connections to the Owner's piping can be made at one location.

f. Ignition electric control system shall be designed to operate from Owner's 400-volt, 50-hertz supply.

7.14 AIR HEATERS

a. The Vendor shall provide at least two regenerative, vertical shaft air heaters. At least one air heater shall be utilized for heating secondary air; the second air heater(s) shall be used for heating primary air. The regenerative air heaters shall be provided with a complete lubrication system, separate removable Corten surfaces on the cold end, motor drive with speed reducer, two lighted observation doors, access doors, electrically operated

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cleaning devices (using air as the blowing medium), water washing system, a low-speed air motor drive, and chromel-constantan thermocouples for monitoring the bearing metal temperature.

b. The Vendor shall furnish isolation dampers for the air heaters at the air outlet and gas inlet. These dampers shall be equipped with heavy-duty operating linkages and shall in no case require more than a total of 220J (200 ft-lb) torque to operate. The damper bearings shall be dust-proof and suitable for the operating temperatures.

c. At all boiler loads from 20 percent to 100 percent of rated capacity, the minimum temperature of the flue gas leaving the air heater, corrected for leakage, will be controlled at 150°C (300°F) by heating the inlet air. Inlet air heating and temperature control devices shall be furnished. For performance predictions and guarantees, inlet air temperature to the regenerative air heaters shall be taken as 38°C (100°F). The Vendor shall be aware that maximum summer conditions entering the FD fans of 50°C (122°F) might result in 65°C (149°F) air to the regenerative air heaters.

7.15 BREECHINGS, AIR DUCTS, AND DUST HOPPERS

a. The Vendor shall furnish all materials for a complete installation of breeching connecting the economizer outlet to the air heater, air ducts connecting air heater to the burner windbox and pulverizers, and tempering air ducts to pulverizers.

b. Breeching connecting the economizer outlet to the air heater inlet shall be 6mm (1/4-inch) minimum thickness steel plate.

c. Air ducts connecting secondary air heater to furnace wind-box, primary air heater to pulverizers, and tempering air to pulverizers shall be 5mm (3/16-inch) minimum thickness steel plate.

d. Air and gas ducts shall be designed with a maximum velocity of 18.3 mps (60 ft/sec) at 30 percent excess air at maximum continuous rating when firing the worst coal.

e. Dust hoppers under the rear boiler pass, the economizer, and air heaters shall be 6mm (1/4-inch) minimum thickness steel plate. The sides of the hopper shall have an adequate slope to prevent bridging of fly ash at the outlet connections. The valley angle shall have a minimum slope of

55 degrees to the horizontal. Suitable poke holes and dust sampling connections shall be provided on each dust hopper outlet. All dust hoppers shall be provided with access doors.

f. The Vendor shall provide all materials necessary to make the steam generating unit airtight from the air heater inlet to the air heater gas outlet, and the necessary stiffeners, bolts and nuts, expansion joints, dampers, doors, seals, hangers, and hanger rods suitable for attaching to support steel.

g. The Vendor shall provide venturi's suitable for total airflow measuring to provide a continuous, reliable signal compatible with the combustion control system.

h. The Vendor shall furnish straightening vanes as may be necessary to achieve maximum gas and airflows with minimum pressure drops.

i. All instrument connections in the ducts and breeching shall be made perpendicular to the duct and shall be ground smooth and flush on the inside. All instrument connections shall be extended beyond the insulation and lagging. Instrument connections shall be located to avoid interference with other structures and equipment. Pressure connections shall be 50mm (2-inch) pipe and temperature connections shall be 32mm (1 1/4-inch) pipe.

j. All damper drives not associated with the automatic boiler control system shall be supplied by the Vendor. All drive units, electric or pneumatic, shall have the following characteristics:

1. Handwheel for local operator.

2. Maximum and minimum travel limit switches.

7.16 FAN

a. Fans shall be designed for constant speed, motor-driven operation.

b. Outdoor fans shall be equipped with air-cooled bearings. Indoor fans shall be equipped with water-cooled bearings. All bearings shall be furnished with chromel constantan bearing metal thermocouples for use by the Owner, and temperature alarm switches for the Owner's annunciator.

c. Fans shall have inlet vanes or louvers and outlet dampers. Outdoor installations shall include inlet and outlet mechanisms with corrosion prevention features including hot-dipped galvanizing of inlet vanes.

d. Fars shall include couplings and guards.

e. Fans shall be equipped with rotor pressure differential taps. Taps shall be designed as indicated by the Owner on fan outline Drawings.

f. All fan rotors shall be dynamically balanced before shipment. Rotor welds shall be completely inspected by magnetic particle, liquid penetrant, or any other acceptable method before shipment.

g. Primary air fans shall be proposed.

h. Two primary air fans shall be supplied, each designed for 50 percent of the primary air requirement when firing the worst coal specified in Paragraph 7.2. The primary air fan net condition shall be determined based on 30 percent excess air delivered to the furnace and an air heater leakage rate of at least 15 percent of the stoichiometric requirement or not less than 45 percent excess air.

The primary air fan test block condition shall be determined by adding not less than the following margin to the net conditions:

a. 10 percent to the weight flow

b. 21 percent to the static pressure requirement

c. Add 17°C (30°F) to the air temperature

The test block condition shall be used as the fan design point.

i. The bearings on the primary air fans and motors shall be provided vibration monitoring as follows:

X-Y relative probe monitoring shall be used. This shall consist of two non-contacting displacement transducers mounted at right angles to each other 45° from true vertical. These transducers are to be located within 75 mm (3 inches) of each bearing. A keyphasor reference shall be installed. This shall consist of a notch in the shaft in the same axial position as the "keyphasor probe" which is a noncontact probe located at any convenient axial location adjacent to the shaft. This shall yield a once-per-revolution pulse with an amplitude greater than 4V and lasting approximately 5^{o} of rotation. All probes are to be installed in accordance with API 670.

Oscillator-demodulators (proximators) shall be readily accessible during normal operation of the unit. Lengthy panel removal procedures for access are to be avoided.

Vibration monitors shall provide buffered outputs of relative shaft bearing motion. Alarms and trips and monitor faceplate indication will be based on the relative displacement of the shaft. Each probe will be monitored. All vibration meters shall be calibrated in units of mils.

The preferred monitor system shall be the Smart monitor which is available from the Bently-Nevada Corporation. This system meets the above minimum requirements and provides additional features, which would aid in diagnostics and machine protection.

Axial shaft movement probes and monitoring system shall also be provided as part of the Bently-Nevada equipment.

7.16.1 Bottom Ash Hoppers

7.16.1.1 General - The unit shall have flooded ash hoppers which is joined by a water seal to the steam generator. The storage capacities of the hoppers shall be determined at 450mm (18 inches) below hopper water level. Hopper slopes should be a minimum of 35^{o} from the vertical.

7.16.1.2 Hopper Water - The exposed refractory above the hopper water level shall be cooled by a water curtain. The water seal is to be capable of sealing approximately 1.7 kPa (7 inches of H_2O) based on a furnace puff and shall be provided with flanged overflow connections for Purchaser's piping to ash hopper sump.

7.16.1.3 Clinker Grinder and Jet Pump - As an integral part of the ash hopper, there shall be included highly reliable clinker grinders and motors of a type that may be easily serviced during plant operation. Clinker grinders shall include drive motors. Grinders shall be double roll automatic reversing. Clinker grinders shall include a gate enclosure which feeds ash to the clinker grinder. The enclosure shall include an access door to the gate, a vent pipe with pressure and vacuum relief valve, and an observation window with flood light. Also, there shall be provided jet type ejectors (jet pumps).

7.16.1.4 Ash Gate - A shutoff gate between the hopper and each clinker grinder shall be supplied with the hopper. One purpose of this gate is to isolate grinder and jet pump from the flooded hoppers for repair.

7.16.1.5 Additional Hopper Features - The ash hopper shall be provided with a minimum of two access doors capable of accommodating spiders, ladders, and scaffolding. One door shall be a minimum of 600mm x 1,200mm (2 ft x 4 ft), while the other shall be at least 760mm x 760mm (30 in x 30 in). A minimum of four observation windows and seven poke holes shall be provided. Each hopper ash gate housing shall be provided with an access opening and one observation window. Each hopper pant leg shall be furnished with a manometer to indicate water level.

7.16.1.6 Areas of Corrosion - All metal surfaces exposed to furnace gas or slurry water shall be fabricated from a noncorrosive material as both gases and slurry are highly acidic.

7.16.1.7 Items Made of Stainless Steel - The following items plus any additional items that the Vendor deems necessary, shall be fabricated of Type 316L stainless steel.

a. Entire water seal trough

b. Entire overflow system up to weir box outlet

c. Hopper access doors and frames

d. Poke door pipe sleeves

e. Observation window pipe sleeves

f. Ash gate piston rods, guide angles, rollers, roller shafts, wedges and renewable wear strips.

g. Ash gate housing, frame, vent pipes, and vacuum relief valve

h. Jet pump nozzle which shall also have a carborundum lining

i. Clinker grinder housing

7.16.1.8 Capacity of Grinder and Jet Pump - The ash removal system shall have a capacity to remove 8 hrs accumulation of ash at boiler MCR in 2 hours.

7.16.1.9 Clinker Grinder Motor - The clinker grinder motor shall be in accordance with Attachment 8, Electric Motor Specification."

7.16.1.10 Hopper Lining - The Purchaser will supply all necessary refractory for lining the ash hopper. The Vendor shall design the side walls for a minimum of 230mm (9") of refractory. The Vendor shall furnish 16mm (5/8") diameter by 76mm (3") long carbon steel anchor bolts with carbon steel nuts and 64mm (2 1/2") diameter washers for use as refractory supports. The nuts shall be welded to the inside of the ash hopper shell on approximately 400mm (16") centers. The bolts, with washers tack welded to the bolt head, shall be shipped loose for later assembly.

7.16.1.1 The Vendor shall furnish overflow weir box(es) and connecting piping to the ash hopper. The weir box(es) shall be mounted on the ash hopper, sufficiently high to permit gravity flow through 200mm (8") pipes to the ash hopper sump at Grade Floor.

7.16.2 <u>Controls for Bottom Ash System</u>

7.16.2.1 General - The system shall operate from control panels and pushbutton stations. It is from these panels and stations that the operator will direct operation for disposal of bottom ash.

7.16.2.2 Description of Operation - An operator, near the ash hopper, will actuate and observe the sequence of operations for emptying the bottom ash hopper.

The operator first starts the high pressure ash water pumps and then checks water supply to hopper from pond water pumps and house service water system. He then chooses the proper bottom ash line. The ash removal sequence is now ready, and the step switch, which controls the bottom ash system, is actuated. The Unit automatically sequences through the slurry valves, jet pump, clinker grinder, and hopper gate, at which time the control timer takes over to control the flushing of the first outlet of the ash hopper and purging of the discharge line. After flushing and purging are complete, the step switch once again sequences through the equipment as outlined before in reverse order, thus shutting the first outlet down. The Unit automatically sequences through other outlets exactly as outlined above for the first outlet. After completing the operation for all outlets the operator then turns off jetting water source.

7.16.2.3 Bottom Ash Panel - There shall be one bottom ash panel located near the ash hoppers at Grade Floor. The following items shall be included on the panel face:

a. Pressure gauges

1. Jetting water supply

2. Bottom ash discharge line

b. Flow diagram with indicating lights showing equipment in operation.

c. Indicating lights

1. Loss of grinder seal water pressure (sounds alarm horn)

2. Bottom ash system in operation

3. Jetting water supply pressure low (sounds alarm horn)

d. "START-STOP" buttons for:

1. H.P. ash water pumps

2. Bottom ash cycle

e. Silence button for alarm horn

f. "AUTO-HOLD" switches for each pant leg which when put in the "HOLD" position stops ash cycle for inspection of hopper.

7.17 PULVERIZER REJECTS SYSTEM

The pulverizer rejects shall be collected in a hopper adjacent to each of the pulverizers. Each hopper shall be emptied of accumulated rejects by means of jetpulsion pumps into a discharge line and sluiced to a transfer tank. From the transfer tank the rejects shall be conveyed to the bottom ash pond via the bottom ash line by means of one jetpulsion pump. System capability shall be such that 8 hrs accumulation of rejects accumulated at boiler MCR can be removed in 2 hours. The system shall have the following design features specified.

7.17.1 <u>Pulverizer Rejects Hoppers</u>

The Vendor shall provide pulverizer rejects hoppers, one for each pulverizer with jetpulsion pump, pneumatic shutoff valve, water seal assembly, flood light 150mm (6") diameter poke hole, level indicator, access door with window, supports and all additional equipment necessary for operation.

7.17.2 <u>Pulverizer Rejects Transfer Tank</u>

The Vendor shall provide one open top pyrites transfer tank of 9.5mm (3/8") steel construction with a storage capacity of approximately one jetpulsion pump, level sensors, flood light, access door with window, poke hole, supports and all additional equipment necessary for operation.

7.17.3 <u>Instrumentation and Control</u>

7.17.3.1 The Vendor shall furnish all instrumentation, controls, control panel and other material as required in order to provide a complete manual control system for the pulverizer rejects removal system.

a. High level indicators shall be provided in each pulverizer rejects hopper to annunciate the need for operation.

b. The pulverizer rejects transfer tank sluice shall be interlocked with that of the bottom ash system so that it cannot be operated when the bottom ash system is being operated.

c. The Vendor shall provide manual selectors to permit the removal of pulverizer rejects from individual pulverizer rejects hoppers.

d. The pulverizer rejects removal system control panel shall be compatible with the bottom ash removal panel.

7.17.3.2 The Purchaser shall provide 220V ac single-phase, 50 Hertz or 125V dc control power for the control system. The control power for all motors larger than 75 kW (100 hp) and annunciators shall be 125V dc. The control power for motors 75kW (100 hp) and smaller, solenoid valves associated with pneumatically controlled valves and all other interface points shall be 220V ac. All apparatus for use in nominal 220V ac and 125V dc systems shall be designed to function within and withstand voltage rangs of 105-140V dc and 120 $\pm$10 percent volts ac.

7.17.3.3 The Vendor shall furnish a control panel NEMA 4 construction for the pulverizer rejects removal system. This panel will be located in the ground floor of the boiler room.

7.17.3.4 The control panel shall include the following features:

a. Necessary switches and visual displays for manual cot·rol of the system.

b. Visual and audible annunciation to indicate completion of cycle as well as malfunction of the pyrites removal system equipment to include loss of air pressure and sluice water. Contacts for remote annunciation on the Purchaser's CRT shall be provided.

c. Pulverizer rejects hopper sequence number.

7.18 INSULATION AND LAGGING

The Vendor shall furnish insulation and lagging based on the following:

a. The setting, flues, ducts, air heater, piping, and other heated equipment furnished by the Vendor, excluding pulverizers and burner piping, shall be insulated with a suitable insulation and secured with fastening clips or studs. The thickness of the insulation shall be sufficient to assure a surface temperature not in excess of 54°C (130°F) with an outside ambient air temperature of 27°C (80°F) and an air velocity at the surface of 50mm/sec (10 ft/min).

b. The Vendor shall not use asbestos insulation. The surfaces of the boiler setting shall be insulated with asbestos-free, calcium silicate hard block. Flues, ducts, and other heated equipment shall be insulated on the outside with either block or blanket type insulation. In areas where an insulation thickness of 75mm (3 inches) or more is required, the insulation shall be applied in two layers.

c. The lagging overall external insulation shall be constructed of fluted, embossed aluminum, and secured to form a weathertight surface and to provide for the necessary differential expansion. The thickness of metal used shall be a minimum of 1mm (0.040 inch) on large flat surfaces and 0.8mm (0.032 inch) on irregularly shaped or curved surfaces. Horizontal surfaces shall be reinforced where they may be used as walkways. The lagging on horizontal surfaces shall be pitched and supported to assure drainage.

d. The boiler lagging shall be fitted lagging and not a draped lagging over the outside of the buckstays. Lagging shall be fastened with sheet metal screws or other removable holding devices approved by the Engineer.

e. The lagging in all areas shall be reinforced and supported to avoid injury to personnel during construction, operation, and maintenance.

f. Frames, sleeves, or boots shall be provided in the lagging around all openings in the steam generator to allow convenient access to all inspection doors, lancing doors, piping, and other equipment installed behind the lagging. These frames, sleeves, or boots shall be designed to allow for expansion between the inner skin casing and the outer aluminum lagging.

g. Insulation and lagging will be installed by others.

7.19 BOILER TRIM AND SAFETY VALVES

a. The following safety valves shall be provided by the Vendor:

   1. All ASME Boiler and Pressure Vessel Code required safety valves for the drum, superheater, and reheater, complete with test gags. These safety valves shall meet all ASME Boiler and Pressure Vessel Code requirements with respect to pressure setting and relieving capacities.

   2. A noncode capacity power-operated safety valve shall be provided for the superheater outlet header together with the nozzles, isolation valves, and single adjustable selectromatic controller. These valves shall be actuated by high pressure from the superheater outlet or by operator selection from a remote panel location. The valves are in addition to those required by the ASME Boiler and Pressure Vessel Code and they shall have a total relieving capacity of 25 percent of the Code required capacity.

b. The Vendor shall furnish the calibration and test equipment for the safety valves offered. This equipment shall be supplied by the safety valve manufacturer and be complete with the necessary accessories.

c. The following additional valves shall be provided by the Vendor:

   1. Feedwater stop valve, electric motor-operated.

   2. Feedwater check valve.

   3. Economizer drain valves, two for each connection.

   4. Superheater and reheater drain and vent valves, two for each connection. The second valve for each connection shall be motor operated, suitable for throttling service, and shall be complete with transmitting slidewire and stem-mounted position indicator.

5. Continuous blowdown valves, two for each connection.

6. Chemical feed shutoff valves, two for each connection.

7. Steam and water sampling shutoff valves, two for each connection.

8. Waterwall header drain valves, two for each connection.

9. Pressure gauge connections for superheater outlet, reheater inlets and outlets, and drum, two valves for each connection.

10. Drum vent valves, two for each connection. The second valve for each connection shall be motor operated, suitable for throttling service, and shall be equipped with transmitting slidewire and stem mounted position indicator.

11. Chemical cleaning connections and valves.

12. Two valves each for all other connections not specified herein, but required for complete installation.

13. The Vendor shall furnish piping between the boiler and the Vendor furnished valves to permit ready accessibility to the valves external to the boiler lagging. The Vendor's second valve on any drain connection originating above the operating level shall be located at the operating level.

14. The Vendor shall furnish a suitable remote water level indicating system complete with illumination, chain-operated shutoff valves, drain valves, and connecting piping from the drum to the gauge. This system shall be Hydrastep, or approved equal.

7.20 INSTRUMENTATION AND INSTRUMENT CONNECTIONS

a. In addition to the general connections listed in this Specification, the Vendor shall supply other connections required for the specific equipment offered in his bid.

b. Metal temperature thermocouples:

1. The Vendor shall furnish permanent thermocouples for monitoring the boiler drum and tube metal temperatures during startup, operation, and shutdown periods. The thermocouples shall be chromel-constantan with glass insulation and spirally wound stainless steel

armor. Thermocouple leads that penetrate the setting shall be provided with a gastight seal. Metal temperature thermocouples shall be terminated in locally mounted terminal boxes for the Owner's connection.

2. Enough tube metal thermocouples shall be supplied to allow for the maximum startup rate and response to load change without exceeding the recommended tube metal temperatures.

3. Each steam drum shall have seven or more thermocouples provided for drum metal temperature measurement, located as recommended by the Vendor.

4. Thermocouples shall be provided for 25 percent of the tubes entering the primary and secondary superheater outlet header. They shall be spaced equidistantly across the superheater header.

5. Thermocouples shall be provided for 25 percent of the tubes entering the reheater outlet header. They shall be spaced equidistantly across the reheater header.

6. Additional thermocouples shall be added as recommended by the Vendor.

c. Steam and water thermocouples:

1. The Vendor shall furnish all thermocouples for controlling and monitoring the steam generator steam and water temperatures. All thermocouples and test wells shall conform to ASME Power Test Code 19.3.

2. Thermocouples shall be chromel-constantan, spring-loaded, and complete with stainless steel well, extension nipple, and weatherproof terminal head. The head shall be accessible for testing and maintenance during operation. The thermocouple elements shall be removable for maintenance while the unit is in operation. Thermocouple accuracy shall be within ±0.3 percent of measured temperature.

3. For each point at which steam or water temperature is to be monitored, one thermocouple and well for monitoring equipment and one thermocouple and well for test purposes shall be provided. If the point is also required for control purposes, an additional thermocouple and well shall be provided.

4. The following points, as a minimum, shall be monitored:

    (a) Superheater outlet.

    (b) Reheater outlets - both.

    (c) Feedwater to economizer.

    (d) Feedwater from economizer - both.

    (e) Steam temperature before each superheater spray.

    (f) Steam temperature after each superheater spray.

    (g) Steam temperature before each reheater spray.

    (h) Steam temperature after each reheater spray.

d. Air and gas temperatures:

1. The Vendor shall furnish 25mm (1-inch)pipe connections with thermocouple and protecting well for all air and gas temperature measuring elements. The following points are considered the minimum for monitoring of performance:

    (a) Air from air heater.

    (b) Gas in rear pass without supplementary cooled probe.

    (c) Gas to economizer.

    (d) Gas from economizer.

    (e) Primary air to the pulverizers.

    (f) Tempering air to the pulverizers.

    (g) Coal-air outlet temperature.

2. The exact number and location of connections at each point will be determined after award of the Contract.

e. Pressure connections:

1. The Vendor shall furnish and install 25mm (1" pipe) connections for steam and water pressures. The following points are the minimum to be included:

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(a) Superheater outlet header

(b) Superheater inlet header

(c) Reheater outlet header(s)

(d) Reheater inlet header(s)

(e) Economizer inlet headers

(f) Main steam outlet header

(g) Steam drum

2. The Vendor shall furnish 50mm (2-inch) pipe connections for monitoring and control of air and gas pressures throughout the unit. The following points are considered the minimum necessary:

   (a) Secondary air heater air outlet

   (b) Secondary air heater gas outlet

   (c) Primary air heater gas outlet

   (d) Primary air heater air outlet

   (e) Windbox.

   (f) Primary air to pulverizers (primary air fan outlet).

   (g) Tempering air to pulverizers.

   (h) Airflow metering device.

   (i) Furnace.

   (j) Rear pass between banks of elements.

   (k) Economizer gas inlet.

   (l) Economizer gas outlet.

   (m) Pulverizer inlet.

   (n) Pulverizer outlet.

3. The exact number and location of connections at each point will be determined after award of the Contract.

f. Flue gas sampling:

Flue gas sampling points shall be provided. The number and location of these points shall be determined by the configuration offered, but in no case shall there be less than four. Provisions shall be made for maintaining the gastight integrity of the casing at all flue gas sampling points.

7.21 COUPLINGS

All rotating equipment supplied by the Vendor shall include drive couplings and guards. The Vendor shall ship the drive halves to the motor manufacturer for finish boring, keyseating, and mounting on the motor shaft. Machining instructions and detailed drawings shall be on each equipment drawing and shall accompany the coupling halves when shipped.

7.22 SOOT-BLOWER OPENINGS

The Vendor shall install soot-blower openings located so that all principal sections of the furnace and convection passes can be cleaned. Tubes bent to provide space for doors and soot-blower openings shall be bent, preferably outward into the casing, but in no case shall tubes be bent into the furnace more than 25mm (1 inch). The Vendor shall allow for thermal expansion and movement of tubes and casing in locating soot-blower positions and shall in all cases provide sufficient space between blowers and tubes to prevent tube cutting.

7.23 SOOT-BLOWING EQUIPMENT

a. The Vendor shall provide one complete steam soot-blower system, including blowers with carriage assemblies, control-system components, and wall boxes, to maintain the steam generator fireside in a commercially clean condition. Commercially clean shall be defined as the degree of cleanliness required for the unit to meet its performance guarantees of capacity and steam temperature while maintaining gas side pressure drops. The Vendor shall, at his own expense, relocate and/or add soot blowers and openings necessary to accomplish the commercially clean condition.

b. The adequacy of the soot-blower system will be determined by the Owner within 1 year after the start of commercial operation of the unit. The period for determination of adequacy will be extended 1 year beyond the date at which any changes are installed.

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c. All manual isolation valves, fittings, piping, wiring, and other facilities necessary to interconnect the equipment will be provided by others.

d. All necessary structural supports for soot blowers shall be provided by the Vendor.

e. Soot Blowers:

   1. The number of blowers and the temperature zones in which they operate shall be listed on the Equipment Data form and shown schematically on a cross section drawing.

   2. Steam sootblowers shall be provided.

   3. The soot blowers shall be valve-in-head type with integral adjustable pressure control. The valve seat shall be separate from the valve body, as opposed to integrally cast and both the seat and the disk shall have Stellite facings. The internals of the valves used on all blowers shall be interchangeable.

   4. Wall blowers shall have both nozzle orientation and wall clearance dimensions adjustable from outside the boiler.

   5. Provision shall be made for easy removal and replacement of the lance tube of the long retractable blowers.

   6. Construction of the long retractable blowers shall be such that the portion of feed tube that is sealed by packing shall not contact the lance tube during any portion of its travel.

   7. The Vendor shall furnish two soot-blower carriages with motor starters mounted on each carriage head. Carriages shall be equipped with dual chromel-constantan thermocouples for the Owner's use to monitor furnace gas temperature during startup. The Vendor shall furnish two temperature transmitters with two temperature indicators, and two position transmitters with two position indicators for mounting on the Owner's panel. Carriages shall continuously traverse the gas passage, and shall be capable of stopping at any position upon operator command. Command shall be initiated from the control room or a local control station. Thermocouple accuracy shall be within 0.5 percent of measured temperature. Lance cooling shall be included. Carriages shall be from the same manufacturer as the soot blowers.

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f. Soot-blower controls:

1. The soot-blower controls shall be the automatic sequential type with group variable control, unit variable control, and boiler trip retraction of blowers. The miniature solid-state control panel shall include a graphic diagram of the boiler showing the location of blowers with indicating lights. Soot-blower controls shall be a microprocessor based design.

2. Long retractable blower units shall be automatically retracted on low blowing medium pressure, upon exceeding the individual elapsed operating time, or upon thermal overload of a motor. Any cause of emergency retraction shall register on the panel as an alarm and lock out further sequencing.

3. A means shall be provided for manually operating from the panel any blower or air-heater blower out of sequence.

4. Controls and an automatic admission valve shall be provided for the air-heater cleaning device.

5. A provision shall be made for operating the air-heater blower either intermittently or continuously while other blowers are in operation.

g. Electrical standards for soot blowers:

1. Control wire, used in low-temperature areas, shall have stranded copper conductors, minimum size 14-gauge (AWG), with 600-volt, 90°C, flame-retardant, cross-linked polyethylene insulation. Wires shall have compression lugs and shall be brought out to terminal blocks conveniently located for the Owner's connections. Low energy wiring shall have minimum size 20-gauge (AWG), stranded copper conductors.

2. Equipment and wiring located in high-temperature areas shall be provided with insulation for elevated temperatures.

3. Each soot blower shall be furnished with a pushbutton station for local control, and shall be factory mounted and wired on the blower. Pushbuttons shall be fully guarded, heavy duty, and oil-tight, in accordance with NEMA ICS 2-216. Pushbuttons that perform a stop function shall be colored red and shall be located below or to the right of other associated buttons, indicating lights, and selector switches.

4. Each electric motor supplied shall be controlled by a separate magnetic starter with thermal overload and undervoltage protection.

5. A motor starter shall be mounted on each blower head. Common transformers, motor starters, and circuit breakers may be separately housed. Enclosures shall be NEMA 4, dust-tight, and watertight. Internal wiring shall be factory installed with connections brought out to terminal blocks or disconnect plugs.

6. The Vendor shall furnish UL approved power and control disconnect and bypass devices, wired at the factory and mounted on the blower to provide deenergizing for clearance purposes and bypassing to allow other blowers in the group and system to operate. Equipment shall include molded case circuit breakers or disconnect plugs for disconnecting under load. Bypass switches or dummy plugs are acceptable for control.

7. All equipment for the soot blowers shall be suitable for continuous operation in 60^{o}C (140^{o}F) ambient temperature.

8. High-voltage power equipment and wiring shall be segregated from low-voltage control equipment and wiring.

7.24 ELECTRICAL STANDARDS FOR STEAM GENERATORS AND ACCESSORIES

a. The electrical power available is 400V, 3 phase, 50 cycle, and equipment shall operate satisfactorily with a voltage range of 314-408 volts.

b. All power cables shall be sized to adequately supply the loads and provide a maximum of $\pm$3 percent voltage drop. Cable shall be based on 90^{o}C EPR insulated with a heavy-duty chlorosulfonated polyethylene jacket and sized per ICEA ratings. Cable shall be derated for grouping, raceway type, and ambient temperature. A cable circuit list of cable sizes, circuit description, route, and lengths shall be provided to the Engineer. The Vendor shall provide all cable.

c. The raceway system shall be designed, sized, and laid out in accordance with NEC requirements.

d. All circuit interrupter devices shall be adequately sized to interrupt the available fault current. The maximum

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available fault current is 22,000 amperes rms symmetrical at 380 volts. The Vendor shall coordinate the protective devices so that the device closest to the fault isolates the fault. The Vendor shall furnish the Owner all the information necessary for a short circuit and electrical system coordination study.

The Vendor shall furnish 400 volt combination motor starters and contactors in accordarce with the attached motor starter specifications.

f. The Bidder shall furnish, with the Proposal, the complete power one line drawings, control schematic drawings, and interconnection drawings.

g. All electrical control equipment cable shall be terminated at terminal blocks. The terminal blocks shall be numbered and shall agree with the schematic and wiring diagram.

h. Control voltage required shall be 220 volts. The Vendor shall supply necessary control transformers to obtain the control voltage.

i. The Vendor shall provide a local visible circuit interrupting means in NEMA 4 enclosures located near each motor or load. This shall be molded case circuit breaker or stop L.O. pushbutton station.

j. All control cables shall be #14 AWG 90°C EPR insulated multi-coductor cables with a heavy duty chlorosolfonated polyethylene jacket. Cables shall be grouped in raceways. A cable circuit list of cable sizes, circuit description route and length.

k. Instrument and thermocouple wiring:

   1. Low-energy signal circuits shall be shielded and shall be 18 gauge (AWG) wire or larger. Wiring temperature ratings shall be suitable for the service temperature intended.

   2. Thermocouple leads shall be brought out to single screw terminal blocks located in accessible junction boxes.

l. Extra contacts:

   All relays or primary sensing devices which give an alarm signal or a trip signal shall have an extra set of electrically separate contacts suitable for the Owner's use.

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m. Pushbutton switches:

Local control devices such as pushbuttons, selector switches, and indicating lights shall be heavy duty and oiltight for indoor service and heavy duty, watertight, dusttight, and oiltight for outdoor service, in accordance with NEMA ICS 2-216.

7.25 MOTOR SPECIFICATIONS

All electric motors shall be furnished in accordance with the Attachment 8 Technical Requirements for Electric Motors.

7.26 ACOUSTICAL REQUIREMENTS

The Vendor shall complete and submit as part of his Proposal the attached Acoustic Data Summary Sheet (Attachment 5). It is preferred that the octave band levels be sound power levels in decibels with a reference power of 10 (exponent 12) watt. However, sound pressure levels in decibels with a reference pressure of 0.0002 microbars will be acceptable providing the weighting network and distance to the sound source are indicated. In the event acoustic-data for the equipment quoted is not available, acoustic data for similar equipment will be acceptable. However, the equipment differences should be indicated and the Vendor's estimate of the acoustical effect of these differences should be indicated.

8.0 PERFORMANCE REQUIREMENTS

8.1 The steam generator when installed and functioning shall meet or exceed the performance requirements listed on the Equipment Data form and the Performance Guarantees form.

8.2 The steam generator and accessories shall be capable of operating on automatic control at all loads from 20 percent of rated capacity to maximum capability. The steam generator shall have the capability of either full pressure or variable pressure operation.

8.3 Adequate waterwall circulation for steaming rates from 0 to 110 percent of the maximum capacity shall be provided.

9.0 MATERIAL REQUIREMENTS

9.1 The materials used in the construction of the steam generating equipment shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section I, the requirements of this Specification, and other applicable codes and standards. All materials of construction shall be fully described on drawings by

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specification number and grade. Where recognized specification and grade designations may not be applicable, the material shall be fully described by proprietary name, manufacturer, and important characteristics.

9.2 Selection of materials of construction, or substitution of materials, shall be subject to approval of the Owner.

10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

All fabrication procedures and qualifications shall conform to applicable codes and standards. The fabrication procedures and qualifications shall be the Vendor's standard, subject to the approval of the Owner. Fabrication and nondestructive examination (NDE) procedures shall not be employed until approval for their use has been given by the Owner.

11.0 INSTALLATION REQUIREMENTS

None

12.0 PERSONNEL REQUIREMENTS

The Vendor shall employ the following qualified personnel to perform the Work:

All welders shall be qualified under ASME Boiler and Pressure Vessel Code, Section IX.

13.0 INSPECTION AND TESTS

The following inspection and tests shall be performed:

a. Shop Inspection and Tests:

1. The Vendor shall submit a complete manufacturing schedule showing the dates and location of all major fabricating operations, testing, and shipping before any production of materials is released.

2. The Owner, or any person appointed by the Owner, may at any time inspect the equipment prior to acceptance. Adequate notice shall be given prior to inspection. Any such inspections shall not relieve the Vendor of his obligations to furnish the equipment in accordance with this Specification.

3. Acceptance by the inspector is limited to the acceptability of the particular piece of equipment, material, or technique being inspected and does not constitute

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a complete acceptance of the product or workmanship which may have other defects outside the inspector's scope of expertise.

4. The Owner or Engineer shall have the right to fully inspect all phases of manufacture of the equipment included in this Specification. Any equipment, material, and workmanship which does not meet the requirements of this Specification or the Vendor's design drawings shall be rejected or repaired at no cost to the Owner. Any inspection by the Owner or Engineer shall not relieve the Vendor of any responsibility for conformance with stated conditions and shall not be considered a waiver of warranty or other rights.

5. All tests required for certification of procedures, personnel, and proof that the equipment conforms to all applicable codes and standards shall be made at the expense of the Vendor.

6. The Owner, the Engineer, or both shall have the right of representation at all tests and they shall be notified at least 1 week prior to any tests.

7. Inspection shall, as a minimum, conform to the ASME Boiler and Pressure Vessel Code, Section I.

b. Initial Field Tests:

The Owner reserves the right to make initial field tests, at his expense, to demonstrate the capability of the equipment furnished by the Vendor. If the results of the tests conducted indicate that modifications are necessary, the Vendor shall, at his expense, make the required changes. Subsequent tests will be conducted at the Vendor's expense to verify that the modifications meet the design objectives. The Owner will supply engineers and technicians for data taking.

c. Performance Test:

1. A steam generator performance test shall be performed. Tests shall be conducted in accordance with the latest ASME Boiler Test Code in effect at the time of test, with any modifications mutually agreed upon by the Vendor and the Owner.

2. Tests shall be conducted within 1 year of initial operation. If the results of the tests conducted indicate that the equipment does not meet the guaran-

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teed performance, the Vendor shall, at his expense, modify the equipment to improve its performance. Subsequent tests until acceptance by the Owner shall be made at the Vendor's expense. The Owner will supply engineers and technicians for data taking.

14.0 CLEANING, CORROSION PROTECTION, AND COATING

14.1 Metal parts shall be clean and free of rust and mill scale prior to painting and shipment. A schedule of the Vendor's preservation procedures shall be submitted for approval.

14.2 Nonmachined surfaces shall be given one coat of primer. Minimum dry film thickness shall be .05mm (2 mils), unless otherwise specified.

14.3 Machined surfaces, including shafts, bearings, and couplings, shall be adequately protected against corrosion and damage during shipment and outdoor storage for a period of 1 year. Openings shall be suitably capped. Metal covers shall be provided where possible.

14.4 Weld end preparations shall be coated with Deoxaluminate or equal, and shall be covered with metal end caps prior to shipment.

15.0 MARKING AND IDENTIFICATION

15.1 Each package, skid, box, and crate shall be marked on the outside with the following information so that it is readily visible:

a. (Owner's name)
(Project identification)
(Owner's address)

b. The Owner's purchase order number.

c. Any special instructions for handling.

d. The weight and lifting points or center of gravity.

e. Bill of Material number(s).

15.2 Equipment shall be identified with a tag number. The number shall be permanently imprinted with at least 5mm (3/16") high letters on a 22 gauge stainless steel tag. The tag shall be attached to the enclosure with pins of a similar material.

15.3 Each unit shall have a permanently secured data plate made from at least 22 gauge stainless steel, permanently imprinted with 5mm (3/16") high letters, and containing the following information:

a. Manufacturer's name and address.

b. Model Number.

c. Serial Number.

d. Date of Manufacture.

e. Duty.

f. Weight.

15.4 The data plate shall be located where it is readily visible and shall be securely attached with pins of a material similar to the plate.

15.5 Equipment item numbers shall be utilized by the Vendor in designating equipment. Numbers so assigned by the Vendor may be reassigned at the option of the Engineer.

15.6 Items furnished under these specifications, but not identified herein, shall have tags inscribed as directed by the Engineer.

16.0 PACKAGING, SHIPPING, AND STORAGE

16.1 Equipment or piping that may have been hydrostatically tested shall be checked to ensure that all water has been drained from the unit prior to placing equipment in storage or on its foundation. After any equipment is in storage or on its foundation, temporary wood or steel plate covers shall be provided over flanges to prevent entrance of water into the unit, and the Vendor shall be responsible for any damage to unit, equipment, and associated piping until it has been accepted by the Owner.

16.2 All exposed machine surfaces and openings shall be coated and protected to prevent corrosion and damage during shipment and storage.

16.3 All metal internal surfaces of the equipment shall be protected with a water-soluble coating to prevent oxidation or corrosion; coatings are subject to approval by the Owner. After this application, all openings shall be blanked off or plugged to eliminate air circulation until the equipment is installed in the operating position. A warning to this effect shall be printed on or attached to this equipment.

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17.0 ACCEPTANCE CRITERIA

17.1 The Owner shall have the right to delay the shipment of equipment and material from the Vendor's shops pending resolution of any deficiencies known at the time of inspection.

17.2 MANUFACTURING ERRORS

Equipment and materials shall be complete in all respects within the limits herein specified. Manufacturing errors and omissions requiring correction in the field shall be performed under the direction of and at the expense of the Vendor. If the error requires shipment back to the factory, the disassembly, handling, shipping, and reassembly shall be at the Vendor's expense.

ATTACHMENT 1

LIST OF BID DRAWINGS

The following Drawings set forth the location and extent of the Work specified herein:

Dwg No.	Rev.	Date	Title

ATTACHMENT 2
EQUIPMENT DATA

STEAM GENERATING EQUIPMENT

BIDDER'S NAME			____________
MANUFACTURER'S NAME			____________
QUOTATION NUMBER			____________
1.	Steam Generator - Design:		
a.	Manufacturer		____________
b.	Proposal number		____________
c.	Type		____________
d.	Drums, number and diameter	mm (in.)	______ ; ______
e.	Furnaces, number and width x depth of each	m (ft)	______ ; ______
f.	Furnace volume (total)	m^3 (ft^3)	____________
g.	Pulverizers, number and type		______ ; ______
h.	Rated steam capacity	tonnes/hr (lb/hr)	____________
i.	Number of burners		____________
j.	Surface area and area:		
(1)	Economizer	m^2 (ft^2)	____________
(2)	Boiler	m^2 (ft^2)	____________
(3)	Waterwalls	m^2 (ft^2)	____________
(4)	Superheater	m^2 (ft^2)	____________
(5)	Superheater - convection	m^2 (ft^2)	____________

ATTACHMENT 2
EQUIPMENT DATA

(6)	Reheater	m^2 (ft^2)	____
(7)	Reheater - convection	m^2 (ft^2)	____
(8)	Burner basket	m^2 (ft^2)	____
(9)	Furnace EPRS	m^2 (ft^2)	____
(10)	Plan Area	m^2 (ft^2)	____

k. Tubes, diameter and spacing:

(1)	Furnace water-wall outer	mm (in.)	____
(2)	Furnace water-wall division	mm (in.)	____
(3)	Superheater - radiant - wall	mm (in.)	____
(4)	Superheater - radiant - platen	mm (in.)	____
(5)	Superheater - convection - pendant	mm (in.)	____
(6)	Superheater - convection - horizontal	mm (in.)	____
(7)	Reheater - radiant - wall	mm (in.)	____
(8)	Reheater - radiant - platen	mm (in.)	____
(9)	Reheater - convection - pendant	mm (in.)	____
(10)	Reheater - convection - horizontal	mm (in.)	____
(11)	Economizer	mm (in.)	____

ATTACHMENT 2
EQUIPMENT DATA

	(12) Downcomers, number and diameter	mm (in.)	;
	(13) Air heater, number and type		;
l.	Weights of unit:		
	(1) Empty	Kg (lb)	
	(2) With water for hydrostatic test	Kg (lb)	
	(3) Hydrostatic test water only	Kg (lb)	
	(4) Water to normal operating level	Kg (lb)	
m.	Superheater control:		
	(1) Method		
	(2) Minimum steam flow at design superheat temperature	tonnes/hr (lb/hr)	
n.	Reheater control:		
	(1) Method		
	(2) Minimum steam flow at design reheat temperature	tonnes/hr (lb/hr)	
o.	Heat release in furnace - net heat release	$Kj/m^2/hr$ ($Btu/ft^2/hr$)	
p.	From fuel only	$Kj/m^2/hr$ ($Btu/ft^2/hr$)	
q.	Furnace projected areas:		
	(1) Waterwall including radiant superheater	m^2 (ft^2)	

ATTACHMENT 2
EQUIPMENT DATA

	(2) Platen superheater	m^2 (ft^2)	______
	(3) Furnace exit	m^2 (ft^2)	______
	(4) Total	m^2 (ft^2)	______
r.	Design factors - net heat release rates:		
	(1) Projected area	Kj/m^2/hr (Btu/ft^2/hr)	______
	(2) Plan area	Kj/m^2/hr (Btu/ft^2/hr)	______
	(3) Burner zone	Kj/m^2/hr (Btu/ft^2/hr)	______
s.	Recirculation ratio		______

2. Air Heater Soot Blowers:

a.	Blower type		______
b.	Manufacturer		______
c.	Model		______
d.	Quantity		______
e.	Nozzle size		______
f.	Number of nozzles		______
g.	Recommended header pressure	KPa (psig)	______
h.	Rate of steam use	tonnes/hr (lb/hr)	______
i.	Steam use per operation	Kg/ (lb)	______
j.	Element blowing arc	degrees	______
k.	Rate of rotation	r/min	______

ATTACHMENT 2
EQUIPMENT DATA

3. Half Tract Soot Blowers:

a.	Blower type		__________
b.	Manufacturer		__________
c.	Model		__________
d.	Quantity		__________
e.	Nozzle size		__________
f.	Number of nozzles		__________
g.	Recommended header pressure	KPa (psig)	__________
h.	Rate of steam use	tonnes/hr (lb/hr)	__________
i.	Steam use per operation	Kg (lb)	__________
j.	Element travel	mm (in.)	__________
k.	Rate of rotation	r/min	__________
l.	Travel per revolution	mm (in.)	__________
m.	Rate of travel	m/sec (ft/min)	__________

4. Long Retractable Soot Blowers:

a.	Blower type		__________
b.	Manufacturer		__________
c.	Model		__________
d.	Quantity		__________
e.	Nozzle size		__________
f.	Number of nozzles		__________
g.	Recommended header pressure	KPa (psig)	__________

h.	Rate of steam use	tonnes/hr (lb/hr)	______
i.	Steam use per operation	Kg (lb)	______
j.	Element travel	mm (in.)	______
k.	Travel per revolution	mm (in.)	______
l.	Travel speed	m/sec (ft/min)	______
m.	Rate of rotation	r/min	______

5. Wall Soot Blowers:

a.	Blower type		______
b.	Manufacturer		______
c.	Model		______
d.	Quantity		______
e.	Nozzle size		______
f.	Recommended header pressure	KPa (psig)	______
g.	Rate of steam use	tonnes/hr (lb/hr)	______
h.	Steam use per operation	Kg (lb)	______
i.	Element blowing arc	degrees	______
j.	Rate of rotation	r/min	______

6. Pulverizer Rejects Hopper

a.	Model Number/Size	______
b.	Number Supplied	______
c.	Material Specification	______

ATTACHMENT 2
EQUIPMENT DATA

	d. Shell Thickness	mm (in.)	______
	e. Weight Empty	Kg (lb)	______
	f. Operating Weight	Kg (lb)	______
7.	Pulverizer Rejects Transfer Tank		
	a. Model Number/Size		______
	b. Number Supplied		______
	c. Material Specification		______
	d. Shell Thickness	mm (in.)	______
8.	Jetpulsion Water Pumps, Pulverizer Rejects Hopper		
	a. Model Number/Size		______
	b. Number Supplied		______
	c. Material Specification		______
9.	Jetpulsion Water Pumps, Pulverizer Rejects Transfer Tank		
	a. Model Number/Size		______
	b. Number Supplied		______
	c. Material Specification		______
	d. Shell Thickness	mm (in.)	______
10.	Water Quantities		
	a. Sluice from Pyrites Hoppers to Transfer Tank		
	(1) l/s (gpm)		______
	(2) Pressure KPa (psig)		______

b. Sluice from Transfer Tank to Ash Pond

(1) l/s (gpm) ______

(2) Pressure KPa (psig) ______

11. Recommended Pipe Size from Pyrites Transfer Tank to Ash Pond mm(in)

12. System Capacity tonnes/hr (tons/hr) ______

13. Bottom Ash Hopper

a. Model Number/Size ______

b. Number Supplied ______

c. Material Specification ______

d. Shell Thickness mm (in.) ______

e. Weight Empty Kg (lb) ______

f. Operating Weight Kg (lb) ______

g. Storage Voume m^3 (ft^3) ______

14. Hours Storage Capacity at Boiler MCR ______

15. Hopper Slope from Vertical degrees ______

16. Hopper Lining Material ______

17. Jetpulsion Water Pumps, Bottom Ash Hopper

a. Model Number/Size mm (in.) ______

b. Number Supplied ______

c. Material Specification ______

ATTACHMENT 2
EQUIPMENT DATA

18. Abrasion Resistant Piping

    a. Size ____________________

    b. Material Specification ____________________

19. Water Quantities

    a. Sluice from Bottom Ash Hoppers to Ash Pond

        (1) l/s (gpm) ____________________

        (2) Pressure KPa (psig) ____________________

20. Clinker Grinders

    a. Number Supplied ____________________

    b. Model Number and Type ____________________

    c. Materials of Construction of Rollers ____________________

    d. Materials of Construction of Casing ____________________

    e. Motor Kw (horsepower) ____________________

21. Hopper Slide Gate Valves

    a. Size mm (in) ____________________

    b. Material of Construction ____________________

ATTACHMENT 3
PERFORMANCE PREDICTIONS

BIDDER'S NAME ______________________

MANUFACTURER'S NAME ______________________

QUOTATION NUMBER ______________________

Note: The performance predictions shall be based on performance coal as specified in paragraph 7.2 with 30% excess air, 27°C (80°F) ambient temperature, and 38°C (100°F) at the inlet to the air heaters.

			Performance Levels					
			25%	40%	60%	80%	95%	100%
1.	Quantities:							
a.	Steam flow at superheater outlet	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
b.	Desuperheating spraywaterfor main steam	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
c.	Feedwater flow to unit	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
d.	Steam flow to reheater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
e.	Reheater desuper-heater spraywater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
f.	Coal burned	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
g.	Air from forced draft fans	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
h.	Air to primary air fans	tonnes/hr (Mlb/hr)	___	___	___	___	___	___

			Performance Levels					
			25%	40%	60%	80%	95%	100%
i.	Air to air heater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
j.	Air from air heater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
k.	Air to pulverizers	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
l.	Cold temperature air	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
m.	Air heater air leakage	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
n.	Flue gas recirculated	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
o.	Flue gas leaving economizer	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
p.	Flue gas entering air heater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
q.	Flue gas leaving air heater	tonnes/hr (Mlb/hr)	___	___	___	___	___	___
r.	Excess air leaving economizer	%	___	___	___	___	___	___
s.	Excess air leaving air heater	%	___	___	___	___	___	___

2. Flue Gas Temperatures:

a.	Leaving furnace boundary	^oC (^oF)	___	___	___	___	___	___
b.	Leaving reheater	^oC (^oF)	___	___	___	___	___	___
c.	Leaving low-temperature super-heater	^oC (^oF)	___	___	___	___	___	___

			Performance Levels					
			25%	40%	60%	80%	95%	100%
	d. Leaving economizer	°C (°F)						
	e. Leaving air heater, uncorrected	°C (°F)						
	f. Leaving air heater, corrected	°C (°F)						
3.	Air Temperatures:							
	a. From FD fans	°C (°F)						
	b. To air heaters	°C (°F)						
	c. From air heater	°C (°F)						
	d. To pulverizers	°C (°F)						
4.	Air Pressure Losses:							
	a. Through air	kPa (in. H_2O)						
	b. Secondary air through burners	kPa (in. H_2O)						
	c. Primary air through burners	kPa (in. H_2O)						
	d. Through ducts furnished by Vendor	kPa (in. H_2O)						
5.	Flue Gas Pressure Losses:							
	a. Through boiler	kPa (in. H_2O)						
	b. Through super-heater	kPa (in. H_2O)						
	c. Through reheater	kPa (in. H_2O)						

			Performance Levels					
			25%	40%	60%	80%	95%	100%
d.	Through economizer	KPa (in. H_2O)	___	___	___	___	___	___
e.	Through air heater	KPa (in. H_2O)	___	___	___	___	___	___
f.	Through flues furnished by the Vendor	KPa (in. H_2O)	___	___	___	___	___	___
g.	Total loss from airheater inlet to air heater gas outlet	KPa (in. H_2O)	___	___	___	___	___	___
6.	Heat Balance Losses:							
a.	Dry gas	%	___	___	___	___	___	___
b.	Hydrogen and moisture in fuel	%	___	___	___	___	___	___
c.	Moisture in air	%	___	___	___	___	___	___
d.	Unburned carbon	%	___	___	___	___	___	___
e.	Radiation	%	___	___	___	___	___	___
f.	Unaccounted	%	___	___	___	___	___	___
g.	Total losses	%	___	___	___	___	___	___
h.	Boiler efficiency	%	___	___	___	___	___	___
7.	Fuel Conditioning Equipment:							
a.	Number of pulverizers in service		___	___	___	___	___	___
b.	Power to pulverizer fuel equipment	kWh/tonne (kWh/ton)	___	___	___	___	___	___

		Performance Levels					
		25%	40%	60%	80%	95%	100%
c. Fineness of grinding:							
(1) Amount through a 200-mesh screen	%	___	___	___	___	___	___
(2) Amount through a 100-mesh screen	%	___	___	___	___	___	___
(3) Amount through a 50-mesh screen	%	___	___	___	___	___	___

ATTACHMENT 4
PERFORMANCE GUARANTEES

BIDDER'S NAME ____________________

MANUFACTURER'S NAME ____________________

QUOTATION NUMBER ____________________

1. Steam Generator Guarantees (performance at rated conditions):

a.	Specified continuous capacity of the steam generator	tonnes/hr (Mlb/hr)	____________
b.	Efficiency of steam generator	%	____________
c.	Total of air pressure losses from air heater air inlets to furnace and gas pressure losses from the furnace to air heater gas outlets	KPa (in. H_2O)	____________
d.	Steam temperature from superheater	^oC (^oF)	____________
e.	Steam temperature from reheater	^oC (^oF)	____________
f.	Pressure drop from steam drum to superheater outlet	KPa (psi)	____________
g.	Steam pressure drop through reheater	KPa (psi)	____________
h.	Pressure drop through economizer	KPa (psi)	____________
i.	Steam purity	ppm	____________

ATTACHMENT 4
PERFORMANCE GUARANTEES

j.	Pressure and quantity of spraywater required for each desuperheater used	KPa, kg/sec (psig;lb/hr)	__________
k.	Maximum air heater leakage		
	(1) Primary air to air	tonnes/hr (Mlb/hr)	__________
	Primary air to gas	tonnes/hr (Mlb/hr)	__________
	(2) Secondary air	tonnes/hr (Mlb/hr)	__________

2. Other Specific Guarantees:

a.	Capacity of coal pulverizers with 70 percent through a 200-mesh screen and 99 percent through a 50-mesh screen	tonnes/hr (lb/hr)	__________
b.	Power required by pulverized fuel equipment as follows:		
	(1) Steam flow	tonnes/hr (Mlb/hr)	__________
	(2) Pulverizer	kWh/tonne (kWh/ton)	__________
	(3) P. A. Fan	kWh/tonne (kWh/ton)	__________
c.	Range of boiler loads at which 513°C (955°F) main steam temperature will be maintained, tonnes/hr (lb steam/h)	min	__________
		max	__________

ATTACHMENT 4
PERFORMANCE GUARANTEES

d.	Range of boiler loads at which 513°C (955°F) reheat steam temperature will be maintained, tonnes/hr (lb steam/h)	min max	________ ________
e.	Guarantee boiler and waterwall circulation adequate for operation up to 100% of rated capacity		________ ________ ________
f.	Guarantee continuous stable combustion on automatic control without the use of supplementary fuel over a range of 20 to 100% of rating		________ ________ ________
g.	Guarantee a gastight enclosure for the entire steam generator as attested by one year's adequacy of the integrity of the casing		________ ________ ________
h.	Acoustic guarantees		________ ________ ________

ATTACHMENT 5

ACOUSTIC DATA
SUMMARY SHEET

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dBA at 1 meter (3 feet)
63	________	____________
125	________	____________
250	________	____________
500	________	____________
1000	________	____________
2000	________	____________
4000	________	____________
8000	________	____________

Kind of levels given, indicate which of the following:

Sound Power Levels re 10 (exp -12) watt	________	____________
Sound Pressure Levels re 2x10 (exp -4) microbars	________	____________

If sound pressure levels are given, indicate both of the following:

Weighting network use A , B, C, or Linear (None)	________	____________
Distance to sound source Feet or Meters	________	____________

Vendor Comments: ____

____

____

____

ATTACHMENT 6
SPECIFICATION EXCEPTIONS

STEAM GENERATING EQUIPMENT

The bidder certifies that the bid is complete and in absolute agreement with the requirements of this Specification, except as specifically stated below. (Use additional sheet is required.)

(BIDDER'S NAME)

(MANUFACTURER'S NAME)

(QUOTATION NUMBER)

Attest:

(SIGNATURE)

(TITLE)

ATTACHMENT 7
TECHNICAL REQUIREMENTS
CENTRIFUGAL FANS

ATTACHMENT 7

TECHNICAL REQUIREMENTS

CENTRIFUGAL FANS

TABLE OF CONTENTS

ATTACHMENT 7
TECHNICAL REQUIREMENTS
CENTRIFUGAL FANS

1.0 DESCRIPTION OF WORK

1.1 The work to be performed includes designing, fabricating, furnishing of material and components and packaging of forced draft and induced draft fans and accessory equipment as specified. Two forced draft and two induced draft fans are to be supplied for each of two 1,312 tonnes/hr (2,893,200 pounds/hour), 13,100 kPa (1,900 psig), 513°C (955°F/955°F) balanced draft drum type generators. The fans will serve each nominal 350 MW reheat condensing turbine generator unit at the Water and Power Development Authority (WAPDA) to be located in Pakistan.

1.2 The unit is designed to operate as a base load unit.

2.0 WORK INCLUDED

The work shall include all necessary forced draft fan and induced draft fan equipment to provide complete and operational fans, including but not necessarily limited to, the following:

a. Two centrifugal forced draft fans complete with inlet vane control mechanism, outlet isolation damper, inlet box, inlet cone, inlet screens, inlet silencer, flexible couplings and coupling guards and including the necessary lubricating oil pumping station.

b. Two modified radial tip centrifugal induced draft fans complete with inlet vane control mechanism, inlet and outlet isolating dampers, inlet boxes, inlet cones, flexible couplings and coupling guards and including the necessary lubricating oil pumping station.

3.0 WORK NOT INCLUDED

The following items are not specifically included in the requirements of this section, but are covered in other sections of the boiler island specifications:

a. Forced draft fan and induced draft fan and other auxiliary equipment motors. These motors will be furnished by Others as described in Attachment 8.0.

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b. Installation of the forced draft fans and induced draft fans will be by Others.

4.0 APPLICABLE CODES, STANDARDS AND REGULATORY REQUIREMENTS

4.1 All work and materials shall be in acordance with the following codes, regulations and standards.

a. Air Moving and Conditioning Association (AMCA) Codes including:

AMCA 99	Standards Handbook
AMCA 203	Fan Application Manual, Section Three, Field Performance Measurement
AMCA 210	Fan Application Manual, Part 1 - Fans and Systems
AMCA 300	Test Code for Sound Rating
AMCA 301	Method for Publishing Sound Ratings for Air Moving Devices

b. American National Standards Institute (ANSI) Codes including:

ANSI B4.1	Preferred Limits and Fits for Cylindrical Parts
ANSI B16.5	Steel Pipe Flanges, Flanged Valves and Fittings
ANSI B16.11	Forged Steel Fittings, Socketwelding and Threaded
ANSI B16.25	Butt Welding Ends
ANSI C96.1	Temperature Measurement Thermocouples
ANSI S1.2	Method for the Physical Measurement of Sound

c. American Society for Testing Materials (ASTM) Codes including:

ASTM Part 1	Steel Piping, Tubing and Fittings
ASTM Part 2	Ferrous Castings, Ferralloys

ASTM Part 3	Steel Plate, Sheet, Strip and Wire
ASTM Part 11	Metallography, Nondestructive Tests

d. American Welding Society (AWS) Codes including:

AWS D1.1	Structural Welding Code -
AWS A5.1	Specification for Mild Steel Covered Arc - Welding Electrodes -
AWS A5.5	Specification for Low-Alloy Steel Covered Arc - Welding Electrodes -

5.0 SUPPLEMENTAL DATA

5.1 Except as listed below, the definitions of the Air Moving and Conditioning Association Inc. shall apply:

a. Inlet - Inlet shall be the inlet of the inlet boxes or when a sound attenuator is used shall be the inlet of the sound attenuator.

b. Outlet - Outlet shall be the fan outlet or when an evase is used shall be the outlet of the evase.

c. Total pressure - The total pressure of a fan shall be the rise of pressure from inlet to outlet as measured by two impact tubes, one at the inlet and one at the outlet, or one impact tube at the outlet when an inlet box is not used.

d. Velocity Pressure - The velocity pressure of a fan shall be the pressure corresponding to the average velocity determination from the volume at the outlet area.

e. Static Pressure - The static pressure of a fan shall be the total pressure diminished by the velocity pressure.

6.0 VENDOR DATA

6.1 The Vendor shall furnish data in accordance with the following requirements:

a. Forced Draft Fan Outline

b. Forced Draft Fan Inlet Damper

c. Forced Draft Outlet Damper

d. Forced Draft Inlet Control Vanes

e. Induced Draft Fan Outline

f. Induced Draft Fan Inlet Damper

g. Induced Draft Fan Outlet Damper

h. Induced Draft Fan Inlet Control Vanes

6.2 The Vendor shall complete Summary Tables 1, 2, 3, and 4 and submit with the Proposal. Failure to complete these tables could result in the Vendor's Proposal being disqualified.

7.0 <u>DESIGN REQUIREMENTS</u>

7.1 The two forced draft fans shall be designed for and guaranteed to meet the requirements specified in Table 1.

7.2 The Vendor shall guarantee the forced draft fans to be suitable for parallel operation.

7.3 The two induced draft fans shall be designed for and guaranteed to meet the requirements in Table 2.

7.4 The Vendor shall guarantee the induced draft fans to be suitable for parallel operation.

7.5 The Vendor shall supply, with each fan, a nonlubricated Thomas limited end float flexible gear type coupling.

7.6 Fans shall be fully suitable for outdoor installation.

7.7 The forced and induced draft fans and couplings shall be suitable for across-the-line motor starting.

7.8 Turning gear shall not be supplied with Centrifugal Flow Fans, if the Vendor determines that it is not required for starting, stopping or normal operation and maintenance of the fan.

7.9 The bearings for the Centrifugal Flow Fans shall be of the antifriction type. Bearings shall be drilled and tapped for/and complete with thermocouples.

The bearings on the forced draft and induced draft fans shall be provided with vibration monitoring as follows:

X-Y relative probe monitoring shall be used. This shall consist of two noncontacting displacement transducers mounted at right angles to each other 45^{o} from true vertical. These transducers are to be located within 75 mm (3 inches) of each bearing. A keyphasor reference shall be installed. This shall consist of a notch in the shaft in the same axial position as the "keyphasor probe" which is a noncontact probe located at any convenient axial location adjacent to the shaft. This shall yield a once-per-revolution pulse with an amplitude greater than 4V and lasting approximately 5^{o} of rotation. All probes are to be installed in accordance with API 670.

Oscillator-demodulators (proximators) shall be readily accessible during normal operation of the unit. Lengthy panel removal procedures for access are to be avoided.

Vibration monitors shall provide buffered outputs of relative shaft bearing motion. Alarms and trips and monitor faceplate indication will be based on the relative displacement of the shaft. Each probe will be monitored. All vibration meters shall be calibrated in units of mils.

The preferred monitor system shall be the Smart monitor which is available from the Bently-Nevada Corporation. This system meets the above minimum requirements and provides additional features, which would aid in diagnostics and machine protection.

Axial shaft movement probes and monitoring system shall also be provided as part of the Bently-Nevada equipment.

7.10 Acoustic Requirements

a. The acoustic data for the fans shall be presented as sound power levels (re. one picowatt) and determined in accordance with AMCA 300-67. The data shall be corrected for fan size, speed and blade passing frequency. The Contractor shall state the percent of full load that the maximum sound power level occurs. Data shall be included for both the maximum sound level condition and for full load operation with inlet vanes fully open.

b. Sound pressure level (re. 0.0002 microbars) data for the stated load conditions will be acceptable as an alternate, provided this change is shown in the Data Summary Tables 3 and 4. In addition to stating the weighting network and distance to the sound source, the calculative or test procedure shall be identified.

7.11 One self contained pressure lubricating system for each fan (both induced and forced draft) shall be provided.

The unit shall consist of two centrifugal oil pumps driven by totally enclosed motors, thermostatically controlled immersion heater, cleanable disc type filter, pressure control switch, oil level sight glass, temperature and pressure gages and air to oil oilcooler. All accessories to be assembled on or within the oil sump tank including all internal oil piping and flexible connection. Motors for fan and pumps shall be in accordance with Attachment 8 of this Specification.

The system shall be designed so that one oil pump is capable of supplying the required lubrication. The other pump is used for standby and is so connected that it will cut in automatically for emergency use.

The complete lubrication system is to be factory assembled, including all safety devices to insure positive lubrication to the bearings at all times.

7.12 The Vendor shall state the maximum guaranteed leakage through the damper, when closed, with the maximum pressure differential produced by the fans.

7.13 Welding of rotating parts shall not be permitted.

7.14 Fans shall be designed for maximum vibration not exceeding 15 microns (.0006") from neutral. Fan blades shall be pre-balanced so that replacement can be made in field without further impeller balancing.

7.15 Vendor shall specify maximum dynamic unbalance required for foundation design.

7.21 The forced draft and induced draft fan housings shall be designed for ease of maintenance and access to the fan impeller. The casing shall be split to provide easy removal of the fan wheel for replacements or repairs.

8.0 PERFORMANCE REQUIREMENTS

8.1 The forced draft fans shall be sized and selected in accordance with the following requirements:

a. The forced draft fan net flow shall be the required weight flow at boiler MCR assuming 30 percent excess air for combustion and allowing an additional 15 percent of the stoichiometric air requirement for air heater leakage.

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b. The forced draft fan test block mass flow shall be the above net condition weight flow plus a 10 percent margin on flow by weight. The forced draft fan test block volume flow shall be based on the test block mass flow and test block density as determined below.

c. Fan pressure specifications shall preferably be in terms of total pressure rise (FTP) from ambient pressure as measured at an outlet reference plane.

d. The forced draft fan net pressure rating (FTP) shall be the sum of the velocity pressure at the fan outlet and the calculated system losses at MCR airflow from the fan outlet through the steam generator burners.

e. The forced draft fan test block pressure rating (FTP) shall be the net pressure rating determined above, plus a 21 percent margin.

f. The net inlet air temperature at the fan inlet shall be 27°C (80°F).

g. The test block inlet air temperature at the fan inlet shall be 50°C (122°F).

8.2 The induced draft fans shall be sized and selected in accordance with the following requirements:

a. The specified induced draft fan net condition flow shall be the weight flow at boiler MCR assuming 30 percent excess air for combustion, 15 percent of the stoichiometric air requirement for air heater leakage and 5 percent of the stoichiometric air requirement for setting infiltration or not less than 50 percent excess air.

b. The specified induced draft fan test block mass flow shall be the above net weight flow, plus a 10 percent margin on flow by weight.

c. The specified induced draft fan test block volume flow shall be based on the above test block mass flow and the test block density as determined below.

d. Fan pressure specifications shall preferably be in terms of total pressure rise (FTP) from fan inlet to fan outlet, as measured at inlet and outlet reference planes.

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e. The specified induced draft fan net inlet pressure (TP_1) shall be the sum of the velocity pressure at the fan inlet (positive) and the draft loss from the point of balanced draft to the fan inlet at the MCR flow rate.

f. The specified induced draft fan net outlet pressure (TP_2) shall be the sum of the velocity pressure at the fan outlet and the draft loss from the fan outlet to the stack exit at the MCR flow rate.

g. The specified induced draft fan test block pressure ratings shall be the net pressure ratings, plus a 21 percent margin.

h. The fan net inlet gas temperature at MCR conditions shall be based on the air heater outlet temperature stated by the steam generator supplier.

i. The test block temperature shall be 175°C (345°F). The mechanical design temperature of the fan rotor shall be 185°C (365°F).

8.3 The system head curves for the forced draft and induced draft fans shall be assumed to vary with the square of the system flow.

8.4 The Vendor shall ship the driving halves of flexible couplings to the driving equipment manufacturer for finish boring, keyseating and mounting on the driving equipment shaft.

8.5 In addition to the conditions specified in 8.1 above, the FD fans shall have the capability to operate at full speed, and static pressure with 0°C (32°F) inlet air temperature.

8.6 PERFORMANCE GUARANTEES

a. The Contractor shall guarantee stability of operation, without pulsation or surging, at all loads for both singular and parallel operations.

b. The Contractor shall guarantee fan performance in accordance with the design conditions noted in Table 1 and 2 (Design Data).

c. The Contractor shall guarantee that the operating speed is at least 20 percent below the first critical speed of the fan.

d. The Contractor shall guarantee that each fan is capable of cold start with temperatures as low as 0°C (32°F).

e. Contractor shall guarantee that fan noise levels shall not exceed 90 dBA within the limits shown on the Acoustic Summary Tables 3 and 4. Should the noise levels exceed those guaranteed, Contractor shall supply inlet attenuators at no cost to the Owner.

9.0 MATERIAL REQUIREMENTS

9.1 The fan inlet boxes, the diffuser and the intermediate piece shall be 6mm (1/4") thick steel for the forced draft fan and 8mm (5/16") thick steel for the induced draft fan.

9.2 Type T-1 steel (ASTM A-514 Grade F) shall not be used in construction.

9.3 MATERIAL SELECTION/FRACTURE TOUGHNESS

A -26°C (-15°F) design metal temperature of the steel shall be used. Each heat of as-rolled steel shall be impact tested (Charpy V-notch) in accordance with ASTM A300 practice at the design temperature to show that the average of three specimens is a minimum of 41J (30 ft-lb) (logitudinal) or 27J (20 ft-lb) (transverse), except that quenced and tempered material shall be impact tested, as heat treated, to show an average of 97J (35 ft-lb) (longitudinal) or 34J (25 ft-lb) (transverse). Alternately, the manufacturer can submit to the Purchaser test data from plates of this material demonstrating that, based on past production from the same mill, the material has provided the required toughness of the -26°C (-15°F) design metal temperature.

10.0 FABRICATION/ASSEMBLY REQUIREMENTS

10.1 Suitable access doors shall be provided on the fan inlet boxes and the fan housing.

10.2 Two drain connections (not less than 100mm (4") diameter) shall be provided in the bottom of each fan inlet box and fan housing.

10.3 Each louver damper unit shall be supplied with heavy duty operating linkage to assure uniform travel and positioning of the individual blades. Blade shaft bearings shall be mounted outside the damper box channel and arranged for convenient inspection and lubrication and shall be protected from duct and fly ash. Stuffing boxes shall be provided on all damper blade shafts.

10.4 Rotor welds shall be cleaned and inspected by magnetic particle test procedures after each weld pass and defects shall be repaired and recorded. After welding is completed, the rotor shall be stress relieved. All rotor welds shall be re-examined by magnetic particle test procedures following stress relieving. Defects shall be repaired, recorded and stress relieved. The above procedure shall not apply if the fan rotor does not have any welded construction.

10.5 WELDING PROCEDURES AND INSPECTION

a. Each weld shall be uniform in width and size throughout its full length. Each layer of welding, as evidenced by visual inspection, shall be smooth and free of slag, inclusions, cracks, porosity, lack of fusion and undercut (see AWS D1.1-72, Section 3, Paragraph 3.6-4). In addition, the cover pass shall be free of coarse ripple, irregular surface nonuiform bead patterns, high crown and deep ridges or valleys between beads.

b. Butt welds shall be slightly convex, of uniform height and full penetration.

c. Fillet welds shall be of specified size with full throat and the legs of uniform height.

d. Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove or reduce the adjacent base metal thickness.

10.6 Longitudinal submerged arc welds made by the submerged arc welding process shall be made only with removable starting and stopping tabs.

10.7 WELDING ELECTRODES

a. Low hydrogen type electrodes shall be used for making all welds, unless otherwise approved.

b. The electrode shall deposit weld metal within the limits of physical properties as specified for the materials to be joined, unless otherwise approved.

c. All electrodes having low hydrogen coverings conforming to AWS A5.1 or A5.5 shall be suplied in hermetically sealed containers and during fabrication storage, drying and redrying shall be as per AWS D1.1-72, Part 11, Section 4.9.

10.8 All temporary attachments shall be ground flush with the surface and magnetic particle or dye penetrant tested. Welding unnecessary attachments shall not be allowed. No arc-strikes shall be allowed.

(B)

10.9 PREHEAT

a. Preheat shall be as recommended in AWS D1.1-72, Section 4.

b. Carbon steel shall be preheated to 93°C (200°F) minimum when the thickness exceeds 32mm (1 1/4").

c. Metal temperature shall be measured prior to welding and at least once every hour and recorded on the inspection log by the shop floor QC or inspection personnel.

10.10 Postheat

Unless otherwise specified, the maximum stress-relief temperature shall not exceed the minimum specified by more than 38°C (100°F). All repair shall be completed prior to the stress-relief heat treatment.

11.0 INSTALLATION REQUIREMENTS

Not applicable.

12.0 PERSONNEL REQUIREMENTS

12.1 WELDING PROCEDURES

a. Owner's Inspector will review qualification records for individual welders and welding procedures.

b. Procedures for qualification test and performance qualification test records shall be prepared on forms similar to those outlined in AWS D1.1-72, Appendix E or ASME Section IX, Appendix II.

12.2 Personnel performing NDE testing shall be qualified in accordance with the most recent revision to ASNT Recommended Practice SNT-TC-1A.

13.0 INSPECTIONS AND TESTS

13.1 The equipment covered by this Specification shall be subject to inspection by the Purchaser and the Owner during fabrication, construction and prior to shipment.

13.2 The shaft shall be inspected using ultrasonic procedures following final machining and prior to assembly.

13.3 Nondestructive Examination (NDE) shall be in accordance with the most recent revisions of the following ASTM Standard Recommended Practices:

a. E109, E138 - Magnetic Particle Testing (MT)

b. E94 - Radiographic Testing (RT)

c. E164 - Ultrasonic Testing (UT)

13.4 NDE shall be performed in accordance with the ASTM Recommended Practices referenced above, or as agreed upon in writing between the Owner and the Contractor.

13.5 All final welds shall be visually inspected and show the welds to be free of porosity, cracks, laps, lack of fusion and excessive undercut.

13.6 Fan shafts shall be given an ultrasonic test.

13.7 The root passes of all blade welds shall be given a 100 percent dye penetrant inspection. Spot magnetic particle inspection shall be performed on the root pass of full penetration welds.

13.8 After welding is completed, fan blades shall be stress relieved.

13.9 After stress relief of the blades, all welds shall be given a magnetic particle examination.

13.10 Radiographic examinations shall be performed on all welds that are located in high stress areas.

13.11 Rotor welds shall be magnetic particle inspected at the following stages of welding:

a. On completion of the root layer or for joints welded on both sides, the reverse side after backgouging shall have MPT (Magnetic Particle Testing) inspection prior to deposition of weld metal.

b. MPT inspection shall be performed after each 6mm (1/4 inch) thickness of deposited weld metal.

c. MPT inspection shall be performed on the face(s) of the completed weld(s) prior to and after stress relieving and annealing.

13.12 MPT acceptance criteria of welds shall be as follows:

a. Welds shall have no cracks, inclusions, lack of fusion or overlaps.

b. The toes of the welds shall blend smoothly into the base material.

c. Maximum depth of undercut shall be .8mm (1/32 inch).

d. Faces of fillet welds may be either slightly convex, flat or concave, but must be in accordance to the required throat size specified by the Contractor's drawings.

e. Reinforcement crowns of groove welds shall not exceed 3mm (1/8 inch).

f. Welds shall be free of linear indications. Linear indications with the length equal to three or more times the width shall be explored/removed and re-inspected. If re-inspection reveals linear indications, the indication becomes an unacceptable condition and must be removed/repaired.

g. Rounded Indications - welds shall be free of rounded indications that are equal to or greater than 0.8mm (1/32 inch) in diameter. No more than four such indications are permitted in any $65mm^2$ (10 square inches) of weld surface.

h. Weld surfaces shall be free of spatter, flux, sharp rides or valleys and arc strikes.

13.13 Acceptance/rejection standards for NDE methods and visual inspection shall be recommended by the Contractor and reviewed by the Owner's Engineer. In general, the acceptance/rejection criteria listed in AWS D1.1 shall apply.

13.14 <u>Inspection Records</u>

The following inspection records shall be provided by the Contractor upon completion of the job:

a. Records of welding rotor welds

b. MPT inspection records of rotor welds

c. Mill Test or Certificate Records of material used on the rotor, including welding electrodes used

d. Stress relieving and annealing records.

13.15 Shop performance tests shall be in accordance with the AMCA Standard 210.

13.16 Performance of fans having wheels larger than 890mm (35 inches) in diameter may be calculated from tests of geometrically similar fans having wheels not less than 890mm (35 inches) in diameter.

13.17 Performance guarantees shall be verified by measurement at the installation site at the Owner's discretion. Verification tests shall be performed in accordance with AMCA Publication 203.

13.18 Fan wheels shall be balanced to within .013mm (0.5 mils).

13.19 The Vendor shall provide a qualified engineer to supervise and conduct the test, and submit a complete report of the test. The Vendor shall notify the Owner ten (10) working days prior to conducting of the test so that the Owner may send a representative to observe the test if desired.

13.20 The Contractor shall submit certification of shop balance, indicating type of balance machine and amount and placement of weights.

13.21 The Owner or his authorized representative shall have access to the Vendor's plant and quality assurance records and to those of the Vendor's subcontractors and suppliers during the production of materials for this contract.

13.22 The Vendor shall submit the following documents:

a. Certified copies of Material Test Reports.

b. Certified reports of Non-Destructive Examination performed.

14.0 CLEANING/CORROSION PROTECTION/COATING

14.1 The equipment shall be clean and free of foreign material. All manufacturing waste shall be removed from the equipment. All mill scale, rust, oil, grease, chalk, crayons, paint marks and other deleterious material shall be removed from interior and exterior surfaces.

14.2 All exterior carbon steel surfaces shall be cleaned in accordance with SSPC-SP6.

14.3 Within 4 hours after cleaning and before any condensation or rust forms, a single coating .075-.1mm (3-4 mils) thick of the Vendors recommended primer shall be applied in a clean atmosphere, free of dust, sand or fumes. The primer shall be applied in strict accordance with the manufacturer's written instructions, using only the spray equipment recommended by the manufacturer.

14.4 Finished and unpainted surfaces shall be cleaned and given a coating of suitable solvent-removable preservative. All stainless steel, Ni-Resist and other corrosion resistant materials need not be painted.

15.0 MARKING AND IDENTIFICATION

15.1 Each fan shall be identified with a separate and unique equipment number.

The equipment numbers shall be referenced on drawings and correspondence. Equipment, components and accessories provided by the Vendor, in compliance with this specification, shall be tagged prior to shipment. Such tags shall bear, in an indelible manner, the appropriate equipment numbers. Tags shall be metal, securely fastened to each item or piece of all fan and fan related components.

16.0 PACKAGING/SHIPPING/STORAGE

16.1 Items shall be free from contamination prior to packaging and shipping.

16.2 The Vendor shall provide temporary bracing to hold sections in proper shape during shipment.

16.3 All external machined surfaces shall be suitably protected to avoid damage in handling storage and shipment.

16.4 All openings into items shall be capped, plugged and sealed from moisture. Weld end preparations shall be protected from corrosion and physical damage.

16.5 Bearings shall be shipped in sealed, water and vapor proof containers, and provided with dessicant.

16.6 The shaft journals shall be unpainted, coated with rust preventative, and wrapped in lead foil, wood blocks, or other acceptable coverings.

16.7 Electrical items shall be protected from water vapor, salt air, dust, dirt and other forms of contamination. Items which can be damaged by condensation trapped within the package shall be packaged with approved desiccant inside the barrier or by an equivalent method.

16.8 The Vendor shall state the specific requirements for storage of the fan components in the Proposal.

16.9 Items shipped on open carriers shall have vapor and water barriers suitably protected against transportation damage.

16.10 The weight, lifting points, or center of gravity shall be indicated on the crate, skid, or packaged by the shipper and shall be utilized to provide proper handling during loading, transfer between carriers, and unloading.

16.11 All austenitic stainless steel and nickel base alloy materials shall be handled in such a manner that they are not in contact with lead, zinc, copper, mercury, or other low melting elements, alloys, or halogenated material.

16.12 Packages and/or preservative coatings shall be visually inspected after loading and damaged areas repaired prior to shipment. Items shipped with desiccants shall be inspected after loading to verify that sealed areas are intact.

16.13 Sealed openings shall be visually inspected after loading to verify closures are intact.

16.14 Written instructions covering the location and stacking limits of the crates or boxes on the transport vehicle shall be specified and marked on the container(s).

16.15 Impeller hubs with regulation components, hydraulic cylinder units and the rotating seal shall be stored in a dry environment. If stored outside, the Vendor shall provide specific instructions.

17.0 ACCEPTANCE CRITERIA

17.1 Prior to acceptance of the fans and final payment, performance guarantees will be verified, at the option of the Owner, by field measurement at the installation site in accordance with AMCA Publication 203 and the attached Field Test Procedure. The allowable test tolerances will be mutually agreed upon prior to award of Contract.

TABLE 1

DESIGN DATA

FORCED DRAFT FANS

DESIGN DATA FOR EACH UNIT

1.	Number of Forced Draft Fans		2
2.	Stoichiometric Air Flow (Theoretical)	- m^3 (CFM)	
3.	Inlet Air Pressure	- KPa n (psia)	
4.	Fan Static Pressure	- KPa n (inches w.g.)	
5.	Fan Inlet Air Density	- Kg/m^3 ($lb/ft.^3$)	
6.	Fan Inlet Air Temperature	- ^oC (^oF)	
7.	Elevation Above Sea Level	- m (ft)	

GUARANTEED FAN PERFORMANCE
(TO BE COMPLETED BY VENDOR)

			Net Conditions	Test Block Conditions
1.	Mass Flow at Fan Inlet (Total for Two Fans)	- tonnes/hr (lb/hr)		
2.	Air Volume at Fan Inlet (Total for Two Fans)	- m^3/sec (acfm)		
3.	Air Temperature at	- ^oC (^oF)		
4.	Inlet Static Pressure Rise	- KPa n (inches w.g.)		
5.	Air Density at Inlet	- Kg/m^3 ($Lb/Ft.^3$)		
6.	Elevation Above Sea Level	- m (Ft.)		

TABLE 2

DESIGN DATA

INDUCED DRAFT FANS

DESIGN DATA FOR EACH UNIT

1.	Number of Induced Draft Fans		2
2.	Stoichiometric Air Flow (Theoretical)	- m^3 (CFM)	
3.	Inlet Air Pressure	- KPa n (inches w.g.)	
4.	Fan Static Pressure	- KPa n (inches w.g.)	
5.	Fan Inlet Air Density	- Kg/m^3 ($lb/ft.^3$)	
6.	Fan Inlet Air Temperature	- ^oC (^oF)	
7.	Elevation Above Sea Level	- m (ft)	

GUARANTEED FAN PERFORMANCE
(TO BE COMPLETED BY VENDOR)

			Net Conditions	Test Block Conditions
1.	Mass Flow at Fan Inlet (Total for Two Fans)	- tonnes/hr (lb/hr)		
2.	Air Volume at Fan Inlet (Total for Two Fans)	- m^3/sec (acfm)		
3.	Air Tempertaure at	- ^oC (^oF)		
4.	Inlet Static Pressure Rise	- KPa n (inches w.g.)		
5.	Air Density at Inlet	- Kg/m^3 ($Lb/Ft.^3$)		
6.	Elevation Above Sea Level	- m (Ft.)		

SUMMARY TABLE 1
FORCED DRAFT FAN
(CENTRIFUGAL)

Manufacturer		______
Number of Fans		______
Fan Size		
Aerodynamic Type		______
Width and Arrangement		______
Design Data		
Capacity of Each Fan	- m^3/sec (CFM)	______
Static Pressure	- KPa (inches w.g.)	______
Density	- Kg/m^3 (lb/cu ft)	______
Speed	- rpm	______
First Critical Speed	- rpm	______
Tip Speed	- m/sec (ft./min.)	______
WR^2 (Rotor)	- Kg-m^2 (lb-ft^2)	______
Brake Horsepower at Design	- m^3/sec (CFM)	______
	@52°C (@125°F)	______
Brake Horsepower at Design	- m^3/sec (CFM)	______
	@ 0°C (32°F)	______
Motor Size	- Kw (Hp)	______
Housing - Material		______
- Thickness	- mm (inches)	______
- Outlet area	- m^2 (sq. ft.)	______
Inlet Box - Material		______
- Thickness	- mm (inches)	______
- Inlet area	- m^2 (sq. ft.)	______
Wheel Diameter	- mm (inches)	______
Blade Type		______
Blade Material		______
Blade Thickness	- mm (inches)	______

SUMMARY TABLE 1
(Continued)

Bearing Ratio		- L/D	______
Bearing Manufacturer			______
Bearing Type			______
Bearing Liner Material			______
Shaft Diameter	- At Wheel	- mm (inches)	______
	- At Bearing	- mm (inches)	______
Shaft Material			______
Shaft Length		mm (inches)	______
Coupling Manufacturer			______
	- Size		______
	- Type		______
Turning Gear	- Size		______
	- Type		______
	- Capacity (Torque)		______
	- RPM		______
	- Motor kW (Horsepower)		______
Outlet Damper	- Torque	j (ft/lb)	______
Inlet Vane Maximum torque required at external lever		j (lb/ft.)	______
Type			______
Operating Angle external lever (closed-open)		- degrees	______
Operating time (closed to open)		- seconds	______
Weights			
Complete fan		- Kg (lbs.)	______
Weight of each impeller		- Kg (lbs.)	______
Weight of bearing assembly		- Kg (lbs.)	______
Total weight of fan rotating parts		- Kg (lbs)	______
Weight of coupling		- Kg (lbs.)	______

SUMMARY TABLE 1
(Continued)

Lube Oil Console		
Lube Oil Capacity	- 1 (Gal.)	________
Lube Oil Pumps	- Kw (Horsepower)	________
Lube Oil Cooler Fan	- Kw (Horsepower)	________

SUMMARY TABLE 2
INDUCED DRAFT FAN
(CENTRIFUGAL)

Manufacturer		________
Number of Fans		________
Fan Size		
Aerodynamic Type		________
Width and Arrangement		________
Design Data		
Capacity of Each Fan	- m^3/sec (CFM)	________
Static Pressure	- KPa (inches w.g.)	________
Density	- Kg/m^3 (lb/cu ft)	________
Speed	- rpm	________
First Critical Speed	- rpm	________
Tip Speed	- m/sec (ft./min.)	________
WR^2 (Rotor)	- $Kg\text{-}m^2$ ($lb\text{-}ft^2$)	________
Brake Horsepower at Design	- m^3/sec (CFM)	________
	@__^oC (@140^oF)	________
Brake Horsepower at Design	- m^3/sec (CFM)	________
	@ 0^oC (@32^oF)	________
Motor Size	- Kw (Hp)	________
Housing - Material		________
- Thickness	- mm (inches)	________
- Outlet area	- m^2 (sq. ft.)	________
Inlet Box - Material		________
- Thickness	- mm (inches)	________
- Inlet area	- m^2 (sq. ft.)	________
Wheel Diameter	- mm (inches)	________
Blade Type		________
Blade Material		________
Blade Thickness	- mm (inches)	________

SUMMARY TABLE 2
(Continued)

Bearing Ratio		- L/D	______
Bearing Manufacturer			______
Bearing Type			______
Bearing Liner Material			______
Cooling Water	1/S (GPM)		
Shaft Diameter -	At Wheel	- mm (inches)	______
-	At Bearing	- mm (inches)	______
Shaft Material			______
Shaft Length		mm (inches)	______
Coupling Manufacturer			______
-	Size		______
-	Type		______
Turning Gear -	Size		______
-	Type		______
-	Capacity (Torque)		______
-	RPM		______
-	Motor kW (Horsepower)		______
Inlet Damper -	Torque	j (ft-lb)	______
Outlet Damper -	Torque	j (ft-lb)	______
Inlet Vane Maximum torque required at external lever		j (ft-lb)	______
Type			______
Operating Angle external lever (closed-open)		- degrees	______
Operating time (closed to open)		- seconds	______
Weights			
Complete fan		- Kg (lbs.)	______
Weight of each impeller		- Kg (lbs.)	______
Weight of bearing assembly		- Kg (lbs.)	______
Total weight of fan rotating parts		- Kg (lbs)	______
Weight of coupling		- Kg (lbs.)	______

SUMMARY TABLE 2
(Continued)

Lube Oil Console		
Lube Oil Capacity	- l (Gal.)	________
Lube Oil Pumps	- Kw (Horsepower)	________
Lube Oil Cooler Fan	- Kw (Horsepower)	________

SUMMARY TABLE 3

FORCED DRAFT FAN

ACOUSTIC DATA SHEET

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dbA at 1 meter (3 Feet)
63		
125		
250		
500		
1000		
2000		
4000		
800		

Tolerance on individual values $\pm$5-6 dB

Kind of levels given, indicate which of the following

Sound Power Levels

re 10 (Exp -12) watt ________ ________

Tolerance $\pm$4 dB.

If sound pressure levels are given, indicate both of the following:

Weighting network used

A, B, C or Linear (None) ________ ________

Distance to sound source

Feet or meters ________ ________

Vendor Comment* The sound power level octave bands are considered at a point source inside the fan. Sound intensity in the airstream may be determined by distributing the sound power level over the outlet area F on the basis of 10 log F.

SUMMARY TABLE 3
(Continued)

The sound pressure data is based on a directivity factor of 8 and a free field. The sound guarantee is based on the installation of sound attenuating baffles at the fan inlet and the application of sound insulation. The sound insulation is applied from the middle of the suction side silencer casing across the fan to the inlet of the air preheater.

The sound insulation consists of 76mm (3 inches) of rockwool of low density and a lagging, aluminum or steel, with 18mm (3/4 inch) flexible concrete on the inside of the lagging. Metal-to-metal contact should be avoided and seals should be as airtight as possible. The flexible concrete is mixed with cement, aluminum containing cement and sand plus a liquid mix. After the mixing, the concrete is trowled on the plate and left for 24 hours before the lagging is put on the duct.

The flexible concrete liquid can be purchased for a price of $180 per 10 gallons, which will be enough to cover 11.6m^2 (125 sq ft). We suggest that you buy the sand, cement, lagging and rockwool and install the insulation. The price includes the guarantee of 90dBA with a tolerance ± 4 dB and typical installation drawings to be used during installation subject to escalation.

Sound Guarantee

Given the above conditions, we guarantee the observance of 90 dBA measured at a distance of 1 meter (3 feet) from the fans. Guarantee tests, if any, according to DIN-45635 and DIN-45632, with all costs in connection with the guarantee tests to be paid by the customer.

If the guaranteed value cannot be measured owing to foreign sound sources that cannot be eliminated, the guarantee will be considered as having been met.

If areas that sould be insulated according to our instructions are left open at the customer's request, our guarantee no longer applies.

SUMMARY TABLE 4
INDUCED DRAFT FAN
ACOUSTIC DATA SHEET

Octave Band Geometric Mear Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dbA at 1 meter (3 Feet)
63		
125		
250		
500		
1000		
2000		
4000		
800		

Tolerance on individual values ±5-6 dB

Kind of levels given, indicate which of the following

Sound Power Levels

re 10 (Exp -12) watt ________ ________

Tolerance ±4 dB.

If sound pressure levels are given, indicate both of the following:

Weighting network used

A, B, C or Linear (None) ________ ________

Distance to sound source

Feet or meters ________ ________

Vendor Comment* The sound power level octave bands are considered at a point source inside the fan. Sound intensity in the airstream may be determined by distributing the sound power level over the outlet area F on the basis of 10 log F. The sound pressure data is based on a directivity factor of 8 and a free field.

SUMMARY TABLE 4
(Continued)

The sound pressure level at 1 meter (3 feet) from the fan casing is based on the application of sound insulation to the ductwork to the fan and across the fan to the ductwork to the stack would be 85 dBA with tolerance ±4 dB. The sound pressure level data is based on a free field and directivity factor of 8.

The sound insulation consists of 76mm (3 inches) of rockwool of low density and a lagging, aluminum or steel, with 18mm (3/4 inch) flexible concrete on the inside of the lagging. Metal-to-metal contact should be avoided and seals should be as airtight as possible. The flexible concrete is mixed with cement, alumium containing cement and sand plus a liquid mix. After mixing, the concrete is trowled on the plate and left for 24 hours before the lagging is put on the duct.

Sound Guarantee

Given the above conditions, we guarantee the observance of 90 dBA measured at a distance of 1 meter (3 feet) from the fans. Guaranatee tests, if any, according to DIN-45635 and DIN-45632, with all costs in connection with the guarantee tests to be paid by the customer.

If the guaranteed value cannot be measured owing to foreign sound sources that cannot be eliminated, the guarantee will be considered as having been met.

If areas that should be insulated according to our instructions are left open at the customer's request, our guarantee no longer applies.

ATTACHMENT 8

Refer to Electrical Motor Specifications E-1 and E-2.

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ATTACHMENT 9

Refer to Motor Data Sheets included in Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 10
TECHNICAL REQUIREMENTS
AIR PREHEATING STEAM COILS

ATTACHMENT 10

TECHNICAL REQUIREMENTS

AIR PREHEATING STEAM COILS

TABLE OF CONTENTS

ATTACHMENT 10
TECHNICAL REQUIREMENTS
AIR PREHEATING STEAM COILS

1.0 DESCRIPTION OF WORK

The work to be performed consists of furnishing and delivering to the jobsite a total of two air preheating steam coils and accessories as shown on the attached Design Data Sheets. These steam coils will be used in the combustion air ducts of each 350 MW net nominal power plant for the Water and Power Development Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

The work to be performed shall include, but not be limited to, the following:

2.1 STEAM COILS

3.0 WORK NOT INCLUDED

3.1 UNLOADING AND STORING

3.2 INSTALLATION

4.0 APPLICABLE CODES, STANDARDS AND REGULATORY REQUIREMENTS

The following codes and standards are applicable to the work to the extent specified herein:

4.1 American National Standards Institute (ANSI):

B16.5 - Steel Pipe Flanges and Flanged Fittings

4.2 American Society of Mechanical Engineers (ASME):

Section VIII, Boiler and Pressure Vessel Code

4.3 American Society for Testing and Materials (ASTM)

A123 Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip, Specification for

A214 Electric Resistance Welded Carbon Steel Heat Exchanger and Condenser Tubes, Specification for

A515 Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service, Specification for

5.0 SUPPLEMENTAL DATA

5.1 SUMMARY TABLE

6.0 VENDOR DATA

6.1 The Vendor shall furnish data in accordance with the following requirements:

a. Outline drawings

b. Completed summary tables

7.0 DESIGN REQUIREMENTS

7.1 This Specification covers the design, manufacture, assembly, inspection, testing, and delivery of air preheating steam coils and accessories as described herein. It is not the intent of this document to completely specify all details of design and construction; however, equipment shall conform in all respects to high standards of engineering design and workmanship. Steam coils shall be ASME code stamped.

7.2 A sufficient number of banks of heating coils are to be furnished for use with one 1,312 tonnes/hr (2,893,000 lb/hr), 13,100 KPa (1,900 psig), 513°C (955°F)/513°C (955°F), balanced draft, drum type, steam generator. The coils will be installed in each of the air discharge ducts from the forced draft and primary air fans.

7.3 The coils shall be capable of heating ambient inlet air at temperatures as low as 5°C (41°F) with entrained moisture. The maximum inlet air temperature shall be 50°C (122°F).

7.4 The heating medium will be steam from the intermediate pressure turbine extraction of the turbine. At low loads, the steam supply will be taken from the turbine cold reheat. For cold start conditions the steam supply will be taken from the auxiliary boiler at 862 KPa (125 psig) and 195°C (383°F).

7.5 Airflow quantities and temperature rise requirements, corresponding to the various steam generator loads, shall be established by the steam generator Vendor and provided on the attached Design Data sheets.

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7.6 The coils shall be the extended surface type and designed for 4,550 KPa (675 psig) pressure and 270°C (520°F) temperature.

7.7 The coils shall be arranged insofar as practical for uniform exit air temperature across the face of the coils.

7.8 The coils and casing shall be designed and fabricated for continuous heavy duty service and shall be able to withstand the thermal stresses and strains encountered in ductwork.

7.9 Individual tubes shall be free to move separately by expansion and contraction without disturbing or loosening the fins and adjacent tubes.

7.10 The number of coil sections and length, width and depth of each section, and number of rows shall be established by the Vendor.

a. The coil sections shall be installed outdoors in the air ducts with steam inlet connections and condensate outlet connections as required by Vendor's design. A 50mm (2") drain connection shall be provided at the low point on each coil. The Vendor shall provide adequate vent connections. A minimum of one vent per section shall be provided.

b. The periphery of each coil bank will be field insulated and lagged as will be the duct downstream of a coil bank. Coil casings shall be designed to accommodate insulation and lagging.

c. Each coil section shall be designed with core removal capability and with airtight coil casings.

d. All piping connections shall be flanged and external of the airstream. Flanges shall be in accordance with ANSI B16.5.

e. The outside dimensions of the banks of coils shall match the adjoining duct connections.

7.11 In designing the coil for spacing, the Vendor shall consider the effect of the accumulation of dust and dirt from the ambient air which enters the Forced Draft fans and Primary Air fans.

8.0 <u>PERFORMANCE REQUIREMENTS</u>

8.1 The air preheating steam coils, when installed and operating, shall meet or exceed the design performance specified by the steam generator Vendor in the Design Data Sheets.

8.2 The airflow pressure drop through the coils shall be kept to a minimum when the unit is operating at full load. The face velocity shall be designed to meet this pressure drop requirement.

8.3 The steam side pressure drop shall not exceed __KPa (__ psi).

8.4 Each coil shall be able to withstand without damage the design requirements established and the pressure temperature rating specified above.

8.5 The Vendor shall guarantee the following:

a. That each coil assembly shall be to perform in accordance with the design values and completed Summary Table.

b. That the tube side of each coil assembly shall be hydrostatically tested at 150 percent of the design pressure and a fluid temperature of 15.6°C (60°F) without jeopardizing the integrity of the equipment.

c. That the air side pressure drop shall not exceed 0.06 KPa (0.25" w.c.) and the steam side pressure drop shall not exceed 34.5 KPa (5.0 psi).

9.0 MATERIAL REQUIREMENTS

9.1 The tubes and fins shall be made of ________ and _________, respectively. The headers and casings shall be made of ____________________. Vendor may propose, in addition to its base offering, alternate material if, in the judgment, such materials will be better and will more economically serve the Purchaser's requirement.

9.2 The tubes shall be not less than ___mm (___inches) OD nor thinner than _____ BWG wall thickness.

10.0 FABRICATION/ASSEMBLY REQUIREMENTS

10.1 The manufacturer's standard fabrication and assembly methods shall apply.

11.0 INSTALLATION REQUIREMENTS

None

12.0 PERSONNEL REQUIREMENTS

All work shall be done by personnel competent in the work assigned.

13.0 INSPECTIONS AND TESTS

The following inspections and tests shall be performed:

13.1 Shop tests shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII. The Vendor shall perform the hydrostatic test at 1.5 times the specified design pressure.

13.2 The vendor shall provide qualified personnel to supervise and conduct the tests. Complete reports of the tests shall be submitted. The Vendor shall notify the Owner 3 working days prior to conducting the tests so that the Owner may send a representative to observe the test if desired.

13.3 The equipment covered by this specification shall be subject to inspection by the Owner during fabrication, construction, and prior to shipment.

13.4 A fabrication plan incorporating mandatory Hold Points shall be submitted by the Vendor 30 days after award of contract so an Inspection and Test Plan may be developed.

13.5 A Hold Point shall be defined as an operation at which certain data are taken, inspections made, or approval required before the next sequential step can be taken.

13.6 Inspection and Test Plan shall be defined as a listing with optimum sequencing, of all the inspections and tests required to be performed for a specific item, component, structure, or system.

13.7 The Vendor shall submit with his Proposal a description of his Quality Assurance/Quality Control Program. This description shall include at least the following items:

13.7.1 Welding and heat treating procedure including personnel qualification.

13.7.2 Nondestructive examination and other test procedures including personnel qualification and rejection criteria and sample report forms.

13.7.3 The Owner or his authorized representative shall have access to the Vendor's plant and quality assurance records and to those of the Vendor's subcontractors and suppliers during the production of material for this Contract.

14.0 CLEANING, CORROSION PROTECTION/COATING

14.1 All manufacturing waste, such as metal chips and filings, welding rods and stubs, waste, rags, debris, and other foreign material, shall be removed from the interior of each unit prior to preparation for shipment. All mill scale, rust, oil, grease, chalk, crayon, or paint marks and other deleterious material shall be removed from interior and exterior surfaces. At the time of shipment each unit shall be clean inside and out.

14.2 Each unit shall be completely drained and purged dry following the hydrostatic test.

15.0 MARKING AND IDENTIFICATION

None

16.0 PACKAGING/SHIPPING/STORAGE

16.1 All flanges, openings, and nozzles shall be wrapped and adequately protected during shipment to prevent damage, corrosion, and entrance of moisture or other foreign material.

16.2 The equipment shall be adequately protected for shipment in a manner that will allow jobsite storage for an indefinite period of time prior to installation. Wood or metal covers shall be provided to protect the units from damage during shipment and storage.

17.0 ACCEPTANCE CRITERIA

The Vendor shall comply with the following requirements before submitting the work for acceptance:

17.1 Submittal of Test Reports, Certifications, Fabrication Plan, Quality Assurance Program, and Equipment Drawings.

17.2 Submittal of Summary Table for each coil.

DESIGN DATA SHEET
FOR
AIR PREHEATING STEAM COILS

Steam Generator Load	25%	40%	60%	80%	95%	100%
Airflow from Fans, tonnes/hr (lb/hr)						
Air Inlet Temperature, $^{\circ}C$ ($^{\circ}F$)						
Air Outlet Temperature, $^{\circ}C$ ($^{\circ}F$)						
Coil Duty, GJ/hr (10^6 Btu/hr)						
Steam Flow, tonnes/hr (lb/hr)						
Steam Pressure, KPa (psia)						
Steam Temperature, $^{\circ}C$ ($^{\circ}F$)						

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The following summary table shall be completed for each coil assembly and shall be made part of the proposal.

SUMMARY TABLE

AIR PREHEATING STEAM COILS

Manufacturer						
Proposal Number						
Airflow:	20%	40%	60%	80%	95%	100%
Flow rate per bank, tonnes/hr (lb/hr)						
m^3/S (cfm) @ inlet temperature, m^3/sec (cfm)						
Inlet temperature, ^oC (^oF)						
Outlet temperature, ^oC (^oF)						
Face velocity, m/sec (ft/min)						
Pressure drop, KPa (in. w.g.)						
Steam Flow:	20%	40%	60%	80%	95%	100%
Flow rate per bank, tonnes/hr (lb/hr)						
Steam temperature, ^oC (^oF)						
Pressure drop, KPa (psi)						
Coil design pressure, KPa (psig)						
Coil design temperature, ^oC (^oF)						
Tubes:						
Material (ASTM Designation)						
OD and wall thickness						
No. of tubes/section						
Length, m (ft)						
Pitch						
Fins:						
Material (ASTM Designation)						
OD and thickness						
Number of fins per cm (inch)						
Method of attachment						

Headers:

Material (ASTM Designation) __________

No. passes/section __________

Gasket material __________

Size, inlet nozzle, mm (in.) __________

Size, outlet nozzle, mm (in.) __________

Flange rating __________

Coil Section:

Size (length x width x depth) __________

Number of sections/assembly __________

Coil Bank:

Size (length x width x depth) __________

Casing:

Material (ASTM Designation) __________

Thickness __________

Weight per coil section, Kg (lb) __________

Weight per coil bank, Kg (lb) __________

- Empty __________
- Operating __________

Steam Coil Arrangement:

1. Overall Heat Transfer Coefficient (U), KJ/hrm^2 ^oC (Btu/hr sq ft ^oF:)

   ^oC (^oF) - KPa (psia) steam, and at 100 percent airflow __________

   ^oC (^oF) - KPa (psia) steam, and at 50 percent airflow __________

*2. Fouling Factor __________

*3. Steam Side Heat Transfer Coefficient, KJ/hr m^2 ^oC (Btu/hr sq ft ^oF) ______________

*4. Air Side Heat Transfer Coefficient, KJ/hrm^2 ^oC (Btu/hr sq ft ^oF) ______________

*5. Design, MTD ______________

6. Total Surface Area, m^2 (ft^2) ______________

7. Effective Surface Area, m^2 (ft^2) ______________

8. Fin Surface Area, m^2 (ft^2) ______________

9. Bare Tube Surface Area, m^2 (ft^2) ______________

*10. Temperature of Condensate Leaving Coil, ^oC (^oF) ______________

*11. Total Steam Side Pressure Drop, KPa (psia) ______________

*12. Total (frame to frame) Air Side Pressure Drop, KPa (w.g.) ______________

13. Total Volume of Coil Interior, m^3 (cu ft) ______________

*These data are at design.

ATTACHMENT 11
TECHNICAL REQUIREMENTS
BURNER MANAGEMENT SYSTEM

ATTACHMENT 11

TECHNICAL REQUIREMENTS

BURNER MANAGEMENT SYSTEM

TABLE OF CONTENTS

ATTACHMENT 11
TECHNICAL REQUIREMENTS
BURNER MANAGEMENT SYSTEM

1.0 DESCRIPTION OF WORK

The work to be performed consists of designing, fabricating, testing, delivering to the jobsite and supervising the installation of burner control and fuel safety systems for one balanced draft, coal-fired steam generator installed at the two x 350 MW power plant for the Water and Power Development Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

The work to be performed shall include at least the following:

a. System and termination cabinets.

b. Function modules.

c. Power supplies and distribution.

d. Control board insert(s).

e. Plug-in cables to connect control-board inserts with system and termination cabinets.

f. Flame detectors.

g. Flame detector cooling/purge air blowers.

h. Any special tools, and test or calibration equipment required for maintenance or calibration unique to the Vendor's system hardware.

i. The services of competent service engineers to supervise the installation of the equipment supplied and to make checks, adjustments, and calibrations necessary to place the system into fully operating condition prior to their leaving the site. If this adjustment phase is temporarily suspended due to unforeseen circumstances during checkout, start-up and initial operation, the engineers and/or technicians may leave the site if approval is given by the Owner. These same engineers and/or technicians shall return within 48 hours after Owner request to complete the work necessary to place the system into a full operating condition.

j. Selecting the type and location of flame detectors for main and ignitor flame envelopes prior to the release of the boiler manufacturer's burner arrangement drawings for fabrication.

k. Factory testing as specified herein.

l. A training program to qualify the Owner's personnel to safely and efficiently operate, troubleshoot, and maintain the complete system.

3.0 WORK NOT INCLUDED

The following items are not included in the requirements of this section but will be accomplished by Others:

a. Pulverizer group hand/automatic control stations.

b. Secondary airflow control including master fuel trip actions.

c. Cable from termination cabinets to field devices.

d. Installation of all equipment at the plantsite.

e. Owner's voltage to Vendor's dry contact outputs: 220V ac

f. Other field mounted sensing devices not required in Article 2.0.

4.0 APPLICABLE CODES AND STANDARDS

The following codes and standards, with the latest revisions, are applicable to the work to the extent specified herein:

a. American National Standards Institute (ANSI):

C-1, "National Electrical Code."

b. American Society for Testing and Materials (ASTM):

1. D635, "Test for Flammability of Self-Supporting Plastics."

2. E84, "Test for Surface Burning Characteristics of Building Materials."

c. Instrument Society of America (ISA):

S5.2, "Binary Logic Diagrams for Process Operation."

d. Insulated Cable Engineers Association (ICEA) Standards.

e. National Electrical Manufacturers Association (NEMA):

1. IS 1.1, "Enclosures for Industrial Controls and Systems."

2. IS 4, "Terminal Blocks for Industrial Controls and Systems."

3. ICS (Industrial Controls and Systems) Parts:

(1) 1-113, "Printed Wiring Assemblies."

(2) 2-125, "Contacts for Control Circuit Devices."

4. WC 30, "Color Coding of Wires and Cables."

f. National Fire Protection Association (NFPA):

85E, "Standard for Prevention of Furnace Explosions in Pulverized Coal-Fired Multiple Burner-Boiler Furnaces."

5.0 SUPPLEMENTAL DATA

5.1 The documents listed on the contents page as attachments are applicable to the work to the extent specified herein. The Vendor shall coordinate with the steam generator Vendor to obtain the following information:

a. Steam Generator:

1. Manufacturer: ________________________.

2. Type: ________________________.

3. Furnace Pressure: Balanced draft.

4. Fuel: Pulverized Coal or No. 6 Furnace Oil or both.

5. Capacity: 1,312 tonnes/hr (2,893,000 lb/h) at 13,100 KPa (1,900 psig) and 513 ^{o}C (955 ^{o}F).

b. Burners:

1. Type: ________________________.

2. Number _____ total, operated as (pairs) in _____ groups. Arrangement:

____

____.

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3. Coal Valves: one per burner.

4. Air Registers: _____ total, operated as _____ mm (in.) _____ groups. Arrangement: ____.

5. Overfire Air Dampers: _____ total, Arrangement: ______________________________________.

c. Ignitors:

1. Type: ____

2. Fuel: ____.

3. Quantity: __________________________.

4. Capacity: __________ tonnes/hr (____ lb/h) at __________ KPa (____ psig).

d. Draft System:

1. Forced Draft Fans: quantity Two (2).

2. Induced Draft Fans: quantity Two (2).

3. Air Heaters: quantity ____________________.

4. Dampers:

(a) Forced Draft Fan Outlet: quantity ____________.

(b) Forced Draft Fan Inlet Vanes: quantity ____________.

(c) Induced Draft Fan Outlet: quantity __________.

(d) Induced Draft Fan Inlet: quantity ____________.

(e) Air Heater Hot Gas Inlet: quantity ____________.

e. Pulverizer:

1. Type: ____.

2. Quantity: _________________.

3. Capacity: _______ tonne (ton) per hour.

4. Feeders: __________; __________ per pulverizer.

5. Primary Air Fans: quantity __________.

6. Dampers:

   (a) Hot Air: _____ per mill.

   (b) Tempering Air: _____ per mill.

   (c) Primary Air: _____ per mill.

   (d) Auxiliary Bypass: _____ per mill.

   (e) Seal Air Damper: _____ per mill.

7. Gates:

   (a) Feeder Inlet.

   (b) Pulverizer Outlet.

f. Control devices to be furnished by Others.

One auto/manual control selector station will be supplied for each of the following services:

1. Mill hot air, tempering air damper combinations.

2. Mill primary air dampers.

3. Feeder speed controllers.

4. Mill pairs of auxiliary bypass dampers.

6.0 VENDOR DATA

The Vendor shall furnish the following data:

a. Written System Description

b. System Logic Diagrams

c. Equipment Dimensional Drawings

d. Installation, Operating, and Maintenance Manuals

e. Electrical Connection Drawings

f. Cabinet Arrangement Drawings

g. Bill of Materials

7.0 DESIGN REQUIREMENTS

7.1 The intent of the design requirements specified herein is to establish minimum design criteria for the system and assure that the equipment to which the system is applied can be operated in compliance with related codes and standards, and the boiler manufacturer's operating requirements.

7.2 FUNCTIONAL REQUIREMENTS

The logic system shall be a microprocessor based electronic system designed to perform the following functions:

a. Burner control, including secondary air dampers, mill outlet gates and low-load burner shutoff valves.

b. Ignition control, including insertion actuator, ignition transformer and fuel shutoff valves.

c. Furnace purge.

d. Ignition fuel trip.

e. Master fuel trip.

f. Pulverizer control, including primary air fans, feeders, seal air fans and pulverizers.

g. Miscellaneous controls.

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7.3 LOGIC REQUIREMENTS

a. Burner and Ignition Control Logic

1. The burner control logic shall provide:

(a) A uniform start sequence for an orderly lightoff of any of the burner groups.

(b) A uniform stop sequence for an orderly shutdown of any of the burner groups.

(c) Emergency stop sequence for each burner group.

2. The start and stop sequences shall control the operation of ignitors, secondary air dampers, coal gates, and fuel shutoff valves.

3. The burner control logic shall be designed for the following modes of operation:

(a) Remote Manual:

In this mode, each step involved in the start sequence and stop sequence for the minimum permissible number of burners in any of the burner groups will be executed by the operator. The control logic shall include all necessary permissives and interlocks to:

(1) Prevent starting any burner equipment unless all required permissives have been satisfied.

(2) Prove completion of each step as a permissive for executing the subsequent step.

(3) Automatically shutdown the minimum equipment to restore safe conditions whenever an unsafe operating condition occurs.

(b) Automatic:

(1) In this mode, the start sequence and stop sequence for each burner group will be initiated by the operator. Once initiated, each step involved in the sequence will be executed automatically.

(2) The control logic shall be designed so that all permissives and interlocks that

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are integral to the remote manual mode shall also be integral to the automatic mode.

(3) Provisions shall be made for the operator to maintain the ignitors after the successful lightoff of the associated burner and also to disable any burner within a burner group prior to lightoff.

(d) Ignitor Operation:

(1) The system shall provide for remote startup/shutdown sequences of the ignitors as a part of the burner control logic.

(2) The system shall automatically shutdown any ignitor if any unsafe operating condition occurs.

b. Furnace Purge Logic

1. The purge logic shall be operator initiated and designed to perform the following functions:

(a) Monitor all purge permissives.

(b) Start purge cycle when all purge permissives are satisfied.

(c) Indicate purge status.

(d) Supervise purge cycle.

(e) Permit master fuel trip reset upon completion of purge cycle.

(f) End the purge and require a purge restart upon loss of any one or more purge permissives before lightoff.

2. Purge permissives shall include the following:

(a) One FD and ID fan pair running.

(b) Air flow greater than 25 percent.

(c) All fuel inputs off.

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c. Ignition Fuel Trip Logic

The ignition fuel trip logic shall be designed to trip the ignition fuel trip valve in the event of the following:

1. Ignitor oil pressure low.
2. Ignitor oil valve malfunction.
3. Ignitor fuel trip pushbutton.
4. Boiler trip.

d. Master Fuel Trip Logic

1. The master fuel trip (MFT) logic shall be designed to perform the following functions:

   (a) Monitor a set of predetermined conditions that initiate the master fuel trip.

   (b) Execute all necessary actions required immediately after a master fuel trip.

   (c) Permit MFT reset after all permissives have been satisfied.

2. The MFT shall be set to trip whenever any one of the following conditions occur:

   (a) Loss of flame.

   (b) Loss of all FD fans.

   (c) Loss of all ID fans.

   (d) High-high furnace pressure.

   (e) Low-low furnace pressure.

   (f) Low-low boiler drum level.

   (g) Emergency pushbutton is pushed.

   (h) Main turbine trip.

   (i) All fuel inputs zero.

   (j) Partial loss of flame.

(k) Total loss of power to combustion control or burner controls.

3. The following actions shall take place when an MFT occurs:

(a) All sources of fuel to the furnace including oil trip valve(s) and pulverizer outlet gates shall be closed.

(b) Pulverizers, feeders and primary air fans shall be tripped.

(c) Airflow actions will be included in the boiler control by Others.

4. Master fuel trip reset shall be initiated automatically after all trip conditions have been removed and the purge cycle has been completed.

5. Provisions shall be made for supplying necessary contact outputs for the Owner's use for monitoring sequence of events.

e. Pulverizer Control Logic

Pulverizer, primary air fan, seal air fan, coal feeder, gates and dampers.

f. Miscellaneous Control Logic

Flame detector cooling blowers.

7.4 OPERATOR INTERFACE

a. Control board inserts shall be provided for operator interface. An insert shall be provided for each pulverizer/burner group and one for the boiler purge/master fuel trip.

b. Pulverizer/burner group control shall include:

1. Back-lit pushbuttons for each burner group for selecting remote manual and automatic modes.

2. Back-lit pushbuttons for each burner group for initiating start and stop sequences in automatic mode.

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3. Back-lit pushbuttons for each functional item of equipment in each burner group for operation in remote manual mode.

4. Flame intensity meters for each flame detector associated with the burner group.

5. Mill emergency-trip pushbutton which shall trip all fuel associated with the mill.

6. Back-lit pushbuttons for start/stop control of the pulverizer, feeder, primary air fan, coal gates and primary air dampers.

7. Status indicating lights for each item of equipment in each burner group for start-up, shutdown and emergency trip sequences.

8. Coal flow indicator.

9. Hand/automatic control stations to be provided by the Owner for primary air control damper, feeder speed, mill temperature control dampers and mill auxiliary bypass dampers.

c. Furnace purge/master fuel trip (MFT) shall include:

1. An indicating light for each of the purge permissives.

2. An indicating light for each of the following conditions:

   (a) Purge required.

   (b) Purge ready.

   (c) Purge in progress.

   (d) Purge completed.

3. A back-lit pushbutton for initiating purge cycle.

4. Two back-lit pushbuttons with guards for emergency (MFT) trip.

5. Back-lit pushbuttons for manual operation of each ignition fuel header trip valve.

6. Status indicating lights for each ignition fuel header trip valve.

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7.5 EQUIPMENT DESIGN REQUIREMENTS

a. Equipment Environment

1. The control room and electronic room will be air-conditioned to maintain approximatley 22°C (72°F). Positive control of relative humidity at 50 percent will be provided; however, in the event of air-conditioning failure and during plant starting, the Vendor's equipment mounted in these rooms shall continue to operate satisfactorily without loss of function for up to 2 hours at 0°C (32°F) and a relative humidity of 85 percent.

2. All field-mounted equipment shall be capable of operating in a dust laden atmosphere and ambient temperature extremes from -29 to 49°C (-20 to 120°F) and relative humidity from 5 to 25 percent.

b. Cabinet-Mounted Function Modules

Cabinet-mounted function modules shall include all electronic modules necessary to perform the computing, logic and control functions as specified in paragraph 7.2 and shall be subject to the following requirements:

1. All computing, logic and controller circuits shall be a microprocessor based printed-circuit design using components with fast response and high noise immunity, and shall be suitable for plug-in mounting in the racks of the system cabinets.

2. Each burner group shall be controlled through independent cards and modules whereby the removal or failure of one card or module will not affect any other burner group.

3. A signal conditioning system shall be supplied to isolate all input and output signals from the system through the use of solid-state devices or buffer relays. Any relay, when used in both ac and dc circuits, shall have the wiring arranged to insure complete separation of ac and dc circuits, thus avoiding any flashover between circuits.

4. All electrical connections to the modules shall be made through plug-in connectors located at the rear of the modules.

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5. Contact output rating requirements:

   10 amp @ 220V ac.

c. Power Supply

   1. The Vendor shall develop and distribute all power required by the system from two independent 220V ac power feeds furnished by the Owner at system cabinet assembly terminals.

   2. The Vendor shall furnish a circuit breaker or fuse for the Owner's power feed. The circuit breaker or fuse shall be located for convenient access and clearly labeled to identify service and rating.

   3. Parallel, redundant, solid-state power supplies shall be furnished for each voltage level required, with provision for automatic transfer to the active power supply of a pair in the event of a failure of one supply. Each power supply shall be furnished with a low-voltage detector that activates an indicating lamp located at the power supply and closes a contact for the Owner's alarm system when the power supply fails.

   4. All power supplies shall be designed to operate at not greater than 50 percent of rated power output.

   5. All power supplies shall be arranged so that manual adjustments are not required. Any power supplies that require periodic adjustment of output voltage shall be furnished with a voltage error alarm contact and a voltmeter having an accuracy commensurate with adjacent requirements. Other power supplies shall be furnished with exterior test jacks located for convenient access.

   6. All field contacts shall be interrogated at 125V dc (by Vendor's power supply).

d. System Cabinet and Termination:

   1. All power supplies, logic modules, flame-detector receivers and flame-signal magnitude-test indicators shall be rack-mounted in a single assembly of cabinet enclosures.

   2. A separate cabinet enclosure shall be furnished for all terminations between field-mounted equipment,

board-mounted equipment and the system cabinet assembly.

3. All cabinets shall be freestanding with a maximum height of 2,290mm (90 inches) and a maximum depth of 760mm (30 inches).

4. System cabinets shall be of all-welded construction fabricated from flat, unpitted, high-grade sheet steel. Joints shall be welded continuously and ground smooth so that joints are not visible or open after the final paint finish is applied. The cabinets shall be reinforced with suitable angles and braces where required for strength without affecting access or operation of cabinet-mounted equipment.

5. Each cabinet shall have both front and rear access using gasketed doors and butt-type, liftoff-type, steel hinges. Locking handles and a latching mechanism shall be provided for each door. The latching mechanisms shall use a three-point door-latching system to secure the door at the lock and at the top and bottom. Termination-cabinet locks shall require a different key than that used for other cabinets. Equipment shall not be mounted on the doors and door opening shall not interfere with access to adjacent cabinets.

6. All control panels and cubicles shall be self-supporting and anchored at floor elevations.

7. A means shall be provided for bolting adjacent cabinets together at shipping splits. Wiring connecting cabinets at shipping splits shall be made by plug-in cable.

8. Filters and plenum chambers, if required, shall be provided at the top and bottom of each cabinet to allow air distribution for cooling purposes and shall be readily accessible for maintenance. Heat-generating equipment shall be mounted near the top of the cabinets or in separate cabinets. Cooling fans shall be furnished, if necessary, to dissipate expected heat. Any forced air flow shall be from cabinet bottom to top.

9. Cabinets shall be composed of mounting racks for mounting of all modules and all required power supplies. Each piece of equipment shall be mounted in the racks in such a manner that its removal and

replacement can be accomplished without disturbing adjacent equipment. Ample space shall be provided for access and servicing of all equipment.

10. All cabinets shall be equipped with removable lifting eyes and shall have an integral lifting frame so that the cabinets can withstand all lifting forces without cabinet distortion.

11. Separate system termination cabinets shall be provided to receive field wiring and shall be capable of being shipped prior to the logic cabinets for field wiring. The following shall also apply to these cabinets.

(a) Sufficient access channels or holes at the cabinet top and bottom shall be provided for all incoming field cable and conduit required by the system. No field wiring shall be allowed in the system logic cabinets except Vendor-supplied prefabricated cable.

(b) The termination cabinets shall be adjacent to and field fastened to the respective system cabinet assemblies.

(c) Terminal blocks for field cables shall be 600V with screw type terminals and shall be capable of accepting two Owner-supplied conductors of the size specified herein or as required by current carrying requirements, whichever is greater. The Vendor's and the Owner's connections shall be by compression type lugs. Terminal blocks shall also conform to the following:

(1) Terminal blocks shall be arranged so that all the Owner's field wiring is terminated on one side of the block and all the Vendor's wiring is on the other side. Also, the Vendor's and Owner's field wiring shall not occupy the same space between adjacent parallel rows of terminal blocks.

(2) Ample space shall be provided for spreading and bending the Owner's incoming cable.

(3) Design shall be such that no more than two lugs may be terminated under any one terminal screw.

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e. System Wiring and Cabling

1. Cabinet wiring shall be installed in a neat, workmanlike manner so as not to obstruct access to devices and shall be suitably supported to avoid straining.

2. All cable including prefabricated interconnecting cable shall be rated 90°C and shall be tinned-copper wire with low-moisture-absorption, ethylene-propylene insulation with a hypalon jacket for all multiconductor cables. Polyvinylchloride (PVC) and polyethylene shall not be used. Conductors for voltage in excess of 50 volts shall have insulation rated for 600 volts. Conductors for voltages less than 50 volts shall have insulation rated for 300 volts.

3. The color coding of control and instrument wiring shall comply with NEMA WC 30.

4. Conductor bundling or conduit shall be employed for the different types of signal wiring separations. The separations are required if noise introduction from one circuit into another is possible.

5. Materials used for wire troughs, conduit, wire and cable ties and terminal boards shall be of material that is nonburning as defined by ASTM E84 and by ASTM D635. Polyvinyl chloride (PVC) and polyethylene shall not be used, nor shall any material which will melt and its droplets carry the flame.

6. Prefabricated cables from the control board inserts shall be for bottom cabinet entry. Wiring termination to the control board insert shall be by cable connectors.

7. Owner furnished wiring for system input and output will be multiconductor 14-gage (AWG) stranded copper with 600 volt insulation. Terminal cabinets shall be arranged to satisfy the following cable entry requirements:

   (a) Bottom entry for wiring to ignitor, air register and flame detectors. The estimated length is 120m (400 feet).

   (b) Bottom entry for wiring to coal mill equipment and burner coal valves.

f. Control Board Inserts

1. Control board inserts shall be provided for operator interface as specified above.

2. Each status indicating window shall be illuminated with a single lamp. There shall be no spillover of light from one window to another. Windows shall be of white, red and green translucent acrylic plastic, with black engraved legends. All lamps shall be accessible and removable through the window side. Window color code shall be:

   (a) Red indicates open or energized.

   (b) Green indicates closed or deenergized.

   (c) Amber indicates permissive satisfied.

3. Status indicating lamp power shall originate in system cabinet assembly from a power suppply that is separate from all other system power supplies. A lamp-test pushbutton shall be furnished for each of two displays to illuminate all lamps in a selected display.

4. Indicating lamps shall be of sufficient brightness so that an operator may easily distinguish lampstate from a distance of 3m (10 feet) with an ambient illumination level of 100 foot-candles. Lamps shall have a minimum life of 25,000 hours.

5. All pushbuttons shall have contacts suitable for the low-current service of the solid-state, electronic logic interface circuits.

6. Provisions shall be made for installation of hand/automatic control stations to be provided by the Owner as specified elsewhere.

7. Flame Detectors

   (a) The Vendor shall supply one flame detector for coal burners and 1 flame detector for oil ignitors..

   (b) Flame detectors shall have a high degree of discrimination for the flame envelopes to which they are applied.

(c) Flame detectors shall be automatically self-checking for the absence of flame condition. Electronic checking rather than electro-mechanical shutter technique is preferred.

(d) Flame detectors shall have a response time adjustment to avoid false response on normal flame intensity variations.

(e) The flame detector cooling system shall be suitable for maintaining the performance of each detector under all operating conditions.

(f) All flame intensity indicators shall be mounted in the control board insert.

(g) Flame detectors shall be designed to fail safe.

(h) Flame detectors shall have provision for keeping the optical components clean with compressed air.

(i) All power for flame detectors shall originate at the main cabinet assembly.

(j) All flame detectors shall be suitable for operating in ambient temperatures for $0^{o}C$ to $50^{o}C$ ($32^{o}F$ to $122^{o}F$).

(k) All flame detectors shall be housed in NEMA 4 enclosures.

(l) All flame detectors shall be furnished complete with sighting tubes and mounting brackets as required.

(m) All flame detectors shall be furnished with an amphenol type MS or equal cable connector for interconnecting conductors.

8.0 PERFORMANCE REQUIREMENTS

The Vendor shall state in his Proposal the guarantee for the control system performance for the purpose defined herein.

9.0 MATERIAL REQUIREMENTS

Except where otherwise specified herein, materials of construction shall be the Vendor's standard which has proven satisfactory in the past and meets applicable code requirements.

10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

The systems shall be fabricated and assembled in accordance with the following requirements:

a. The codes and standards stated above.

b. The accepted Vendor's QA/QC program.

11.0 INSTALLATION REQUIREMENTS

None

12.0 PERSONNEL REQUIREMENTS

The Vendor shall employ personnel qualified to perform the work in accordance with the Vendor's QA/QC program.

13.0 INSPECTIONS AND TESTS

13.1 The Vendor shall submit a written description of procedures for factory and field tests for approval 10 weeks before planned commencement of the tests.

13.2 The following inspections and tests shall be performed.

a. Each flame detector shall be checked to verify functional operation.

b. All control logic and interface modules, including flame-detector receivers shall be mounted in system cabinets and subjected to a complete functional test to verify that each function operates as specified. Functional tests shall include information displays and associated interconnecting cables, all in as-shipped condition. The Vendor shall provide all necessary equipment to simulate Owner-furnished inputs and flame-detector signals for functional tests. The tests shall be conducted at the factory after the Vendor has completed system checkout. The Owner shall have the right to witness these tests.

c. Minimum accumlative burn-in time of all electrical components shall be 100 hours at cycling temperatures and relative humidity.

d. The Vendor shall demonstrate functional operation of the system with flame detectors in service after installation and subsequent adjustment and calibration have been completed. The following tests shall be performed upon Owner request.

1. Verification of ignition and loss of ignitor flame for each ignitor with adjacent ignitors in service.

2. Verification of ignition and loss of coal flame for each coal burner with adjacent coal burners in service and with and without its respective ignitor in service.

3. Verification that putting an adjacent coal burner in service does not cause other burners to trip due to loss of flame.

14.0 CLEANING, CORROSION PROTECTION AND COATING

Vendor's Standard.

15.0 MARKING AND IDENTIFICATION

15.1 Each package, skid, box and crate shall be marked on the outside with the following information so that it is readily visible:

a. (Owner's name)
(Project identification)
(Owner's address)

b. The Owner's purchase order number.

c. Any special instructions for handling.

d. The weight and lifting points or center of gravity.

e. Bill of Material number(s).

15.2 TAGGING

a. Equipment item numbers shall be used by the Vendor in identifying equipment. Numbers assigned by the Vendor may be reassigned at the option of the Engineer.

b. Items of equipment shall be supplied with a punched metal tag, permanently affixed, giving the identifying number and description.

16.0 PACKAGING, SHIPPING AND STORAGE

16.1 Equipment or piping that may have been hydrostatically tested or that may be damaged by freezing shall be checked to ensure that all water has been drained from the unit prior to placing equipment in storage or on its foundation, temporary wood or steel plate covers shall be provided over flanges to prevent entrance of water into the unit, and the Vendor shall be responsible for any damage to unit, equipment and associated piping until it has been accepted by the Owner.

16.2 All exposed machine surfaces and openings shall be coated and protected to prevent corrosion and damage during shipment and storage.

16.3 All metal internal surfaces of the equipment shall be protected with a water-soluble coating to prevent oxidation or corrosion; coatings are subject to approval by the Engineer. After this application, all openings shall be blanked off or plugged to eliminate air circulation until the equipment is installed in the operating position. A warning to this effect shall be painted on or attached to this equipment.

16.4 Shipment shall be by rail unless the Owner and the Vendor agree otherwise.

17.0 ACCEPTANCE CRITERIA

17.1 The Owner shall have the right to delay the shipment of equipment and material from the Vendor's shops pending resolution of any deficiencies known at the time of inspection.

17.2 MANUFACTURING ERRORS

Equipment and materials shall be complete in all respects within the limits herein specified. Manufacturing errors and omissions requiring correction in the field shall be performed under the direction of and at the expense of the Vendor. If the error requires shipment back to the factory, the disassembly, handling, shipping and reassembly shall be at the Vendor's expense.

17.3 Vendor Data shall be provided as specified in Article 6.0.

ATTACHMENT 12
TECHNICAL REQUIREMENTS

STRUCTURAL STEEL
PLATEWORK
ELEVATORS
PLANT ENCLOSURES

ATTACHMENT 12

TECHNICAL REQUIREMENTS

STRUCTURAL STEEL, PLATEWORK, ELEVATORS AND PLANT ENCLOSURES

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ATTACHMENT 12
TECHNICAL REQUIREMENTS
STRUCTURAL STEEL, PLATEWORK, ELEVATORS AND PLANT ENCLOSURES

1.0 DESCRIPTION OF WORK

The work shall include the layout, analysis, design, detail, furnish, fabricate, and delivery of all structural steel and related materials and equipment required for the boiler room, ductwork, and precipitators.

2.0 WORK INCLUDED

The structural steel to be provided shall include all supporting structures required for the boiler, air heaters, forced air supply ductwork, primary air ductwork, flue gas ductwork, coal bunkers, coal bunker conveyor room and tripper floor, precipitator and all ancillary equipment, cable trays, piping, tanks, and access. The structural steel shall also include the air supply ductwork, primary air ductwork, flue gas ductwork, coal bunkers, and enclosure steel.

The scope of supply shall include necessary floor and access platforms (concrete, grated, or checker plated), stairs, ladders and cages, handrail, hoistways and hoists, elevators, all doors, louvers/roof ventilators, building girts, insulation and siding, roofing, ductwork insulation and lagging, and embedded steel.

3.0 WORK NOT INCLUDED

Although designed by the Vendor, the concrete and reinforcing steel shall be supplied by others.

Other work not included are the foundations, coal conveyors and trippers, chimney, and turbine room and heater bay structural steel.

4.0 APPLICABLE CODES, STANDARDS, AND REGULATORY REQUIREMENTS

All design, materials, fabrication, examination, testing, inspection, certification, and documentation shall conform to the applicable portions of the following codes, standards, and regulations.

American Concrete Institute

ACI 301 "Specifications for Structural Concrete for Buildings"

ACI 318 "Building Code Requirements for Reinforced Concrete"

American Institute of Steel Construction

AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings"

AISC "Code of Standard Practice for Steel Bridges and Buildings"

AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts"

American National Standards Institute

ANSI A58.1 American National Standard Minimum Design Loads for Buildings and Other Structures

ANSI B30.11 Monorail and Underhung Cranes

ANSI B30.16 Overhead Hoists (Underhung)

ANSI A17.1 American National Standard Safety Code for Elevators and Escalators

ANSI A17.2 American National Standard Practice for the Inspection of Elevators, Escalators, Moving Walks, Inspection Manual, including Supplement A17.2a

American Society for Nondestructive Testing

ASNT Recommended Practice No. SNT-TC-1A

American Society for Testing and Materials

ASTM-Section 1, Volume 01.04 - Steel-Structural, Reinforcing, Pressure Vessel, Railway

ASTM-Section 3, Volume 03.03 - Metals Test Methods & Analytical Procedures

ASTM-Section 15, Volume 15.08 - General Products, Chemical Specialties & End Use Product

American Welding Society

AWS D1.1 "Structural Welding Code - Steel"

Builder's Hardware Manufacturer's Association

International Conference of Building Officials

UBC - Uniform Building Code

National Association of Architectural Metal Manufacturers

NAAMM - "Bar Grating Manual" - ANSI/NAAMM A202.1

Steel Joist Institute

SJI - "Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders"

Steel Structures Painting Council

SSPC - Systems & Specifications - Steel Structures Painting Manual Volume 2, 4th Edition

Code of Federal Regulations Title 29, Labor. Chapter XVII Occupational Safety and Health Administration

Part 1910 - Occupational Safety and Health Standards

Part 1926 - Safety and Health Regulations for Construction

American Society of Civil Engineers

American Society of Civil Engineers, Paper No. 2507 "Design of Large Coal Bunkers"

5.0 SUPPLEMENTAL DATA

The Vendor shall work closely with the Engineer to provide necessary interface requirements and to provide Vendor support for such items as: coal conveyors and tripper equipment, tanks, ancillary equipment, cable trays, and piping systems designed by Others.

6.0 VENDOR DATA

The Vendor shall supply the following information as part of his work:

All base details, loads and other foundation requirements.

Individual load tables shall be prepared for dead, live, wind and seismic loads for each structure or piece of grade supported equipment furnished.

Dynamic as well as static requirements of rotating equipment.

Equipment removal plans and methods of maintenance for major equipment such as fan rotors and motors, coal pulverizers, air heaters, major valves, conveyor motors and pulleys and precipitator transformer/rectifiers.

Fifteen copies of all operating and maintenance manuals for the hoists and elevators including recommended spare parts inventory, installation, operation and maintenance instructions, and control schematic diagrams.

Dimensions, interface details, loads and arrangement drawings of the pit hoistway and machine room for each elevator.

7.0 DESIGN REQUIREMENTS

7.1 GENERAL

The structure shall be designed for the following (loads listed are minimum and shall be increased if necessary by the Vendor):

Grating Platforms

Grating Platform Dead Load	195 Kg/m^2 (40 lb/ft^2)
Grating Platform Live Load	195 Kg/m_2 (40 lb/ft^2)
Grating Material	976 Kg/m^2 (200 lb/ft^2)

Concrete Floor

Support Steel Dead Load	195 Kg/m^2 (40 lb/ft^2)
Concrete Dead Load	based on 732 Kg/m^2 (150 lb/ft^3)
Concrete Floor Live Loads	976 Kg/m^2 (200 lb/ft^2)

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Stairway Loads

Live Loads	1,360 Kg/3m (3000 lb/ 10 ft) of Rise
Dead Loads	318 Kg/3m (700 lb/ 10 ft) of Rise

Conveyor and Tripper Loads (by Engineer later)

Construction/Erection Loads

Thrust loads from temporary steam blow piping (by Vendor)

Boiler steam drum erection loads (by Vendor)

Flyash in flue gas ductwork	585 Kg/m^2 (120 lb/ft^2)
Boiler implosion and ductwork pressure loads	$\pm$7.5 KPa ($\pm$30 inches) water

Operating and maintenance access, hoisting and loads for such items as, but not limited to:

Forced draft fan rotor and motor removal

Primary air fan rotor and motor removal

Induced draft fan rotor and motor removal

Coal Pulverizers

Combustion Air, Steam or Glycol, Preheat Coils

Rotary Style Combustion Air Heater Baskets and Bearings

Coal conveyor motors and pulleys

Wind and Seismic loads as dictated by the reference codes for the plant site location.

7.2 COAL BUNKERS

The coal bunkers shall be designed for a minimum of 8 hours of storage at boiler MCR.

The following design data shall be used in the design of the bunkers:

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Bunker Storage Capacity*	by Vendor tons
Coal Unit Weight (in Bunkers)	800Kg/m^3 (50 lb/ft^3) for Volume Calculations
	1,040 Kg/m^3 (65 lb/ft^3 for Structural Load
Coal Angle of Response	35^o Degrees

*This capacity shall be achieved by normal tripper filling without leveling.

The minimum slope of the hopper's valley angle or in the case of cylindrical bunkers the slope of the lower conical section (to the horizontal) shall be at least 72^o for the hopper section between the outlet and the level where the coal span is 2.50 m (8') or above. Above this point the minimum slope shall be at least 65^o. Fillet plates at least 25 mm (1") wide shall be fitted in the valley angles. Hoppers with other than pyramidal or conical shape may be provided but in all cases they shall be designed for mass flow in accordance with the Jenike method. Adequate allowance shall be made in the thickness of the bunker shells to provide for corrosion and erosion over a life in excess of 25 years. Cross bracing and structural members within the coal stream and the bunker will not be permitted.

A concrete floor and an enclosure to accommodate the conveyors and trippers shall be provided above the bunkers and for the full length of the bunker bay including the lengths between boilers and beyond the boiler limits at each end. All conveyors, trippers, conveyor enclosure and flooring shall be supported by the bunker bay steel independently from the bunkers. Adequate sealing of the conveyor enclosure and flooring and between the bunker and the floor shall be provided so that the complete installation is dust proof. Suitable openings shall be provided in the floor to permit the coal to be transferred from the travelling trippers to the bunkers. The openings shall be continuous and suitable to fit seals between the travelling tripper discharge chute and the floor to prevent the dust from the bunker entering the conveyor housing.

The Vendor shall design and supply the bunker ventilation and dust suppression systems.

Separate openings shall be provided in the floor over each bunker for access to the interior of each bunker. These openings shall be fitted with hinged weatherproofed covers which can be readily opened and closed by one man.

All surfaces in contact with sliding coal on the bunker side walls and hoppers shall be lined with 304L stainless steel plate minimum 5mm (3/16") in thickness and a 2B surface finish. Interior bunker steel not in contact with coal shall be either gunited with a 50mm (2") minimum cover or galvanized with a 2 oz minimimum thickness.

The shape of the hopper and finish of the surface in contact with the coal shall provide a smooth surface on which the coal will readily slide under the worst possible coal conditions particulary with a large percentage of fines and high moisture.

7.3 ELEVATORS - STAIRWAYS - HOISTWAYS

The boiler building shall be equipped with:

1 - 2270 Kg (5,000 lb) (minimum) personnel elevator with a minimum floor area of 1.8m x 2.7m (6'-0" x 9'-0") and a speed of 1m/sec (200 fpm).

1 - 6800 Kg (15,000 lb) passenger-freight elevator with a minimum floor area of 1.8m x 2.7m (9'-0" x 12'-0") and a speed of 500mm/sec (100 fpm).

2 - full height stairways.

1 - full height hoistway. The hoist capacity and hoistway area shall be sized for the maximum equipment or component removal and as a minimum shall be 10 tons as 3m x 3m (10' x 10') in area.

Hoists, monorails and trolley as a minimum shall be provided for:

Location	Lift	Trolley
Hoistway	Electric	None
Rotary Air Heater Basket Removal	Electric	Electric
Rotary Air Heater Bearings	Electric	Electric
Combustion Air Heater Coils	Electric	Chain Gear
Electrostatic Precipitator T/R Removal	Electric	Push
Pulverizer Mill Maintenance	Electric	Electric
P.A. Fan & Motor Maintenance	Electric	Push

Location	Lift	Trolley
F.O. Fan and Motor Maintenance	Electric	Chain Gear
ID Fan and Motor Maintenance	Electric	Chain Gear

7.3.1 Operation

The elevator shall be provided with selective collective automatic operation as defined in ANSI A17.1.

The elevator shall be provided with a two-way automatic maintaining leveling device as defined in ANSI A17.1.

Car and hoistway doors shall be power operated, two-speed, horizontally sliding type. They shall be provided with automatic door bottom slot cleaning devices. Door movement shall be cushioned at both limits of travel to eliminate slamming.

The car shall be equipped with one photo electric cell actuated by a single light ray across the entrance to the car. Interruption of the light ray shall prevent the doors from closing or cause them to stop and reopen if they are in the process of closing. The photo cells shall cause the doors to remain open as long as the flow of traffic continues and permits them to close shortly after the last object passes through the door opening. A photo cell cutout switch shall be provided to be operated in the event of photo cell unit failure. This switch shall by-pass the photo electric door protective devices when turned to the off position.

A key operated switch shall be provided in the car operating panel for selecting Independent Service operation. When this switch is turned to the "on" position, all previously registered car calls shall be cancelled and the call shall be transferred automatically to Independent Service for operation by an attendant. The car shall park with doors open. Closing of the doors and starting of the car shall be subject to constant pressure on a car button until the car starts in motion. After the car is in motion, the button may be released and the car shall automatically proceed to and stop at the landing for which the car call has been registered.

7.3.2 Operating Devices and Signals

The car shall be provided with one operating panel containing a series of pushbuttons with illuminated markers, numbered to correspond to the various landings served. Each marker shall remain illuminated until the call has been answered.

A car position indicator consisting of a horizontal bank of illuminated markers corresponding to the landings and the direction of travel shall be located above the door, inside the car, and above the doors at each landing.

Each landing shall be provided with pushbutton operating panels with illuminated markers for registering calls. A single button at the terminal landings and up-down buttons at the intermediate landings shall be provided. Each marker shall remain illuminated until the call has been answered.

All car and landing operating panels and position indicators shall be designed to be vandal proof.

7.3.4 Control

The system of control shall be generator-field control as defined by ANSI A17-1.

7.3.5 Power Supply

The Owner furnished power supply will be 380 volt, 3 phase, 50 Hz and the lighting supply will be 220 volt, 3 phase, 50 Hz.

Power supply for controls shall be 220V, 3 phase, 50 Hz.

7.3.6 Electrical Equipment

Electrical equipment supplied by the Vendor shall be designed for continuous operation and minimal maintenance. The electrical equipment shall be capable of being idle for periods of time with no adverse effects to components or materials.

All electrical equipment provided by the elevator Vendor including limit switches, pushbuttons, or similar devices shall be in NEMA 12 enclosures.

7.3.7 Elevator Wiring

Control panel wiring for 220 volt ac or 125 volt dc voltage shall be 1/C No. 12 AWG, 7 strand, 600 volt SIS wire, annealed, coated copper conductor with 0.75mm (30 mils) flame retardant cross-linked polyethylene insulation, for continuous operation at 90°C in dry locations. Extra flexible wire shall be used for equipment located on hinged panels and any torque on these wires shall be via a twisting (not bending) motion. Amp Special Industries, self-insulated ring-tongue terminal connectors shall be provided for all control wiring. The hand crimping tool used shall utilize a ratchet mechanism which requires a full crimping cycle to be completed before the tool can be released. The crimping tool shall produce a raised symbol on a properly crimped termination. This symbol shall indicate that the correct die size was used and that a complete crimp was made.

Multiconductor control cable shall be rated 600 volts and have No. 12 AWG, unshielded, 7 strand, annealed, coated copper conductors. Insulation shall be ethylene propylene rubber or cross-linked polyethylene insulation with a heavy-duty neoprene or heavy-duty chlorosulfonated polyethylene jacket over individual conductors (if EPR insulation) and overall and shall be capable of continuous operation at 90°C in wet or dry locations. The use of asbestos in any form in the makeup of the cable is not acceptable.

Traveling cables between car and hoistway shall have flame retarding and moisture resisting outer cover. They shall be flexible and shall be suitably suspended to relieve strains in the individual conductors.

User connections shall be terminated on Marathon 1600 ST terminal blocks.

7.3.8 Controller

The Controller shall be of the electro-magnetic type with switches mounted on enclosed panels supported by a steel frame. It shall be designed to control starting, stopping and prevent damage to the motor from overload or excess current and to automatically cut off the power supply, apply the brake and bring the car to rest in the event of the actuation of any of the safety devices, or failure of power from any cause. A relay shall be provided on the controller, as required, designed to prevent the operation of the elevator in case of phase reversal, phase failure or low voltage in supply circuits.

7.3.9 Additional Features

The elevator cab shall be furnished with a roof escape hatch, ventilating fan, fan switch, a light and a light switch.

A ceiling flush mounted speaker and a wall flush mounted intercom handset and cabinet in the elevator cab, complete with traveling cable and necessary wiring shall be provided.

Guiding members required by ANSI A17.1 shall consist of rubber tired wheels running on the three finished rail surfaces. Each wheel shall be equipped with ball bearings and arranged to maintain contact with the rail surfaces.

7.4 DUCTWORK

The Vendor shall design and furnish all materials, fabricated and otherwise, for a complete installation of:

a. Air ductwork connecting the FD and PA fans to the air heaters and the air heaters to the windbox and pulverizers.

b. Flue gas ductwork connecting the economizer outlet to the air heaters. The air heaters to the precipitators, the precipitators to the ID fans and the ID fans to the chimney flue.

The work shall include the necessary plate, stiffeners, bolts, and nuts, expansion joints, dampers, flow corrective devices (turning vanes, divider, baffle walls), sampling, test and instrumentation taps and ports, mandoors, seals, hangers and hanger rods, and insulation fastening clips and/or studs.

The following platework design criteria shall be followed regarding maximum allowable deflection resulting from maximum design pressure combined with deadweight and all other live loading such as ash load, wind load, and equipment load:

Member	Maximum Deflection
Plate	$\frac{\text{Span}}{360}$
Stiffener	$\frac{\text{Span}}{240}$

Maximum span to depth ratio L/24.

Air ductwork shall be 5mm (3/16") minimum thickness ASTM A36 steelplate. Flue gas ductwork, economizer hoppers, air heater casings and dust hoppers shall be 6mm (1/4") minimum thickness ASTM A36 steelplate. A 1.5mm (1/16") corrosion allowance on the flue gas ductwork shall be deducted when designing the ductwork.

The sides of all hoppers shall have an adequate slope to prevent bridging of fly ash at the outlet connections. A minimum slope of 55^{o} to the horizontal is required. Suitable poke holes and dust sampling connections shall be provided on each dust hopper outlet. Ductwork, hoppers, and supports shall be designed to prevent excessive stress and to prevent distoration caused by thermal expansion.

The Vendor shall provide suitable total airflow measuring devices to provide a continuous, reliable signal compatible with the combustion control system.

The Vendor shall furnish such straightening vanes as may be necessary to achieve maximum gas and airflow with minimum pressure drops.

A model study will be performed by Others and the Vendor's final duct design shall incorporate design features resulting from the model study.

All instrument connections in the ductwork shall be made perpendicular to the duct and shall be ground smooth and flush on the inside. All exterior instrument connections shall extend beyond the insulation and lagging. Wherever possible, instrument connections shall be located to avoid interference with other structures and equipment. Pressure connections shall be 50mm (2") pipe and temperature connections shall be 32mm (1 1/4") pipe.

All ductwork expansion joints shall be as manufactured by R&M Industrial Products Inc. in accordance with R&M recommendations for the joint service intended.

7.5 SUPPORTING STEEL

All steel shall be stiff enough to resist ordinary pulsations in the furnace without excessive vibration.

All steel shall be designed to accommodate all thermal expansions, piping and ductwork pressure, thrust heads, and any required equipment deflection and alignment requirements.

7.6 ENCLOSURES - WEATHER PROTECTION

Enclosures (roofing, floors, siding), as a minimum, shall be provided for the following:

a. Main coal conveyor room and galleries (including concrete floor) spanning between boiler structures.

b. Coal bunker conveyor rooms (including concrete floor).

c. Top of each boiler.

d. Boiler burner area (including concrete floor and roof).

e. Complete elevator lift areas. Elevator landing doors shall be weatherproofed where the areas adjacent to the doors is not weatherprotected.

f. The boiler room operating floor shall be concrete and shall extend over the full area of each boiler room except where areas are required for piping, ducting, trays, hoisting, expansion movements and equipment penetrations. Siding shall extend below the operating floor to the mezzanine floor and beyond if necessary to protect the mills, fans, and other items installed at the grade level.

g. All enclosures shall be designed for adequate ventilation for the service intended.

h. Curbing shall be provided around the perimeter and all openings through concrete floors.

i. Gutters and downspouts shall be provided for all roofed areas.

8.0 PERFORMANCE REQUIREMENTS (NOT USED)

9.0 MATERIAL AND FABRICATION REQUIREMENTS

9.1 ELEVATOR

Unless otherwise specified, the materials of construction shall be the elevator Vendor's standard with proven suitability for the design conditions. All materials of construction shall meet the requirments of the applicable codes, standards, and regulations referenced in this Specification.

The car enclosure shall be rigidly constructed of 14 gauge minimum thickness sheet metal.

Car frames and platform frames shall be made of steel. Platform floor shall be steel checkered plate.

Car and hoistway doors shall be 32mm (1 1/4") thick and constructed of 14 gauge minimum thickness sheet metal.

9.2 STRUCTURAL STEEL

Structural steel shall be ASTM A-36 unless otherwise noted in this Specification or on the drawings.

All welding shall be performed by AWS qualified welders. Welder qualification records wil be retained on file until the completion of the job.

9.3 BOILER SUPPORT GIRDERS

The boiler support girders shall be fabricated from plate meeting the requirements of ASTM Designation A-516, Grade 70 material.

All plates used for boiler support girders are to be produced from cross-rolled slabs.

Charpy V-Notch Tests from longitudinal and transverse samples shall be performed for A-516 material in accordance with Standard Specification for General Requirements for Steel Plates for Pressure Vessels, Section 12.1 Charpy V-Notch Tests ASTM Designation A-20. The temperatures and minimium energy absorption values for the Charpy V-Notch Tests shall be as given in Table 16 of ASTM A-20. Lateral expansion measurements shall also be performed and measurements shall be not less than .4mm (15 mils) regardless of plate thickness. Temperature at which lateral expansion measurements are made shall be stated but shall be no greater than -12°C (+10°F). Materials which do not meet the requirements of the above specified test results shall not be used. Two copies of all test results shall be forwarded to the Engineer.

All plates other than web stiffeners used for the boiler support girders shall be ultrasonically tested for lamellar separation before fabrication begins in accordance with the requirements of ASTM Specification A-435 including supplementary requirement S1.

The Vendor shall submit his recommended fabrication procedures for built-up members including weld area preparation, inspection, welding procedures and welding sequence to the Engineer for approval prior to fabrication. Welding procedures shall be AWS qualified and suitable for the steel used. Electroslag welding shall not be used.

9.4 BUILT-UP MEMBERS (PLATE GIRDERS)

Built-up members shall be fabricated from plate meeting the requirements of ASTM Designation A-36 materials.

High-strength steel will be considered for the flanges of plate girders where there will be a significant savings.

Charpy V-Notch Tests shall be performed for A-36 material in accordance with the Standard Specification for Sampling Procedure for Impact Testing of Structural Steel, ASTM Designation A-673. The testing frequency shall be a modified (H)

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frequency such that at least one Charpy V-Notch test (a set of three specimens) will be performed for each plate thickness produced for each heat of steel. Both longitudinal and transverse tests shall be made. The average impact test result for each specimen shall not be less than 27J (20 ft-lb) at -12°C (+10°F) for both the longitudinal and transverse directions. Lateral expansion measurements shall be made and recorded at the time of each Charpy V-Notch test. Materials which do not meet the requirements of the above specified test results shall not be used. Two copies of all tests results shall be forwarded to the Engineer.

All plates used for built-up members are to be produced from cross-rolled slabs.

All plates other than web stiffeners used for built-up members shall be ultransonically tested for lamellar separation before fabrication begins in accordance with the requirements of ASTM Specification A-435 including supplementary requirement S1.

The Vendor shall submit his recommended fabrication procedures for built-up members including weld area preparation, inspection, welding procedures and welding sequence to the Engineer for approval prior to fabrication. Welding procedures shall be AWS qualifed and suitable for the steel used.

Mill test reports for all structural steel used shall be retained and forwarded to the Engineer.

9.5 WELDING

All welders and tackers shall be AWS qualified.

Weld procedures and welder qualification records for AWS qualification on nonprequalified welds shall be submitted to the Engineer for review and approval prior to use.

Documentation shall be submitted indicating that nonprequalified welds were actually performed by the welder qualified for the subject work.

9.6 SHOP CONNECTIONS

Shop assembled joints may be welded (E70-XX electrodes or flux cored or submerged ARC) or bolted using high-strength (A325) bolts. Welds over 12mm (1/2") in size shall be made using low hydrogen rod.

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9.7 FIELD CONNECTIONS

Field connections shall be high-strength (A325) bolted friction type connections. Bolt tightening shall be by turn of the nut method or load indicator washers.

The Vendor shall furnish ASTM A-325 high-strength heavy semi-finished hexagon steel bolts, nuts, and one hardened washer (flat or beveled as required) for each bolt, for all bolted field connections indicated plus any extra required to cover erection requirements and waste. For steel that is furnished but not erected, the Vendor shall furnish necessary field connection bolts, nuts, and washers plus 2 percent extra to cover waste. No other type bolt shall be used without written approval of the Engineer.

Oversize holes a maximum of 5mm (3/16") larger than the bolt diameter shall be allowed only for vertical bracing connections of diagonal members to gusset plates and gusset plates to columns.

All connections shall meet the requirements of the reference specifications.

9.8 TOLERANCES

Allowable tolerances shall be as stated in AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, Section 1.23.8 except as noted on the drawings and as follows:

a. Toeplates shall be within 6mm (1/4") plumb and shall not be out-of-line more than 3mm (1/8") at any joint or 6mm in 6m (1/4" in 20').

9.9 GRATING AND HANDRAIL

All grating shall be standard welded grating with 25mm x 5mm (1" x 3/16") bearing bars on 30mm (1 3/16") centers with cross bars at 100mm (4") centers. Grating shall comply with the National Association of Architectural Metal Manufacturers Designation WD-19-4 and shall be hot-dipped galvanized in accordance with ASTM A123.

All stair treads shall be of welded construction with depth of bearing bars as required to safely resist design loads. All stair treads shall have an abrasion type nosing and be not less than 265mm (10 1/2") in width. Stair treads shall be hot-dipped galvanized in accordance with ASTM A123.

Steel pipe for handrail shall be furnished in accordance with the Specifications for Welded and Seamless Pipe, ASTM A53-80. Size shall be 40mm (1 1/2") standard pipe 48mm (1.9" O.D.)

Miscellaneous plates used for handrail connections shall be ASTM A-283, A-633, or A-36.

Bolts and nuts for handrail shop and field connections shall conform to ASTM Specification A-307.

The Contractor shall provide 10mm (3/8") diameter drain holes, preferrably in the web of members, in all locations where water may be trapped in the completed structure.

Bearing bars and cross bars in adjoining sections of grating shall line up. At all end joints, bearing bars shall be banded to prevent telescoping. Mechanical fasteners (minimum four per panel) shall be used to attach all grating to the structural steel.

Grating panels shall be detailed to provide panel joints with split toe plate rings at piping floor penetrations.

Handrail welds on top rail sections and mitered corners shall be ground smooth to eliminate any personnel hazard.

Handrails shall be fabricated in sections readily handable in the field.

9.20 BUILT-UP ROOF AND RELATED ITEMS

The built-up roofing shall be a 5 ply, asphalt and gravel type, on metal roof deck. The roof system shall conform to Factory Mutual Class I construction and UL for Fire Rated Deck Construction and carry a 20 year guarantee.

The roofing and all related work such as flashings shall be guaranteed for a period of 5 years against defects in workmanship and materials. The Vendor shall submit a written guarantee to the Purchaser stating that the Vendor shall promptly repair and/or replace any part of this work which does not remain watertight or otherwise proves defective during the guarantee period without cost to the Purchaser.

Felts shall be 7Kg (15 lb) perforated asbestos felt.

Asphalt shall be Aquadam, Type I.

Flashing shall be Johns-Manville system. Metal counter flashings shall be 0.8mm (.032") aluminum.

Gravel-stops for use at roof sumps shall be fabricated from No. 21, B and S gauge sheet aluminum, formed into an angle member with a 100mm (4 inch) minimum width horizontal leg. The vertical leg shall be doubled over to form a leg of double thickness not less than 25mm (1 inch) high. The vertical leg shall be perforated with 10mm (3/8 inch) diameter holes spaced 25mm (1 inch) on centers and located on the centerline of the leg.

Roof drains shall be of coated cast iron with cast iron dome, clamp ring, and anchor flange, integral gravel stop, adjustable top with wide roof flange and deck clamp caulk outlet.

Roof drains shall be Josam Series 2100 or fully cross-indexed units by Wade, Zurn, or Smith

The roof drainage sumps shall be flashed with 4 pound soft sheet lead cut to fit the sumps and securely fastened in place with sump clamping rings. The flashing shall extend a minimum of 600mm (24 inches) in all directions, measured from the center of the sump in flat areas, and shall be exposed and follow the contour of intersections with adjacent inclined surfaces.

The roof aggregate shall be a light-colored gravel, applied as recommended by the composition roofing manufacturer. The aggregate shall be free of all dirt, loam, and foreign matter. The aggregate shall be graded between 20mm (3/4 inch) and 6mm (1/4 inch) and shall be applied during the same day as the application of the felts.

The aggregate shall pass the following sieve tests:

Not more than 3 percent shall be retained on a 20mm (3/4 inch) sieve.

Not more than 3 percent shall pass a 6mm (1/4 inch) sieve.

At least 50 percent shall be retained on a 10mm (3/8 inch) sieve.

Artificially crushed rock shall not be included in the aggregate.

The aggregate shall be dry prior to installation.

Gravel shall be applied at the rate of not less than 20Kg/m^2 (400 lbs per 100 sq ft).

The Vendor shall supply 100mm x 100mm (4 inch x 4 inch) x 45° continuous fiber cant strips at roof intersections framed with vertical surfaces. Cants shall be anchored securely to the sub-roof at 600mm (2 feet) on centers.

Metal cants where shown on the Drawings shall be 100mm x 100mm (4 inch x 4 inch) x 45° galvanized 18 gauge sheet metal, welded to the deck and fastened to the vertical by welding or sheet metal screws.

9.11 UNINSULATED METAL WALL PANEL

Uninsulated metal wall panels and all associated flashing and copings, gutters, and downspouts shall be by one of the following manufacturers, or similar product by other manufacturer approved by the Purchaser's Engineer, subject to compliance with the specification requirements:

H. H. Robertson
Elwin G. Smith
Inryco
Steelite

Uninsulated metal panels shall be 38mm (1 1/2 inches) thick.

Gutters and downspouts or roof drains shall be installed on all roof areas.

The steel panel shall be similar to V-Beam by E. G. Smith. The panels shall be 38mm (1 1/2 inches) deep and 910mm (36 inches) wide of 20 USS gauge stucco embossed galvanized steel.

Both faces of panel shall be thoroughly cleaned and shop coil primed and finished with factory baked-on polyvinilidene flouride "Kynar" finish. The color shall be the manufacturer's standard color selected by the Purchaser.

Clips and fastenings shall be of rust-resistant materials. Self-tapping screws shall be of stainless steel. Sheet metal screws shall be of stainless steel and have integral neoprene washers when used in exposed locations. Clips shall be of stainless steel or galvanized black steel. Heads of exposed screws shall be finished to match the adjoining work.

Coping and flashing shall be as shown on details, of minimum 16 USS gauge steel, finished to match the wall panels. Gutters shall be 125 x .13mm (5" x .050) aluminum and downspouts shall be 100 x .13mm (4" x .050) aluminum.

9.12 HOLLOW METAL DOORS AND FRAMES

Hollow metal doors and frames shall be by one of the following manufacturers, or a similar product by another manufacturer approved by the Purchaser, subject to compliance with the Specification requirements:

Overly Manufacturing Company

Fenestra, Inc.

Pioneer Industries

Ceco Corporation

Williamsburg Steel Product Company

Republic Builders Products Corporation

Doors shall fit closely and parallel to frames and to floors and thresholds. Swinging vertical edge shall be slightly beveled. Clearance between doors and frame and door bottom and floor or threshold shall not exceed 3mm (1/8 inch) unless otherwise specifically requested.

Door shall be flush hollow construction, with a one piece, high density urethane core, securely bonded, under heat and pressure, to both face sheets.

Doors shall be formed of two stretcher leveled quality cold-rolled sheet furniture steel, free of scale, waves, or other defects. Door shall be formed of No. 16 U.S. gauge sheets. Face sheets of all doors shall be seamless. Edges shall be continuously welded and ground smooth so as to form an invisible seam. Use of fiberglass or body filler at welded and ground door edge seams will not be allowed. Top and bottom 16 gauge reinforcing channels shall be welded within the doors, extending full width, to both face sheets.

Provide and weld in place all concealed reinforcement complete with drilled and tapped holes as required to accommodate finish hardware. Reinforcement shall be No. 16 gauge for locks and trim, 3mm (1/8 inch) thick for closers and 5mm (3/16 inch) thick for hinges.

Doors having glazed panels shall be framed with rabbeted openings to receive glass and provided with fitted metal glazing stops. Glazing moldings shall be rectangular in form, drawn from not less than No. 20 gauge steel, mitered and welded and secured with countersunk oval head steel machine screws.

Top rails in glazed doors shall be a minimum of 150mm (6 inches) to receive hardware.

When fire rated doors are specified, hollow metal doors and frames shall be constructed in accordance with requirements of the Underwriters' Laboratories for the class specified and delivered to the site bearing the appropriate UL label. A full height 38 x 5mm (1 1/2 x 3/16 inch) steel astragal shall be fastened with countersunk machine screws to the active leaf of pairs of fire labeled doors.

Frames shall be formed of No. 16 gauge steel, coped or mitered at intersections, continuously welded and ground smooth to create a nonvisible joint connection. Side and head jamb door stops, 16mm (5/8 inches) thick, with provisions for a recessed closed cell neoprene weather seal gasket, shall be provided continuous on all door frames. Fiberglass or body filler shall not be used at welded and ground coped or mitered intersections.

The Vendor shall provide a minimum of three 10mm (3/8 inch) countersunk head bolts per jamb for anchorage. They shall be provided with self-locking nuts and 10mm (3/8 inch) expansion shield.

Mortise and reinforce frames to receive all hardware, with 5mm (3/16 inch) plate reinforcement for hinges and 3mm (1/8 inch) thick reinforcement for all other cutouts. Drill and tap reinforcements for mortised hardware and provide No. 26 gauge steel plaster guards spot welded to frame to protect tapped holes from entrance of mortar.

For openings over 1m (3 feet 6 inches) wide, reinforce head members full length with No. 12 gauge steel channels spot welded to frame at 150mm (6 inches) on center.

All surfaces which are concealed or inaccessible after assembly of units shall be properly cleaned and given one coat of a rust inhibitive primer. Frames in masonry construction shall be back painted with an asphaltic paint.

Assembled doors and frames shall then be properly cleaned and prepared to receive final shop prime coat finish. Apply filler and sand exposed surfaces to attain a uniform smooth surface.

Apply a minimum of one baked-on coat of primer and deliver to the job site ready to receive final field coat of paint.

9.13 ROLL-UP DOORS

Roll-up doors shall be by one of the following manufacturers, or a similar product by another manufacturer approved by the Purchaser, subject to compliance with the specification requirements:

Atlas Door Corporation
Cookson Company
Jim Walter/North American Doors
J. G. Wilson

Curtains shall be constructed of interlocking roll formed 20 gauge galvanized steel slats to provide a curtain stiffness to withstand a pressure of 98 Kg/m^2 (20 lbs per sq ft) from either side. Door shall be insulated with slats designed to enclose foam insulation between two layers of metal. The insulation shall have a U rating of less than 4 $KJ/hr\text{-}m^2\text{-}^oC$ (0.2 $Btu/hr\text{-}ft^2\text{-}F^o$).

End blocks shall be malleable iron.

Guides shall be formed of standard rolled steel angles, minimum 5mm (3/16 inch) thick and of sufficient depth to retain curtain in place under the specified pressure.

Roller shaft shall be steel pipe of sufficient diameter to limit deflection to 2.5mm/m (0.03 inch per foot).

All gearing shall be of high tensile gray iron with teeth case from machine cut pattern.

Brackets shall be of a heavy cast iron or steel.

Operator bracket hub and plug in spring end of shaft shall be fitted with self-lubricating bronze bearings or permanently lubricated, sealed ball bearings.

Hood shall be a minimum of 24 gauge bonderized, hot-dip galvanized steel. Furnish neoprene air baffle in hood.

Curtain shall be equipped with a bottom bar consisting of two angles of equal weight with a minimum leg width of 38mm (1 1/2 inches), one each side, fastened to bottom of curtain.

The ends of alternate interlocking slats (each interlocking for fire rated doors) shall be fitted with end blocks, which shall act as a wearing surface in the guide and prevent lateral movement of individual curtain slats. Doors shall be equipped with windlocks.

The roller shaft shall house all counterbalancing mechanisms including oil tempered steel springs capable of counterbalancing weight of curtain. Spring tension shall be adjustable by means of adjusting wheel on the outside of the end bracket.

Brackets shall be designed to form end closure support for hood.

Hood shall be formed to fit contour of end brackets and reinforced with rolled edges and brackets for proper support and stiffening.

Doors shall be weatherstripped with a compressible rubber or vinyl seal attached to door bottom, rubber or vinyl weathering seal in hood and manufacturer's standard weather seal at guides on each side of door.

The door shall be manually operated by chain gear with gear reduction to reduce pull on hand chain to not over 16 Kg (35 lbs). Hand chain shall be galvanized.

The curtain, hood, and all other exposed surfaces shall have a baked acrylic primer, suitable for finish painting on the job site.

Motor operators are required for all overhead doors. The motor operators shall be a standard of the manufacturer suitable for the U. L. Class A label door of size shown on the Drawings and listed in accordance with U. L. Bulletin 325.

The electric characteristics of the motor are 380 Volts, 3 Phase. The power unit shall consist of a heavy duty, hoist-type motor, gears designed to AGMA standards, running in multi-temperature lubricant; mechanical self-adjusting brake; rotary limit switch to set Open and Close positions; NEMA-9 motor controller with overcurrent protection and one NEMA-9 three position pushbutton station with Open, Close, and Stop positions on each side of the door. All electrical components shall be suitable for use in an NEC Class II, Division I, Group F environment.

The power operator, as described above, shall be equipped with an automatic chain operator which is operable when the power is off without the use of pull levers of chains.

9.14 FINISH HARDWARE

Locksets shall meet latest Federal Specification FF-H-106 or ANSI A156.2.

Labeled doors shall be equipped with hardware of the proper function to comply with local Building Code requirements and shall bear the Underwriters' Laboratories label.

9.15 Louvers shall be 6063 T5 aluminum finished to receive paint of Purchaser's choice. Louvers shall include aluminum bird screens on the exterior, 19mm (3/4 inch) mesh x 1.3mm (.051 inch).

9.16 ROOF VENTILATORS

Electrical equipment provided with the bunker room ventilation shall carry a NEMA-9 rating and be suitable for use in a NEC Class II, Division II, Group F area.

Motorized roof ventilators shall be provided with steel propellers, aluminum damper doors, prefabricated curbs, and safety disconnect switches mounted on the outside of the ventilator. The ventilators shall also have hot-dip galvanized coatings.

9.17 DRAWINGS

Shop Drawings

Certified shop detail drawings and erection diagrams are to be forwarded to the Engineer for all items furnished by the Vendor.

The title block of each shop drawing will note the part of the structure for which the drawing is made. The Vendor's reference drawing numbers shall be referenced on each drawing.

Shop detail drawings prepared by subcontract detailing shops shall show the shop's name in the title block.

Details of all beams and girders shall indicate the elevation of the top and be laid out such that the left end of the beam corresponds to the mark numbered end on the erection drawing.

The compass orientation of all columns shall be indicated on the Face "A" view of the detail drawing.

All call-outs shall be in accordance with the current AISC Specification (Examples: W12x27, M14x17.2, C8x11.5...).

All original shop detail drawings, erection diagrams and shop bills shall become the property of the Owner. Upon completion of the work, they shall be shipped, prepaid, to the Engineer. High quality reproducibles and prints shall be furnished for satisfactory print and microfilm reproduction.

10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

(See 9.0 MATERIAL REQUIREMENTS

11.0 INSTALLATION REQUIREMENTS

(None)

12.0 PERSONNEL REQUIREMENTS

(None)

13.0 INSPECTIONS AND TESTS

13.1 GENERAL

The Engineer and Owner reserve the right to inspect the materials used and the workmanship.

The term "Inspector" referred to herein is defined as the authorized representative of the Engineer and the Owner.

The Vendor shall cooperate with the Inspector and shall permit his free access to all work areas.

13.2 WELDING

The cost of weld inspection is to be a part of the Vendor's fabrication expense. If ASNT qualified inspectors are not a part of the Vendor's Quality Control Program, an independent testing lab shall be retained by the Vendor and at the Vendor's expense. All ASNT qualified inspectors are to be qualified per SNT-TC-1A level II. The Vendor's inspectors shall not be involved in production work while acting as an inspector.

Reports of weld test results for the nondestructive examination program shall be submitted to the Engineer for review within 5 days after testing.

There shall be four categories of welds established for the purpose of defining the level and type of nondestructive examination required. These categories are as follows:

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a. Plate girder welds

b. Critical welds 13mm (1/2") and over in size and full penetration welds

c. Critical welds under 13mm (1/2") in size

d. Noncritical welds

Plate Girders - All tension flange butt welds for plate girders shall be subject to nondestructive examination. Tension flange butt welds on the main boiler support girders shall be examined using gamma radiography. Secondary boiler support girders and all other plate girder tension flange butt welds shall be examined ultrasonically. All plate girder web to flange welds shall be subject to nondestructive examination for their full length. The nondestructive examination method used for each weld shall be as mutually agreed upon between the Vendor's ASNT qualified Inspector and the Engineer.

Critical Welds 13mm (1/2") and Over In Size and Full Penetration Welds - 20 percent of all welds in this category shall be subject to nondestructive examination by one or more of the following methods: magnetic particle, dye penetrant, ultrasonic or gamma radiography. The nondestructive examination method used for each weld shall be as mutually agreed upon between the Vendor's ASNT qualified Inspector and the Engineer.

Critical Welds Less Than 13mm (1/2") In Size - Typical examples of welds in this category are:

a. The end connections of beam members carrying axial loads.

b. Seat connections and column base hold down assemblies.

c. Diagonal bracing gusset plate connections.

d. Truss connections.

e. Steam drum and boiler hanger supports.

Ten percent of all welds in this category shall be subject to nondestructive examination.

Noncritical Welds - This category is limited to welds 13mm (1/2") and smaller. Typical examples are:

a. Minor members serving as platform supports.

b. Handrail and toeplate welds.

c. Intermediate coal bunker stiffener welds.

Noncritical welds, welding materials and procedures shall be subject to visual examination. Where substandard welds occur or improper materials or procedures are noted, nondestructive examination shall be requested to determine the presence and extent of weld defects. The cost of the nondestructive examinations and weld repairs shall be borne by the Vendor.

All test reports shall be forwarded to the Engineer.

13.3 AUTHORITY TO REJECT

The Inspector shall have authority to reject all materials and workmanship not conforming to the drawing and/or specifications. Any defective material found during the progress of the work shall be promptly replaced or corrected by the Vendor to the satisfaction of the Engineer.

13.4 LIABILITY FOR DEFECTIVE MATERIAL

If the Inspector, through oversight or otherwise, has accepted material or work which is defective or contrary to these specifications or design drawings, this material, no matter in what stage of completion, may be rejected by the Engineer.

The Owner and the Engineer shall be notified before placing of mill orders and starting of fabrication.

14.0 CLEANING, CORROSION PROTECTION AND COATING

14.1 SHOP PAINT

Unless otherwise noted on the drawings, structural steel shall be given one shop coat equivalent of Carbo Zinc II inorganic zinc primer as manufactured by Carboline Co. or Owner approved equal, primer shall be applied in accordance with manufacturer's recommendations to not less than 3 mill dry film thickness.

All structural steel to be shop painted shall be, as a minimum, cleaned and prepared for painting after fabrication in accordance with Surface Preparation Specification SSPC-SP6 "Commercial Blast Cleaning".

Material shall be kept from exposure to weather until it has been shop painted. Steel shall be free from moisture, above freezing, and shall remain under cover until paint has dried.

14.2 GALVANIZED MATERIAL

All galvanizing shall be hot-dipped in accordance with the Standard Specification for Zinc (Hot Galvanized) Coatings of Structural Steel Shapes, Plates, Bars and their Products by the American Society for Testing and Materials (ASTM Designation A-123) modified as follows:

a. Material rejected by reason of defective coating shall have coating completely removed in acid bath before re-dipping. If any defective material is found upon receipt of material at destination, the Vendor shall replace this material free of charge fob destination. Such replaced material shall be subject to inspection.

b. The Vendor shall be responsible that all galvanized material is straight, marked, and packed for shipment in accordance with this Specification.

c. All material warped by galvanizing shall be straightened without injury to the galvanizing.

Bolts, Nuts, and Washers - Bolts, nuts, and washers shall be furnished hot-dipped galvanized in accordance with ASTM Specification covering Zinc Coating (Hot-Dipped) ASTM Designation A-153.

Connections - Only bearing type bolted connections conforming to the requirements of the reference specifications will be permitted in joints connecting the members that have been galvanized.

Identification and Shipping - All pieces shall be stamped before galvanizing with piece marks shown on the erection drawings, with the marking not less than 20mm (3/4") high placed in the same relative location on all pieces. The marking shall be plainly visible after galvanizing.

As a minimum all grating and embedded steel shall be galvanized.

15.0 MARKING AND IDENTIFICATION

Mark the compass direction on the Face "A" of all columns.

Beams and girders shall be marked such that the mark number reads right side up on the left end of the piece. The left end is the mark numbered end as shown on the erection drawing.

Each piece mark shall include the number of the shop drawing on which the piece is detailed, and each column piece mark shall also include the column designation appearing on the design drawings.

Vendor erected members weighing more than 9 tonnes (10 tons) and "leave out" members weighing more than 2.7 tonnes (3 tons) shall have the weight marked thereon.

All steel other than ASTM A-36 shall be clearly marked with its ASTM Specification and heat number. Markings shall be legible through all steps of fabrication and erection.

It is the Vendor's responsiblity to affix tags or marks so they will remain attached and will be legible after normal shipping, handling and field outdoor storage. Tags shall be waterproofed and piece mark lettering shall be a minimum of 13mm (1/2") high.

16.0 PACKAGING AND SHIPPING

Bolts of one length and diameter, and one type, loose nuts of each size, and flat and beveled hardened washers of each size shall be packaged separately.

Pins, small parts and small packages of bolts, flat and beveled hardened washers and nuts shall be shipped in boxes, crates, kegs, or barrels, but the gross weight of any package shall not exceed 136 Kg (300 lb).

Particular attention must be paid to protecting bolts and nuts from moisture.

A list and description of the contained material shall be plainly marked on the outside of each shipping container.

To facilitate the sorting and storing of steel as it is unloaded, each piece shall be marked to indicate the division of which it is a part.

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The delivery sequence shall be approved by the Engineer before the work is started.

Structural steel shall be shipped to jobsite:
(Address Later)

17.0 ACCEPTANCE CRITERIA

The material will be accepted after receipt and acceptance of all Vendor data listed in paragraph 6.0 and acceptance of inspections requirements as listed in paragraph 13.0.

LAKHRA POWER FEASIBILITY STUDY

SPECIFICATION M-2

TURBINE GENERATORS AND ACCESSORIES

SPECIFICATION M-2

TURBINE GENERATORS AND ACCESSORIES

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SPECIFICATION M-2

TURBINE GENERATORS AND ACCESSORIES

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LAKHRA POWER FEASIBILITY STUDY

TECHNICAL SPECIFICATION M-2

TURBINE GENERATORS AND ACCESSORIES

1.0 DESCRIPTION OF WORK

The Work to be performed consists of designing, fabricating, testing, and delivering to the jobsite a turbine generator and accessories to be used for two 350 MW net nominal power plants for the Water and Power Development Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

The Work shall include at least the following for each unit:

a. One tandem compound, two-flow steam turbine.

b. Hydrogen or hydrogen and liquid-cooled generator.

c. Governing system.

d. Electro-hydraulic control system.

e. Lubricating system.

f. Steam seal system.

g. Excitation system.

h. Instrumentation.

i. Insulation.

j. Special tools and rigging equipment.

k. The services of a qualified technical representative to provide technical direction during installation and startup and provide training for plant personnel.

3.0 WORK NOT INCLUDED

The following items are not included in the Work, but will be accomplished by others:

a. Foundations.

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b. Field labor for unloading and erection.

3.1 Steam, water, oil, air, and gas piping and ducting external to the following points:

a. Main steam stop valve inlet connections.

b. Extraction steam piping nozzle connections on high and low pressure cylinder piping.

c. Cooling water inlet and outlet connections to Vendor-supplied coolers.

d. Miscellaneous connections on the turbine, generator, vessels, or piping provided by the Vendor for vents, drains, condensate, and other miscellaneous services.

e. Generator hydrogen and carbon dioxide distribution header connections.

f. Reheat stop valve inlet connections.

4.0 APPLICABLE CODES, STANDARDS, AND REGULATORY REQUIREMENTS

4.1 Design, materials, manufacture, installation, examination, testing, inspection, and documentation shall conform to the applicable portions of the following specifications, codes, and standards, including case rulings, interpretations, and addenda as applicable and in force at the time of issue of this Specification.

4.2 It is not intended that the internal design of the turbine, which is the Vendor's responsibility, conform to any below listed codes or standards. However, the generator, exciter, and any auxiliary equipment; viz., heat exchanger or other vessel, piping system, wiring, etc., shall be supplied in accordance with the latest edition of such codes and standards as are applicable to their category of equipment. The Vendor shall not be relieved of the responsibility for complying with the referenced codes or applicable portions of the codes.

4.3 CODES AND STANDARDS, GENERAL LISTING

a. American Society of Mechanical Engineers (ASME).

b. American National Standards Institute (ANSI).

c. American Society for Testing and Materials (ASTM).

d. National Electric Manufacturers Association (NEMA).

e. National Fire Protection Association (NFPA).

f. Institute of Electrical & Electronic Engineers (IEEE).

g. Tubular Exchanger Manufacturer's Association (TEMA).

h. Hydraulic Institute Standards.

i. American Gear Manufacturers Association (AGMA).

j. Instrument Society of America (ISA).

4.4 Codes and standards which are directly applicable to particular items are as follows:

4.4.1 American National Standards Institute (ANSI):

a. B31.1, "Power Piping."

b. C50.10, "Synchronous Machines."

c. C50.13, "Cylindrical Rotor Synchronous Generators."

d. C57.13, "Requirements for Instrument Transformers."

4.4.2 American Society of Mechanical Engineers (ASME):

a. 116, "Recommended Practices for the Design of Steam Turbine Generator Oil Systems."

b. TDP-1, "Recommended Practice for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation."

c. Boiler and Pressure Vessel Code:

(1) Section VIII, Division 1, "Pressure Vessels."

(2) Section IX, "Welding and Brazing Qualifications."

4.4.3 Institute of Electrical and Electronic Engineers (IEEE):

a. 43, "Testing Insulation Resistance of Rotating Machinery."

b. 95, "Insulating Testing of Large AC Rotating Machine with High Voltage."

c. 115, "Test Procedure for Synchronous Machines."

d. 421A, "Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems."

4.4.4 National Electrical Manufacturers Association (NEMA), MG 1, "Motors and Generators."

5.0 SUPPLEMENTAL DATA

The documents listed on the contents page as attachments are applicable to the Work, to the extent specified herein.

6.0 VENDOR DATA REQUIREMENTS

6.1 The Vendor shall furnish data in accordance with the requirements indicated on the attached Vendor Data Requirements and Submittal Schedule.

6.2 The Vendor data furnished in accordance with paragraph 6.1 shall include the following: (Data which are representative rather than exact shall be identified as such.)

6.3 DRAWINGS

a. Dimensioned outline and sectional drawings of equipment.

b. Turbine-generator outline drawing and loading diagram.

c. Oil tank arrangement drawings.

d. Turbine-generator piping drawing.

e. Turbine-generator wiring diagram and interconnection diagrams.

f. Suggested schematic diagrams of electrically operated auxiliary equipment for comments.

g. Lifting drawings.

6.4 Guaranteed electrical output of turbine-generator unit.

6.5 Heat balance diagrams at guaranteed conditions for basic arrangement and alternates specified.

6.6 Curves of heat-rate variation due to changes in turbine back pressure from 3.386 to 16.93 kPa (1.0 to 5.0 inches of mercury).

6.7 List of equipment necessary for operation and maintenance in addition to what is already specified in paragraph 7.1.4.

ICS

6.8 Tabulation of materials of construction.

6.9 Weights and foundation loadings of equipment including dynamic loadings. Vendor required foundation design criteria, such as natural and resonant foundation frequency limitations plus maximum bearing deflections and shaft curvature limitations.

6.10 Description of lubrication systems.

6.11 Description of control systems.

6.12 Cooling water flow requirements, temperature limitations, and pressure drop for all equipment requiring cooling water.

6.13 Operating limitations with feedwater heaters out of service.

6.14 Allowable main steam temperature and pressure variations.

6.15 Maximum expected steam flow at valves-wide-open conditions, with top feedwater heater out of service.

6.16 Complete generator data, including:

a. Guaranteed kVA, pf, kW, rpm, kV, amperes, and hydrogen pressure at rated initial steam conditions.

b. Permissive negative sequence current at rated output of the generator expressed in percent of rated line current on the basis of safe temperature rise.

c. H constant for stability study purposes.

d. Field amperes at no load rated voltage and at guaranteed load.

e. Ventilation:

(1) Complete description of liquid cooling system, if used.

(2) Type, number, and location of temperature detectors furnished with generator and exciter, including detectors for Owner's use as specified herein.

f. Curves:

(1) Saturation and synchronous impedance curves.

(2) Reactive and power capability curves at maximum hydrogen pressure and at 1 atmosphere and 2 atmospheres below maximum pressure.

(3) "V" curve.

g. Type and description of rotor grounding device, including illustrations or drawings or both.

6.17 Complete description of exciter and accessories.

6.18 Time required after receipt of Purchase Order to submit certified drawings required in Paragraph 6.3, b. through g.

6.19 Approximate weights of:

a. Heaviest piece to be handled during erection.

b. Heaviest piece to be handled during overhaul.

6.20 Required hook lift for Owner's overhead crane.

6.21 The Vendor shall furnish procedures and instructions for all field installation and all required startup tests. Operating and maintenance manuals for the equipment shall be furnished.

6.22 A list of recommended spare parts.

6.23 Heat Balance and Heat Rate Calculations:

The basic bid turbine cycle heat rates and heat balance diagrams shall be based on the following criteria:

a. Cycle conditions and arrangement as specified in paragraphs 7.1.1 and 7.1.3.

b. Generation at rated power factor and normal operating hydrogen pressure.

c. Condenser air removal will be by means of mechanical vacuum pumps.

d. Heat rate shall be on a gross turbine cycle heat rate basis and is defined as total heat added including makeup flow divided by generator terminal output.

e. Target heat balances are included as Attachment 3.

6.24 QA/QC REQUIREMENTS

a. The Vendor and his subvendor(s) shall have in effect in their shops at all times an inspection, testing, and documentation program that will ensure that the equipment furnished under this specification meets, in all respects, the requirements specified herein.

b. The Vendor shall submit a copy of his quality control program to the Engineer.

6.25 PERFORMANCE TEST REPORTS AND CERTIFICATIONS

The following performance reports and certifications shall be submitted to tne Owner prior to acceptance of the Work:

a. Two copies of alignment data sheets for rotating equipment shall be prepared and submitted to the Engineer.

b. Rotating equipment shall be lubricated and lubrication sheets shall be prepared, issued currently, and certified by both the Vendor and Engineer.

c. Certified copies of all shop test data shall be forwarded to the Engineer for later distribution to the Owner.

6.26 MATERIAL TEST REPORTS AND CERTIFICATIONS

Three certified copies of all mill test reports and results of nondestructive weld tests for the structural steel furnished shall be supplied to the Owner.

6.27 SPECIAL TOOLS AND SPARE PARTS

a. The technical representative shall furnish all special installation test instruments and tools as required in paragraph 2.0,j.

b. The Vendor shall furnish one complete set of special tools, new and in first-class condition, which will be required for maintenance of the equipment covered by this Specification. Identification of all tools by name and number shall be provided, and this number shall appear on the drawings and in the instructions to indicate the application of the tools furnished and to permit ordering replacements.

c. The Vendor shall supply, with his proposal, pricing for 1 and 5 year supplies of spare parts.

7.0 <u>DESIGN REQUIREMENTS</u>

7.1 Turbine Cycle Design Requirements (Guarantee):

7.1.1 Steam Conditions:

a.	Initial pressure	kPa (psia)	12,410	(<u>1,800</u>)
b.	Initial temperature	^{o}C (^{o}F)	510	(<u>950</u>)

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c.	Reheat temperature	°C (°F)	510	(950)
d.	Exhaust pressure	kPa (inHg abs)	11.85	(3.5)
e.	Main steam flow	tonnes/hr (lb/hr)	1,312	(2,893,000)
f.	Makeup to condenser	% @ 21.1°C (70°F)		(3)
g.	Final feedwater temperature	°C (°F)	238.5	(461.3)

h. Extraction steam piping pressure drop will be 3% of the stage pressure.

i. Reheat pressure drop from HP turbine exhaust to reheat turbine inlet will be 350 kPa, 51 psi.

7.1.2 The guaranteed turbine generator output shall be based on the above conditions of service.

7.1.3 The feedwater cycle arrangement shall be as follows:

a. Four low-pressure heaters with 5.6°C (10°F) drain coolers and 2.8°C (5°F) terminal temperature difference.

b. One deaerator with a 0°C (0°F) terminal temperature difference.

c. Two high-pressure heaters with 5.6°C (10°F) drain coolers and 0°C (0°F) terminal temperature difference.

7.1.4 Duty cycle design basis

The turbine generator is expected to operate as a base load unit. The unit shall be designed to facilitate future operation in a cycling mode with daily and weekly shutdown.

7.1.5 Turbine accessories:

a. Protective valve system, consisting of:

(1) Main stop valves.

(2) Control valves.

(3) Combined intermediate valves, or reheat stop valves and intercept valves.

(4) Internal bypass or pilot valve in main stop valves, remotely positioned for warming.

(5) Protective screens for main stop valves and reheat intercept valves, with fine mesh startup screens.

(6) Means of remotely testing stop, control, reheat, and intercept valves during operation.

(7) Supports or hangers or both for above valves.

b. Piping consisting of:

(1) Steam piping from stop/control valve assembly to high-pressure turbine.

(2) Steam piping from reheat stop/intercept valves to low-pressure turbine inlets.

(3) Gland steam supply and return piping, complete.

(4) Lube oil supply and return piping, complete. (See paragraph 7.1, 4., c.)

(5) Generator, stator, and exciter gas or liquid cooling piping or both, complete.

(6) High-pressure hydraulic control oil piping, complete.

(7) Generator seal oil piping, complete.

(8) Turbine exhaust hood spray piping complete with control valves.

(9) Supports and hangers as required for piping in subparagraph b., (1) thru (8).

c. Lubricating oil system, complete with oil reservoir, including:

(1) Float-type indicating oil gage having high and low level switches.

(2) Top-mounted relief and access doors.

(3) Oil piping, all external bearing feed and return lines. Oil lines in all areas shall be guarded. Design of oil piping shall comply with ASME Standard 116.

(4) Shaft-driven, centrifugal, main oil pump.

(5) Ac motor-driven, centrifugal, auxiliary oil pump.

(6) Ac motor-driven, centrifugal, turning gear oil pump.

(7) Dc motor-driven, centrifugal, emergency bearing oil pump with motor starter suitable for 125 volts dc.

(8) Two full-size oil coolers, with tubes of suitable material for treated, cooling water at ^{o}F maximum, psig with the following chemical characteristics:

(a)	pH		8.9 - 9.2
(b)	TDS	ppm	25
(c)	DO	ppm	.1
(d)	Source		Closed Circuit Cooling Water System

(9) Ac motor-driven vapor extractor.

(10) Oil strainers located at each pump suction and at oil return to reservoir.

(11) Pressure switches, complete with hand test valves for test and automatic operation of auxiliary turning gear and emergency bearing oil pumps.

(12) Mesh-type, lube-oil mist eliminator to be mounted by the Owner.

(13) High-pressure bearing lift system, if required, motors, and controls.

(14) Electric oil heaters, with thermostatic controls, rated 380 volt, 3 phase, 50 hertz ac, with sufficient wattage to maintain the oil at the required minimum operating temperature with the unit inoperative and the building ambient at 4.4^{o}C (40^{o}F).

d. Electro-hydraulic control system, complete, consisting of:

(1) Electric control circuits, including:

(a) Speed control unit.

(b) Load control unit and power-load unbalance control unit.

(c) Valve positioning units for:

1 Main stop valves.

2 Control valves, including load limit, stage pressure feedback, and protection against a decrease in initial pressure. Control valves shall be sufficiently responsive to permit rapid or instantaneous generator electrical load rejection without excessive overspeed or trip.

3 Combined intermediate (reheat stop and intercept) valves.

(d) Constant voltage dc power supplies with shaft-mounted permanent magnet generator in turbine front standard.

(e) Logic circuits for turbine protection and operation.

(f) Testing circuits for turbine steam valves.

(g) Speed-matching of turbine-generator unit-to-line frequency. (Synchronizing equipment for closing the main circuit breaker will be supplied by others.)

(h) Interface provisions for the Owner's load control, and/or load frequency control, computer control.

(2) Valve operating devices, including:

(a) Servo valves using high-pressure, fire-resistant fluid.

(b) Feedback transducers for valve positioning and indicating circuits.

(c) Solenoid test valves for steam inlet valves.

(3) Emergency trip devices, including:

(a) Mechanical overspeed trip with provisions for testing under load.

(b) Vacuum trip (electrical) with provision for remote reset at the console.

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(c) Local manual trip lever.

(d) Logic circuits for the emergency trip system.

(4) High-pressure hydraulic system for use with fire-resistant fluid, including the following:

(a) Reservoir with access doors and a float-type indicating gage for hydraulic fluid level having high and low level switches.

(b) Stainless steel piping or tubing or both from reservoir to turbine and to steam valve hydraulic actuators.

(c) Two full-size, ac motor-driven pumps, one pump to serve as a backup.

(d) Fluid accumulators.

(e) Two full-size hydraulic fluid coolers, suitable for 38.3°C (101°F) maximum, 861.8 kPa (125 psig) condensate-quality cooling water, and transfer valve.

(f) Filtering equipment, including transfer and filtering unit.

(g) Fluid strainers or filters located at pump inlet and discharge.

(h) Pressure switches, complete with hand test valves, for test and automatic operation of fluid pumps.

(i) Electric oil heaters with thermstatic control, rated 380 volt, 3 phase, 50 hertz ac, with sufficient wattage to maintain the fluid at the required minimum operating temperature with the unit inoperative and the buildings ambient at 4.4°C (40°F).

(5) Freestanding vertical control cabinet which may be located remotely from the turbine and which includes the solid-state control system, power supplies, and other required auxiliary equipment. All field run control wiring shall terminate in this cabinet.

(6) Operating panel, for mounting in the Owner's control board, including the following:

(a) Speed selector.

(b) Startup rate selector.

(c) Synchronizing speed vernier and load selector.

(d) Load limit control with position indicator.

(e) Controls for initial pressure decrease protection.

(f) Valve test station with valve position indicators.

(g) Speed indicator.

(h) Load indicator.

(i) Reheat (or intermediate) pressure indicator.

(j) Initial pressure indicator.

(k) Condenser vacuum indicating lights for "vacuum low" and "vacuum normal".

(l) Electric indicating gage for "hydraulic fluid pressure".

(m) Trip and reset button for emergency trip system and indicating lights.

(n) Test station for testing overspeed trip at load and indicating lights.

(o) Vacuum trip indicating lights for "tripped" and "reset".

(p) Master trip indicating lights for "tripped" and "reset".

(q) Continuous vacuum trip monitor and alarm relay.

(r) Electrical malfunction indicating light.

(s) Load rate selector, load selector control, and load set meter, when applicable.

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(t) Pushbutton for load control computer control or frequency control selection or both.

(u) Controls for turbine warming.

(v) Necessary interconnecting cables from control cabinet to control panel, with plug connectors; approximate length, 30.5m (100 ft).

(w) Pushbuttons for electro-hydraulic control (EHC) automatic or manual speed/load control.

e. Steam seal equipment, including automatic regulating system with valves, steam packing condenser with two full-capacity, motor-driven blowers, steam seal piping from turbine to steam seal regulating valves and to steam packing condenser, and motor-operated shutoff and bypass valves. The condenser shall be designed for cooling by condensate at approximately 2650 kPa (385 psig).

f. Thermostatically controlled or load-controlled turbine exhaust water spray system, using condensate at (later) psig minimum.

g. Motor-operated turning gear with low-speed sensing device and solenoid for local or remote engagement, interlocked with lubrication system to prevent operation without bearing lubrication.

h. Protective devices consisting of the following:

(1) Hydraulic thrust bearing wear detector.

(2) Atmospheric relief diaphragm(s) for turbine exhaust hood.

(3) Exhaust hood alarm and trip thermostats with two sets of contacts, one thermostat per exhaust connection.

(4) Air relay type dump-valve for operating the Owner's air-operated nonreturn valves in extraction lines.

(5) Two low lube oil pressure switches for alarm or trip.

(6) Safety and relief valves as required to protect equipment in the Vendor's supply lines.

(7) Motor-operated vacuum breaker.

i. Instrumentation:

All gages and instruments necessary for startup and operation of the unit in accordance with the following:

(1) Chromel-constantan thermocouples on shells, exhaust hoods, and valve casings.

(2) Two chromel-constantan thermocouples in each front and rear thrust-bearing plate.

(3) One dual element chromel-constantan thermocouple embedded in each main bearing.

(4) Chromel-constantan thermocouples in all main-bearing drains, thrust bearing drains, oil inlet and outlet of oil coolers, EHC fluid coolers, and HP/LP cross-over steam leads.

(5) Thermometers in all main-bearing drains, thrust bearing drains, oil inlet and outlet of oil coolers, and oil feed to bearings at front standard.

(6) Thermometers in exhaust hoods.

(7) Oil gages (mounted on unit) for indication of main oil pump suction, bearing-header, main oil pump discharge, and hydrogen seal oil pressures.

(8) Oil gages (mounted on oil tank) for indication of bearing oil header, main oil pump discharge, booster nozzles, and booster oil pump discharge pressures.

(9) All pressure gages shall be 115 mm (4-1/2 inches) in diameter, complete with pulsation snubbers.

(10) Direct reading, 115 mm (4 1/2 inch) gages for exhaust hood water spray and gland exhauster vacuum.

(11) Indicating transmitter for steam seal and steam chest pressures with an output of 4-20 mA.

(12) Pressure transducers for initial, first stage, and reheat steam pressures for use with the EHC control system.

j. Supervisory Instruments:

(1) Sensing devices, amplifiers, and recorders (for mounting on the Owner's control board) for the following:

(a) Shaft eccentricity.

(b) Speed and valve position.

(c) Shaft vibration.

(d) Shell differential and rotor expansion.

(e) Turbine metal temperature.

Note: Items (a) thru (d) above shall be complete with isolated dc signals for use as input to the Owner's digital computer.

(2) Vibration phase angle meter and selector switch for mounting in the Owner's control board. Shaft-mounted reference detector and required supervisory circuitry shall be included.

k. Test Connections:

Turbine shall be equipped with necessary pressure test connections, piped out to convenient points in the lagging, with shutoff valves, for the Owner to perform an ASME turbine test. Connections shall include basket-type turbine exhaust pressure taps.

l. Grounding pad on exhaust hood or bearing standard or both, and shaft grounding device.

m. Turbine metal appearance lagging where applicable for protection of certain turbine components. Sound deadening material shall be applied to all inside surfaces.

n. Heat retention material in accordance with manufacturer's specifications, consisting of the following:

(1) Plastic insulating cement, block or sprayed insulation for upper and lower turbine shells, steam valve bodies, and exhaust casings, where required.

(2) Preformed, segmental pipe insulation for main and reheat steam piping, crossover piping, steam seal piping, and all other steam piping furnished by the vendor.

(3) Removable stainless steel covers filled with block or plastic or both, heat retention material for main stop valves, reheat stop valves, intercept valves, flanges at turbine shells, and flanges in crossover pipes, where required.

(4) Reusable blankets for those horizontal and vertical joints which must be parted for turbine maintenance.

o. Lifting slings, bolt heaters, and special tools and wrenches, as required by turbine design for installation and maintenance. Lifting drawings are also required.

p. Foundation plates, shims, and subsole plates, where required.

q. Drains:

Suitable means shall be provided for draining condensate from the turbine casing. This may be accomplished either by internal openings through the diaphragms or by external drain connections. External drain valves which must be opened during turbine startup shall be pneumatically or motor operated. Drains shall be in accordance with recommendations in ASME TDP-1.

7.2 GENERATOR AND EXCITER DESIGN REQUIREMENTS:

7.2.1 Generator Cooling System:

a. In order to maintain the generator temperature within operating range, the generator stator conductors shall be internally cooled with demineralized water, and the rotor core and field shall be cooled by circulating hydrogen through the generator casing. The stator conductor cooling equipment shall be complete in all respects and include pumps, reservoirs, closed make-up tanks, filters, coolers, gauges, indicators and alarms. A polishing purifier shall be provided in the water circuit to maintain the water in a satisfactory condition. Duplicate full capacity a-c motor driven pumps shall be provided to circulate the coolant, one to act as standby, and the pump motor control will include automatic changeover features. Failure of the cooling water flow to the stator windings shall be detected and shall be arranged to:

1. Start the standby pump

2. Initiate alarms, and

3. Trip the turbine-generator,

as necessary to prevent overheating of the windings. The flow failure equipment shall be arranged to incorporate redundance and trip condition verification features, and facilities for on-load testing of all devices. The generator coolers shall be designed for cooling water from the same system as used for the turbine oil coolers.

Note: As an alternative, a machine cooled by hydrogen only may be acceptable.

b. Complete hydrogen seal and control systems shall be furnished. Oil seal glands shall be provided at the generator shafts to prevent loss of gas and shall be designed so that the upper bearing caps may be removed for inspection without removing the hydrogen from the generator casings. The seal oil system shall include an emergency seal oil pump driven by a dc motor supplied with its dc starter. An ac seal oil pump and starter shall be provided for seal oil supply for turning gear operation. The seal oil systems shall be furnished complete, including automatic control of the seal oil to the shaft seals and all internal piping assemblies. The assemblies shall include a reservoir, vacuum tank, regulating valves, scavenging and filling facilities, purity monitoring, instruments and alarms, and any other equipment required for the system.

c. Hydrogen and stator winding liquid control cabinets shall be provided to control and monitor the operation of the systems. The cabinets shall contain, as a minimum, solid-state annunciators with retransmitting contacts suitable for 140 V dc, hydrogen purity indicator, hydrogen pressure indicator, conductivity recorder, electrical hydrogen pressure transmitter for remote indicator, and stator coolant temperature indicators.

d. Temperature elements shall be provided for the Owner's use to monitor temperature rise of each coil of the stator winding.

e. Resistance temperature detectors (RTD's) shall be provided for the Owner's use to monitor the stator slot, stator cooling system, and temperature rise of the hydrogen.

f. Rotor temperature monitoring system shall be provided.

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7.2.2 Excitation System:

a. The exciter shall be either a rotating alternator with solid-state rectifier or a static system with transformers and solid-state rectifier.

b. The voltage response ratio of the exciter as defined by IEEE 421A shall be at least 0.5.

c. The ceiling voltage as defined by IEEE 421A shall be at least 120 percent of rated voltage when operating with a load resistance equal to the generator field.

d. Shaft-mounted excitation equipment shall be totally enclosed and air cooled. Temperature detectors shall be provided for recording the temperature of air entering and leaving the enclosures.

e. All leads inside the exciter housing shall be terminated on terminal blocks in a common terminal housing accessible from the turbine generator operating floor.

f. The excitation cubicles shall be completely metal enclosed with hinged doors for easy accessibility.

g. The Vendor shall supply all devices necessary to protect the generator field excitation system from excessive thermal conditions.

h. The excitation system shall have at least the following features:

(1) Maximum excitation limiter and over-excitation protection.

(2) Minimum excitation limiter.

(3) Underexcited reactive ampere limit.

(4) Volts-per-hertz regulator function.

(5) Redundant volts-per-hertz relays.

(6) Reactive current compensator.

(7) Generator and exciter field ground relays.

(8) Manual voltage adjuster with automatic follower.

(9) Automatic voltage adjuster.

(10) Regulator buck-boost voltmeter.

(11) Voltage error indicators.

(12) Generator field voltage and amperage indicators with provisions for computer monitoring.

(13) Exciter field voltage and amperage indicators with provisions for computer monitoring.

(14) Field breaker.

(15) Field flashing equipment.

(16) Test facilities.

7.3 ACOUSTIC REQUIREMENTS

7.3.1 The Vendor shall submit as part of his Proposal a tabulation of octave band sound power levels in accordance with 7.3.3 below for the equipment being quoted without acoustic treatment or guarantee. The Proposal will be considered incomplete without this information.

7.3.2 The Vendor shall submit as part of his Proposal an additional price for a guaranteed maximum sound level of 90 dBA (90 decibels, A network weighted) when measured with a Type I precision sound level meter at slow response and at a distance of 1 meter (3 feet) in any direction from the nearest surface of the equipment. The Vendor shall also submit with his Proposal a tabulation of octave band sound levels in accordance with 7.3.3 below for the equipment in the sound attenuated condition.

7.3.3 The Vendor shall complete and submit as part of his Proposal the attached Acoustic Data Summary Sheet. It is preferred that the octave band levels be sound power levels in decibels with a reference power of 10 (exponent -12) watt. However, sound pressure levels in decibels with a reference pressure of 0.0002 microbars will be acceptable providing the weighting network and distance to the sound source are indicted. In the event acoustic data for similar equipment will be acceptable. However, the equipment differences should be indicated and the Vendor's estimate of the acoustical effect of these differences should be indicated.

7.3.4 The maximum sound power or sound pressure levels will be verified by measurements at the installation site at the Purchaser's discretion. The Purchaser's Engineer will perform these requested tests in accordance with standard test procedures as applicable to the particular installation or type of equipment.

7.3.5 Where no specific testing procedure is applicable, verification tests shall be conducted in accordance with the following:

7.3.5.1 Institute of Electrical and Electronics Engineers (IEEE) Standard 85, "IEEE Test Procedure for Airborne Sound Measurements on Rotating Machinery."

7.3.5.2 American National Standards Institute (ANSI) S1.2, "Method for the Physical Measurement of Sound."

8.0 PERFORMANCE REQUIREMENTS

The generator when installed and functioning shall meet or exceed the following requirements:

8.1 The generator shall be a three-phase, synchronous, direct driven machine with a kW rating matching the turbine rating at valves in wide open condition with rated pressure, temperature, and specified condenser vacuum, and rated as follows:

a.	Rating	kVA	487,059
b.	Power factor		.85
c.	Short circuit ratio		Not less than 0.58
d.	Rated voltage	volts	later
e.	Rated frequency	hertz	50

8.2 The generator shall operate continuously without detrimental heating at maximum kVA, rated power factor and frequency, and at any output voltage within a range of 5 percent above and below rated voltage.

8.3 The generator shall be capable of withstanding a three-phase short circuit at its terminals in accordance with ANSI C50.13, Section 6.

8.4 The deviation factor of the open-circuit terminal voltage wave of the generator shall not exceed 10 percent.

8.5 The balanced (line-to-line) telephone influence factor of the generator shall not exceed 40. The residual (open-delta) component telephone-influence factor shall not exceed 30.

8.6 The generator shall be capable of withstanding without injury, the effects of a continuous current unbalance corresponding to a negative phase sequence current of 8 percent, provided rated kVA is not exceeded, and the maximum current does not exceed

105 percent of rating in any phase. The rotor short-term capability for withstanding unbalanced fault currents shall be in accordance with ANSI C57.13.

8.7 The generator shall be wye connected and shall be suitable for operation with the neutral ungrounded or grounded through a distribution transformer and secondary resistor.

8.8 Both ends of each winding shall be brought out to phase segregated porcelain bushings with terminals. Line side terminal arrangement and spacing shall be suitable for connection to the isolated phase bus. Generator neutral lead enclosure shall be provided complete with flexible connections, interphase connections, and provisions for connecting the neutral bus to the generator neutral grounding transformer through the Owner's bus duct.

8.9 Each line side terminal shall be provided with 2, 14,000 ampere secondary bushing current transformers. Each ground side terminal shall be provided with 3, 14,000 ampere secondary bushing current transformers. Current transformers shall be suitable for metering or relaying in accordance with ANSI C57.13. Metering current transformers shall be specially calibrated for future service in performance tests on the turbine generator unit. These specially calibrated current transformers shall be identified with a tag. Certified test reports shall be provided for the metering current transformers, giving ratio correction factor and phase angle for the specified burdens.

8.10 Bearings shall be constructed so as to prevent circulation of damaging shaft current.

8.11 A shaft grounding brush shall be provided.

9.0 MATERIAL REQUIREMENTS

Except where otherwise specified herein, materials of construction shall be the Vendor's standard which has proven satisfactory in the past and meets applicable code requirements.

10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

The motors shall be fabricated and assembled in accordance with the following requirements:

a. The codes and standards stated in article 4.0.

b. The Vendor's QA/QC program.

11.0 INSTALLATION REQUIREMENTS

None

12.0 PERSONNEL REQUIREMENTS

The Vendor shall employ personnel qualified to perform the Work in accordance with the Vendor's QA/QC program.

13.0 INSPECTIONS AND TESTS

The following inspections and tests shall be performed:

13.1 The Owner shall have the right to make tests at his expense to demonstrate the ability of the equipment to operate under the conditions specified and to meet the guaranteed performance. These tests will be conducted in accordance with the latest applicable test code(s) in effect at the time of the test, with such modifications as may be agreed upon between the Owner and the Vendor. If the results of the tests conducted indicate that the equipment does not meet the guaranteed performance, the Vendor shall, at his expense, make all necessary adjustments or changes to improve the performance. All subsequent tests, until acceptance by the Owner, shall be made at the Vendor's expense.

13.2 In addition to the tests required to obtain the performance data, standard factory tests including at least the following shall be performed:

a. Mechanical inspection.

b. Rotor balance.

c. Rotor overspeed run.

d. Measurement of cold resistance of stator and rotor windings.

e. Winding insulation resistance measurement.

f. Dielectric tests:

(1) Stator - The standard test voltage shall be an alternating voltage whose effective value is 1000 volts plus twice the rated voltage of the generator. This test shall be applied for 60 seconds duration immediately prior to shipment of the generator stator.

(2) Rotor - The standard test voltage shall be an alternating voltage whose effective value will be ten times the field-rated excitation voltage, but not less than 1500 volts, nor more than 5500 volts. This test shall be applied for 60 seconds duration immediately prior to the shipment of the generator rotor.

g. Air leakage test on hydrogen cooled stator frame.

h. Resistance temperature detector test.

i. Water flow continuity for each armature channel.

14.0 CLEANING, CORROSION PROTECTION, AND COATING

14.1 CLEANING:

Parts shall be free from dirt, scale, and unwanted grease. The equipment shall be handled throughout production and packaging so that no foreign matter will be introduced into or onto the equipment and impair its mechanical or electrical operation.

14.2 CORROSION PROTECTION AND COATING:

Nonmachined metal surfaces shall be thoroughly chemically cleaned and treated for rust prevention. The painting procedure shall include the Vendor's standard prepaint treatment, primer, and finish coats of (later).

15.0 MARKING AND IDENTIFICATION

15.1 Each package, skid, box, and crate shall be marked on the outside with the following information so that it is readily visible:

a. (Owner's name)
(Project identification)
(Street address)
(City, state, and zip code)

b. The Owner's purchase order number.

c. Any special instructions for handling.

d. The weight and lifting points or center of gravity.

e. The Engineer assigned tag numbers(s) or Bill of Material numbers(s).

15.2 Items of equipment shall be supplied with punched metal tags, permanently affixed, giving the equipment item number and description. Identifying numbers shall be assigned by the Vendor, but may be reassigned at the option of the Owner or Engineer.

16.0 PACKAGING, SHIPPING, AND STORAGE

Equipment or piping that may have hydrostatically tested or that may be damaged by freezing shall be checked to ensure that all water has been drained from the unit prior to placing equipment in storage or on its foundation. After any equipment is in storage or on its foundation, temporary wood or steel plate covers shall be provided over flanges to prevent entrance of water into the unit, and the Vendor shall be responsible for any damge to unit, equipment, and associated piping until such time as it has been accepted by the Owner.

17.0 ACCEPTANCE CRITERIA

17.1 MANUFACTURING ERRORS:

Equipment and materials shall be complete in all respects within the limits herein specified. Manufacturing errors and omissions requiring correction in the field shall be corrected under the direction and at the expense of the Vendor. If the error requires shipment back to the factory, the disassembly, handling, shipping, and reassembly shall be at the Vendor's expense.

17.2 INSTALLATION INSTRUCTIONS:

a. The Vendor shall provide copies of an instruction book covering all equipment being furnished. The instruction book shall have hard front and back covers and have proper identification on the front cover of the contents. Instruction books shall be distributed prior to equipment being shipped.

b. Instruction books are not considered design manuals, and if any discrepancies arise between the Vendor's drawings and instruction books, or if items are omitted from the drawings which are contained in the instruction book recommendations, the Vendor shall amend the instruction books or shall modify the installation at his own expense, whichever is deemed by the Owner as giving the most proper and operative final installation.

ATTACHMENT 1

EQUIPMENT DATA

A. Turbine and Accessories

1. Bidder's Name ______________
2. Manufacturer's Name ______________
3. Quotation Number ______________
4. Physical description:
   a. Turbine type ______________
   b. Last stage blade length ______________
   c. Shaft speed rpm ______________
   d. Number of LP casings ______________
   e. Exhaust annulus area m^2 (ft^2) ______________
   f. Number of valve points ______________
   g. HP cylinder flow arrangement ______________
   h. Generator capacity kVA at .85 pf ______________
5. Guaranteed throttle flow point at 3% makeup:
   a. Throttle flow tonnes/hr (lb/hr) ______________
   b. Capacity kW ______________
   c. Heat rate kJ/kWh (Btu/kWh) ______________
   d. Exhaust Pressure kPa (inHgA) ______________
   e. Last stage flow tonnes/hr (lb/hr) ______________

6. Max. expected throttle flow at 3% makeup with top heater out of service:

   a. Throttle flow — tonnes/hr (lb/hr) ____________

   b. Capacity — kW ____________

   c. Heat rate — kJ/kWh (Btu/kWh) ____________

   d. Exhaust Pressure — kPa (inHgA) ____________

   e. Last stage flow — tonnes/hr (lb/hr) ____________

7. Expected capabilities at design vacuum and 3% makeup:

   a. Normal steam conditions, all heaters in service — kW ____________

   b. Normal steam conditions, top heater out — kW ____________

   c. Additional capability - zero air heating — kW ____________

   d. Maximum possible capability:

      (1) Normal pressure, top heater out, zero air heating — kW ____________

8. Design features:

   a. Type of rotors ____________

   b. Expansion provisions:

      (1) Axially ____________

      (2) Radially ____________

ATTACHMENT 1
(Continued)

c. High temp. nozzle construction ____________

d. Generator core steel ____________

e. Casings ____________

f. Nozzle material ____________

g. Blade material ____________

h. Diaphragm material ____________

i. Turbine seals:

(1) Interstage ____________

(2) Shaft ____________

j. Bearings:

(1) Journal ____________

(2) Thrust ____________

(3) Insulated ____________

9. Features and accessories included:

a. Main steam stop valve
_______ with:
(number)

(1) Solenoid trip for remote operation ____________

(2) Switches for remote indication of valve position ____________

(3) Switch for interlocks ____________

(4) Test station panel ____________

(5) Removable steam strainer ____________

(6) Temporary fine mesh startup screens ____________

ATTACHMENT 1
(Continued)

(7) Spring supports ____________

(8) Suitable for hydro test ____________

b. Reheat steam stop valves ________ (number) with:

(1) Switches for remote indication of valve position ____________

(2) Switch for interlocks ____________

(3) Test station panel ____________

(4) Spring supports ____________

(5) Suitable for hydro test ____________

c. Reheat intercept valves ________ (number) with:

(1) Switches for remote indication of valve position ____________

(2) Switch for interlocks ____________

(3) Test station panel ____________

(4) Remote steam strainers ____________

(5) Temporary fine mesh startup screens ____________

(6) Spring supports ____________

(7) Suitable for hydro test ____________

d. Overspeed governor with provision to test overspeed trip without tripping turbine ____________

e. Constant speed governor with provision for hand or motor operation range ____________

ATTACHMENT 1
(Continued)

f. Initial pressure regulator ____________

g. Load limit controller ____________

h. Startup panel ____________

i. Miscellaneous operating panel for drain valves, etc. ____________

j. Exhaust hood sprays ____________

k. Exhaust hood thermometer ____________

l. Exhaust hood thermostat ____________

m. Low vacuum trip device with alarm contacts and remote solenoid trip ____________

n. Exhaust relief diaphragms ____________

o. Main turbine:

   (1) Metal lagging ____________

   (2) Heat insulation ____________

   (3) Sound deadening material ____________

p. Soleplates ____________

q. Moisture removal technique ____________

r. Provision for full arc admission ____________

s. Vacuum breaker valves ____________

t. Welded condenser connection ____________

u. Turbine rotor grounding device ____________

10. Oil system:

a. Oil reservoir with sloping bottom, removable screens, oil level indicator, HI and LO level alarm switches ____________

ATTACHMENT 1
(Continued)

b. Main oil pump ____________

c. Oil driven booster pump ____________

d. Auxiliary oil pump ____________

e. Turbine gear oil pump ____________

f. Dc emergency bearing oil pump ____________

g. Dual oil coolers ____________

h. Vapor extractor ____________

i. Low bearing oil pressure alarm contact and trip ____________

j. Bearing metal thermocouples ____________

k. Bearing oil drain line thermometers and sight flow boxes ____________

l. Thermometers for oil cooler outlet ____________

m. Provision in oil drain lines for Owner's thermocouples ____________

n. Oil pressure gages ____________

o. Thrust bearing failure alarm device ____________

p. Air relay valve for extraction nonreturn valve operation ____________

q. All interconnected guarded oil piping ____________

r. Piping supports ____________

11. Gland steam seal system:

a. Steam seal regulator ____________

b. Gland steam condenser ____________

c. Motor driven vacuum pumps ____________

ATTACHMENT 1
(Continued)

d. Safety valves __________

e. Emergency blowdown valve __________

f. Pressure gages __________

g. Piping __________

h. Supports __________

12. Testing:

a. Tests:

(1) Balancing __________

(2) Overspeed __________

(3) Governor __________

(4) Generator __________

(5) Exciter __________

b. Instrument connections provided for full scale field heat rate test __________

c. Performance acceptance test recommendation __________

d. Rotor field test provisions __________

e. Valve testing facilities and load reduction __________

13. Motors and motor controls __________

14. Special tools __________

15. Slings for maintenance __________

16. Time required (weeks):

a. Foundation loadings __________

b. Outline drawings __________

ATTACHMENT 1
(Continued)

c. Oil tank drawings ____________

d. Oil and steam piping drawings ____________

e. Wiring diagrams ____________

17. Allowable operating condition variations:

a. Main steam pressure kPa (psi) ____________

b. Main and reheat steam temp. in excess of rated temp. ^{o}C (^{o}F) ____________

c. Main and reheat steam temp. difference ^{o}C (^{o}F) ____________

d. Reheat steam pressure kPa (psi) ____________

e. Removal of heaters from service ____________

f. 5% overpressure operation ____________

g. Generator stator temp. rise (by detector) ^{o}C (^{o}F) ____________

h. Generator field winding temp. rise (by resistance) ^{o}C (^{o}F) ____________

i. Cumulative life limits for reduced frequency operation ____________

18. Major dimensions:

a. Turbine-generators m (ft-in):

(1) Length ____________

(2) Width ____________

(3) Minimum center-to-center ____________

ATTACHMENT 1
(Continued)

(4) Dismantling height __________

(5) Generator rotor removal space (length) __________

(6) Minimum crane hook height, including rigging, from the operating floor __________

(7) Minimum distance required between basement and operating floor m (ft) __________

(8) Layout area required m^2 (ft^2) __________

b. Exciter length m (ft) __________

19. Equipment net weights (pounds):

a. HP turbine __________

b. LP turbine __________

c. HP casing __________

d. LP casing __________

e. Total __________

f. Oil reservoir and accessories __________

g. Heaviest piece for erection __________

h. Heaviest piece after erection __________

20. Design features:

a. Number; type; size of bearings, HP turbine __________

ATTACHMENT 1
(Continued)

b. Number; type; size of bearings, LP turbine ____________

c. Governor valve operating sequence ____________

d. Flange heating requirements ____________

e. Oil cooling - main unit:

   (1) Number of coolers ____________

   (2) Cooling water required at 95^oF l/s (gpm) ____________

   (3) Pressure drop kPa (inH_2O) ____________

f. Allowable forces and moments for piping connections ____________

g. WR^2 $kg\text{-}m^2$ ($lb\text{-}ft^2$):

   (1) HP ____________

   (2) LP ____________

h. Segregation required between boiler and turbine, other than turbine stop valves ____________

i. Instrumentation:

   (1) Suitable for computer performance calculation and control ____________

   (2) Turbine thermocouples ____________

   (3) Thermocouples for startup wiring to terminal blocks ____________

   (4) Speed and valve position recorder or cam shaft position ____________

ATTACHMENT 1
(Continued)

(5) Rotor eccentricity and vibration recorder ______

(6) Shell and differential expansion recorder ______

(7) Axial rotor position or thrust load recorder ______

(8) Temperature difference indicator ______

(9) Shaft or phase rotation indication for synchronization ______

j. Heat balance ______

k. Turbine performance curves ______

l. Generator performance curves ______

m. Heat rate curve ______

n. Back pressure correction curve ______

B. Generator and Accessories

1. Rating

a.	kVA		______
b.	Power factor		______
c.	kW		______
d.	Speed	rpm	______
e.	Phase		3
f.	Frequency	Hz	______
g.	Voltage	V	______
h.	Current	A	______
i.	Hydrogen pressure	kPa (psig)	______

ATTACHMENT 1
(Continued)

j.	Short circuit ratio		______
k.	Moment of inertia (Wk^2)	$kg\text{-}m^2$ ($lb\text{-}ft^2$)	______

2. Insulation Class

a.	Armature winding		______
b.	Armature connection		______
c.	Field winding		______

3. Temperature Rise

a.	Armature winding by detector)	^{o}C	______
b.	Field winding by resistance)	^{o}C	______

4. Dielectric Tests

a.	Armature winding	V ac	______
b.	Field winding	V dc	______

5. Calculated Data

a.	Synchronous direct (unsat.) reactance,* X_d	p.u.	______
b.	Transient direct (sat.) reactance,* X'_d	p.u.	______
c.	Subtransient direct (sat.) reactance,* X''_d	p.u.	______
d.	Negative sequence* sat. X_2	p.u.	______
e.	Zero sequence* sat. X_0	p.u.	______
f.	H constant	kW-sec/kVA	______

*p.u. reactance values @ rated kVA, voltage, and frequency.

g. 3-phase windings capacitance to ground — mf ____________

h. I_2^2t capability — % ____________

i. Open circuit time constant T_{CO} — sec ____________

6. Operating Data

a. Field amperes @ no load rated voltage — A ____________

b. Field amperes @ guaranteed load — A ____________

c. Temperature of inlet water to coolers (@ rated load and hydrogen pressure) — ^{o}C (^{o}F) ____________

d. Number of coolers for stator cooling ____________

e. Volume of cooling water required for stator cooling system @ 95^{o} — l/s (gpm) ____________

f. Pressure of cooling water required for stator cooling system — kPa (psi) ____________

g. Pressure drop in each stator cooler — kPa (ftH_2O) ____________

h. Number of coolers for hydrogen system ____________

i. Volume of cooling water required for hydrogen system — l/s (gpm) ____________

ATTACHMENT 1
(Continued)

j.	Pressure of cooling water required for hydrogen system	kPa (psig)	__________
k.	Pressure drop in each hydrogen cooler	kPa (ftH_2O)	__________
l.	Hydrogen consumption at rated hydrogen pressure	m^3/day (ft^3/day)	__________
m.	Hydrogen volume for scavenging CO_2	m^3 (ft^3)	__________
n.	CO_2 volume for scavenging air; hydrogen	m^3 (ft^3)	__________
o.	Generator capability with one cooler out of service (percent of rating @ safe temperature	%	__________
p.	Generator efficiency:		
	(1) At rated hydrogen pressure and rated load	%	__________
	(2) One atmosphere below maximum pressure	%	__________
	(3) Two atmospheres below maximum pressure	%	__________
q.	Is the generator capable of operating continuously at maximum rating without damage, with 5% armature voltage variation?		__________

ATTACHMENT 1
(Continued)

r.	Relay and meter current transformer quantity accuracy classification		______
7.	**Exciter**		
a.	Rated capacity	kW	______
b.	Rated voltage	V	______
c.	Rated current	A	______
d.	Speed	rpm	______
e.	Ceiling voltage	V	______
f.	Response ratio		______
8.	**Weights**		
a.	Rotor	kg (lb)	______
b.	Generator (total)	kg (lb)	______
c.	Exciter (total)	kg (lb)	______
d.	Stator (net shipping)	kg (lb)	______
e.	Exciter (shaft driven)	kg (lb)	______
9.	**Hydrogen Seal Oil System**		
a.	Hydrogen seal oil unit		______
b.	Main seal oil pump		______
c.	Emergency seal oil pump		______
d.	ac seal oil pump		______
e.	Vacuum pump		______
f.	Control panel		______

ATTACHMENT 1
(Continued)

g. No. of bottles of hydrogen ____________

h. No. of bottles of carbon dioxide ____________

10. Generator Coolant System

a. Demineralizers ____________

b. Heat exchangers ____________

c. Piping ____________

d. Supports ____________

e. Pumps ____________

1. No. ____________

2. Size, kPa (psig) TDH m (ft) ____________

f. Resin capacity kg (lb) ____________

g. Temperature limits ^{o}C (^{o}F) ____________

ATTACHMENT 2

SPECIFICATION EXCEPTIONS

(CLIENT)

(PROJECT NAME)

GILBERT/COMMONWEALTH TURBINE GENERATORS AND ACCESSORIES

The bidder certifies that the bid is complete and in absolute agreement with the requirements of this Specification, except as specifically stated below. (Use additional sheets if required.)

(BIDDER'NAME)

(MANUFACTURER'S NAME)

(QUOTATION NUMBER)

Attest:

(SIGNATURE)

ATTACHMENT 3

Refer to Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 4

Refer to Motor Data Sheets included in Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 5

ACOUSTIC DATA SUMMARY SHEET

TURBINE GENERATOR AND ACCESSORIES

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dBA at 1 meter (3 feet)
63	________	____________
125	________	____________
250	________	____________
500	________	____________
1000	________	____________
2000	________	____________
4000	________	____________
8000	________	____________

Kind of levels given, indicate which of the following:

Sound Power Levels re 10 (exp -12) watt	________	____________
Sound Pressure Levels re 2x10 (exp -4) microbars	________	____________

If sound pressure levels are given, indicate both of the following:

Weighting network use A, B, C, or Linear (None)	________	____________
Distance to sound source Feet or Meters	________	____________

Vendor Comments: ____

____

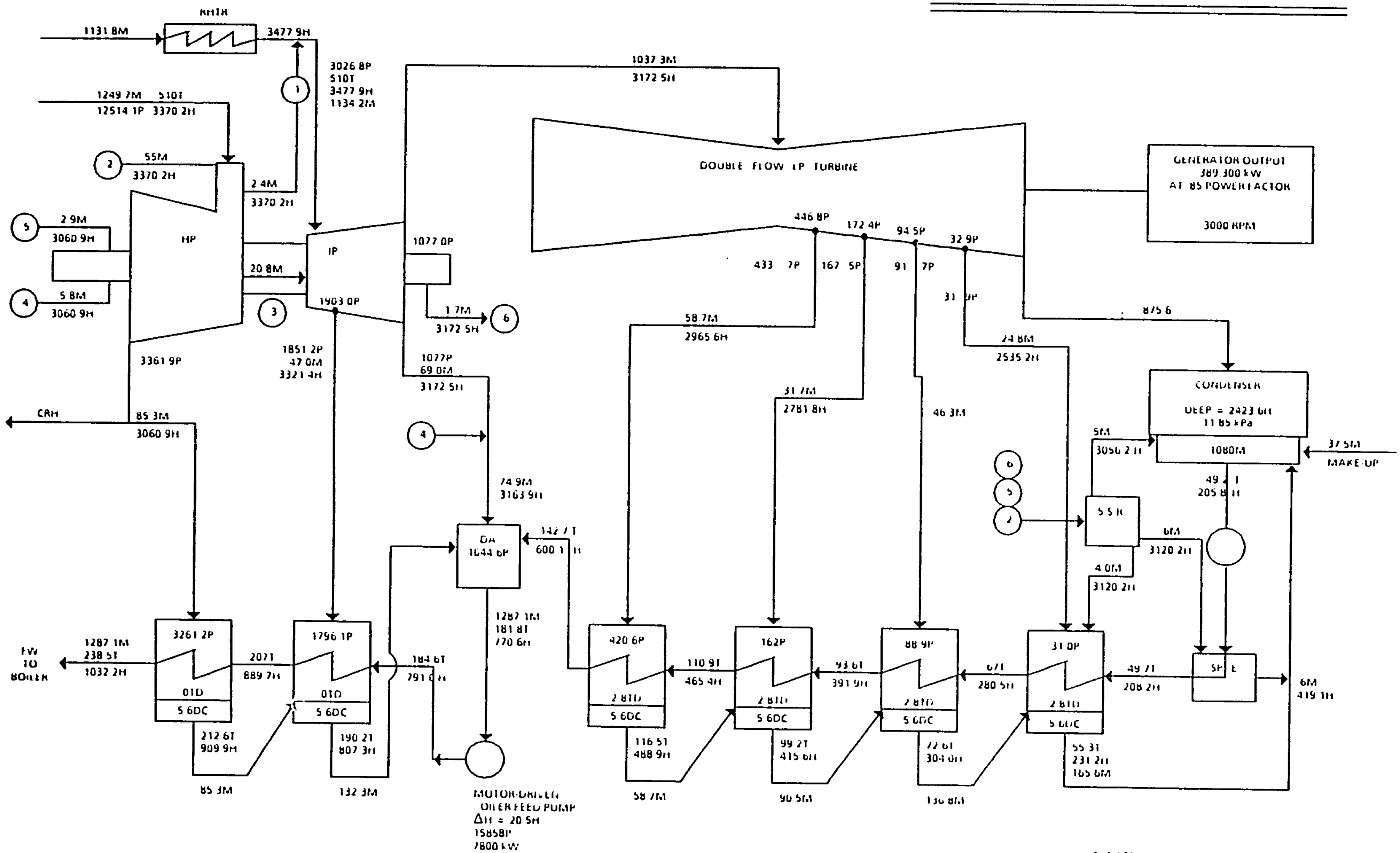
____

____

ATTACHMENT 6

HEAT BALANCES

GUARANTEED – 11.85 kPa, 3% MU, TC2F



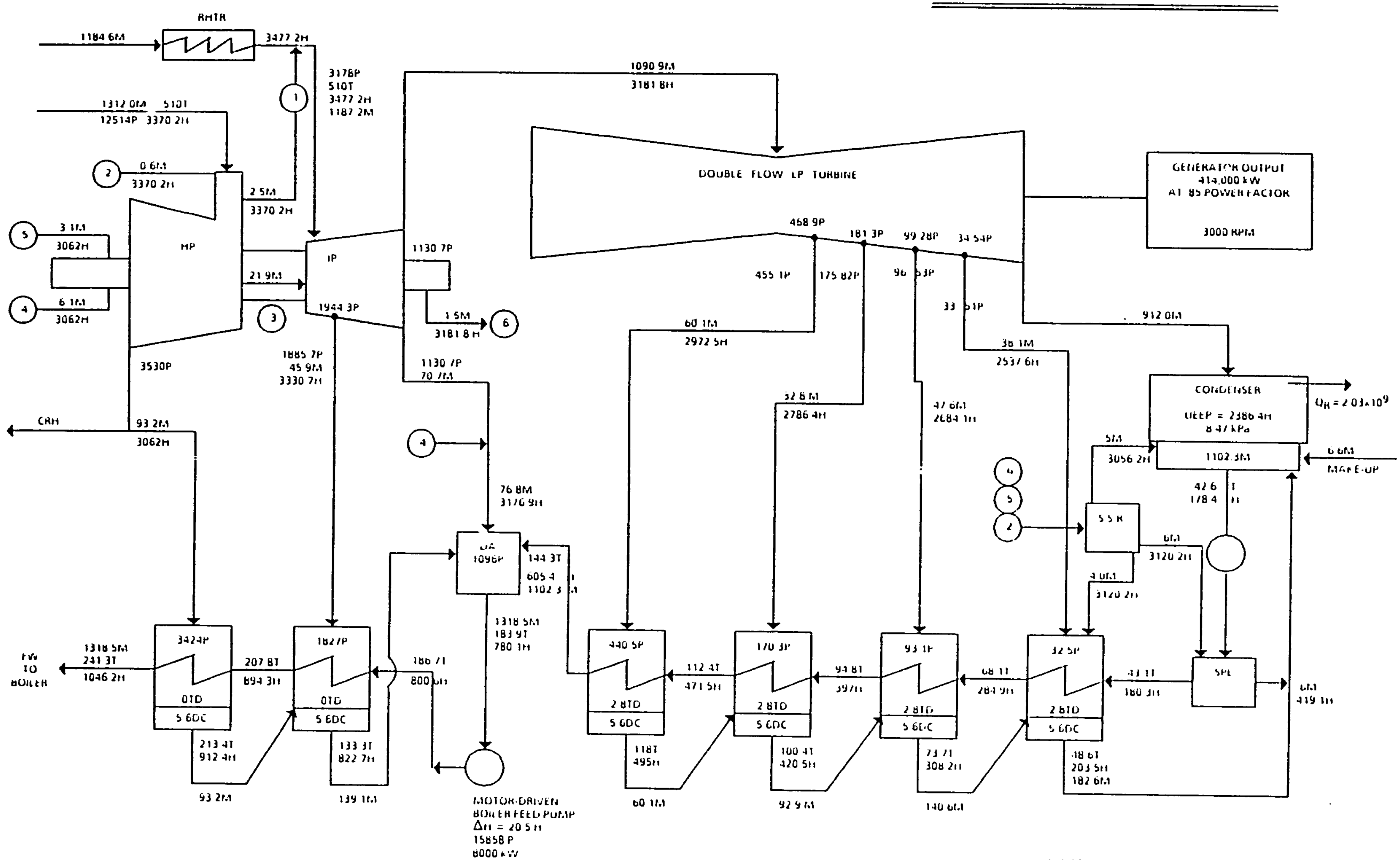
GROSS HEAT RATE = 8717 kj/kWh
(Heat Rate may vary depending on the T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – °C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-1

B1619-4/GF #72

VWO – NP – 8.47 kPa, 0.5% MU, TC2F



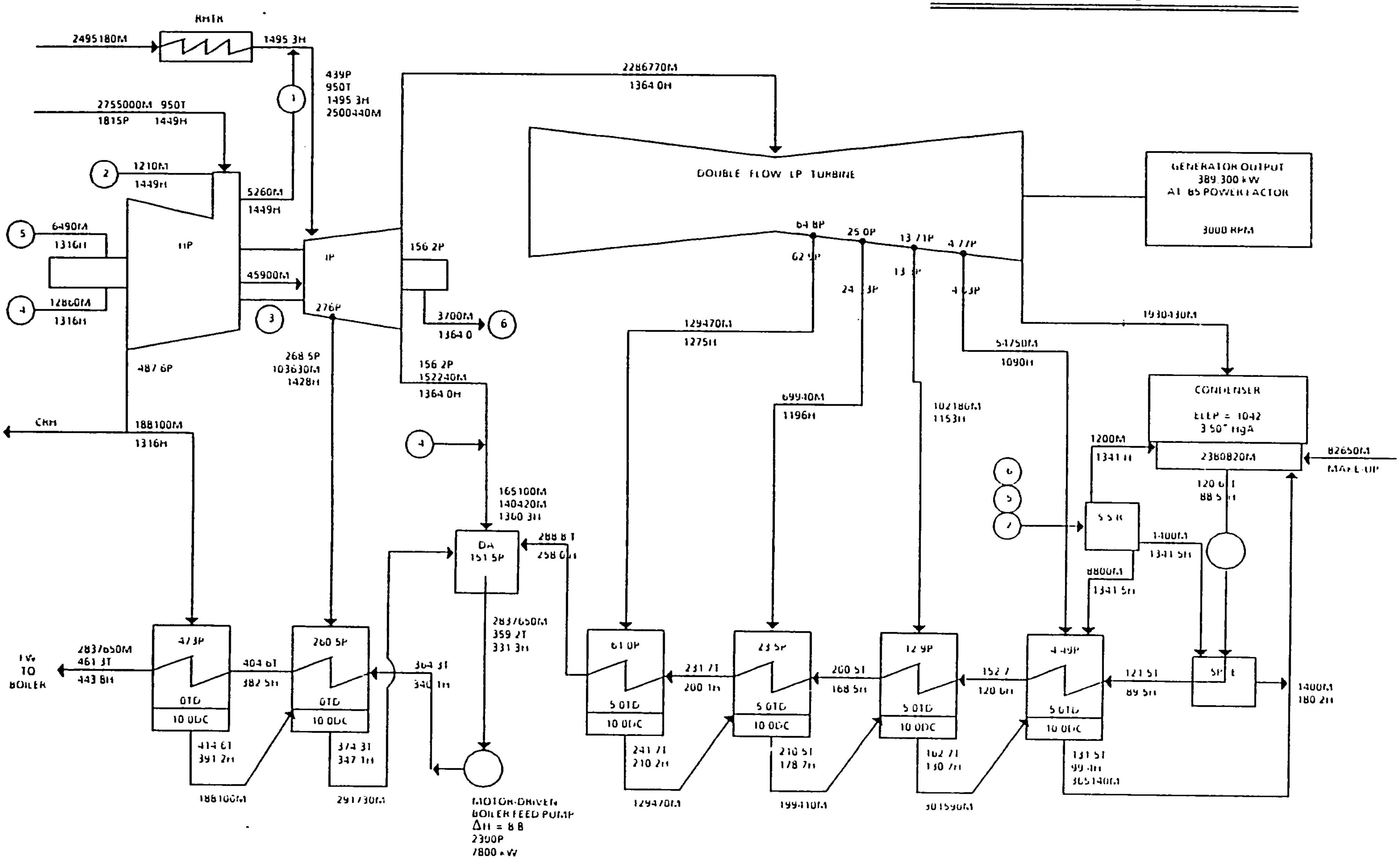
GROSS HEAT RATE = 8554 kj/kWh
(Heat Rate May Vary Depending on T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – °C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-2

B1619-2'GF#7

GUARANTEED – 3.5" HgA, 3% MU, TC2F



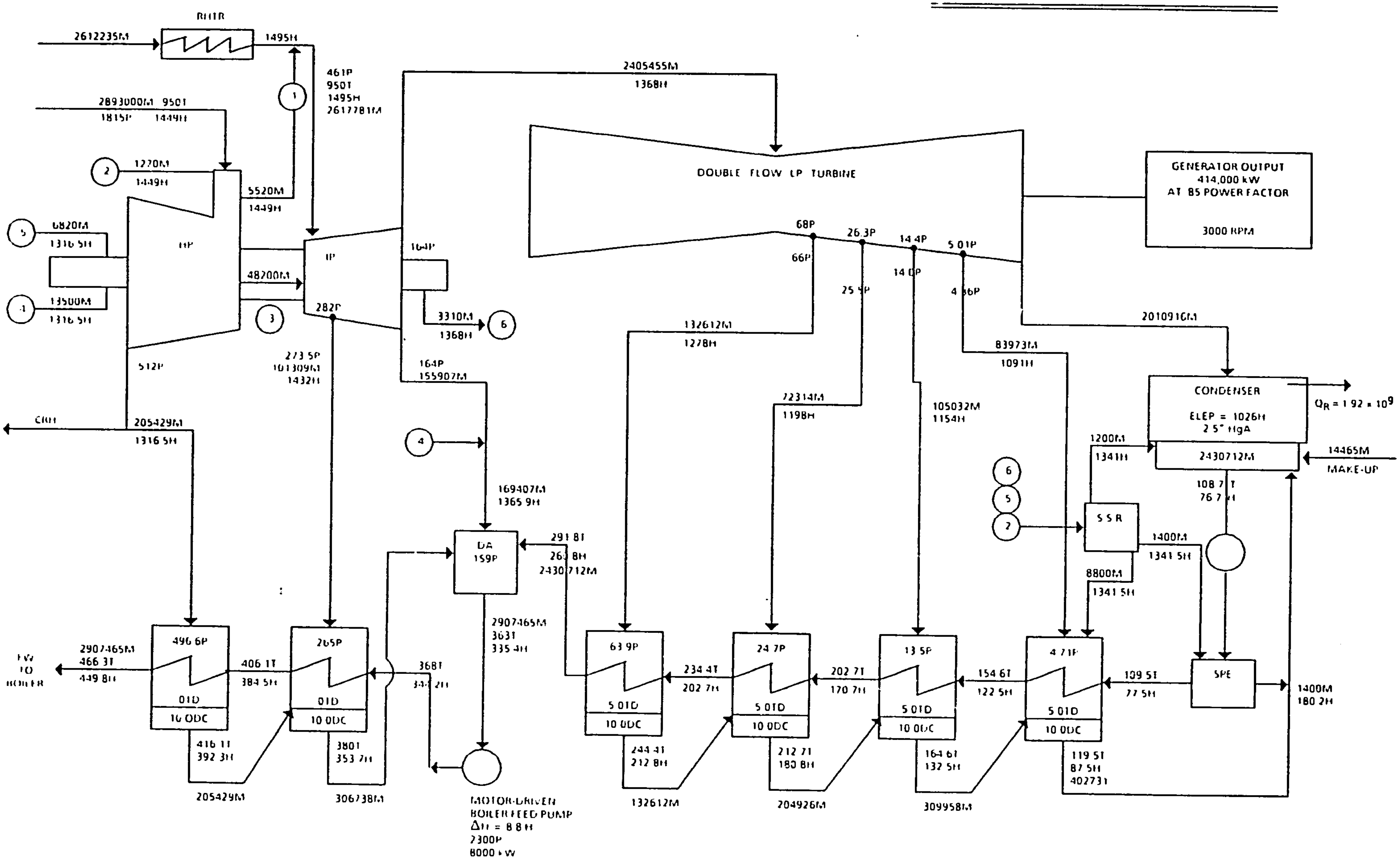
GROSS HEAT RATE = 8263 Btu/kWh
(Heat Rate may vary depending on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – °F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
ENGLISH UNITS
G/C II 11/12/85 HB-1

81619-3/GF#72

VWO – NP – 2.5" HgA, 0.5% MU, TC2F



GROSS HEAT RATE = 8108 Btu/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – °F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
ENGLISH UNITS
G/C II 11/12/85 HB-2

1619-1/GF#72

LAKHRA POWER FEASIBILITY STUDY

SPECIFICATION M-3

CONDENSER

SPECIFICATION M-3

CONDENSER

TABLE OF CONTENTS

SPECIFICATION M-3

CONDENSER

TABLE OF CONTENTS
(Continued)

ATTACHMENTS

LAKHRA POWER FEASIBILITY STUDY
TECHNICAL SPECIFICATION M-3

CONDENSER

1.0 DESCRIPTION OF WORK

The Work to be performed under this Contract shall include the design, furnishing of materials and components, fabrication, delivery to the jobsite, assistance during start-up and initial operation, and acceptance testing of the condenser in accordance with the requirements of this Specification. The condenser will be installed at two 350 MW power plants, for the Water and Power Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

The Work shall include at least the following for each unit:

a. One single-shell, single-pressure, two pass main condenser, oriented transverse to the main turbine shaft. Condenser shall be shop tubed.

b. Technical direction during condenser erection.

c. Two 100 percent capacity condenser vacuum pumps.

d. Rubber belt-type condenser neck expansion joints.

e. Supports for extraction steam piping and the feedwater heaters in the condenser neck.

3.0 WORK NOT INCLUDED

The following items are not included in the requirements of this Section, but will be accomplished by others:

a. Anchor and foundation bolts.

b. Field-erection labor.

c. Neck-mounted feedwater heaters.

d. All electrical wiring.

e. Condensate pumps.

f. Extraction steam piping and expansion joints for piping located in the condenser neck.

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g. Condenser tubes as specified in Paragraph 7.2,h.

h. Stainless steel lagging on heaters and extraction piping.

4.0 APPLICABLE CODES, STANDARDS, AND REGULATORY REQUIREMENTS

Design, materials, manufacture, installation, examination, testing, inspection, and documentation shall conform to the applicable portion of the following specifications, codes, and standards, including case rulings, interpretations, and addenda as applicable and in force at the time of issue of this Specification:

a. American Society for Testing and Materials (ASTM) standards.

b. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code:

  a. Section VIII, "Pressure Vessels, Division 1."

  b. Section IX, "Welding and Brazing Qualifications."

c. American Water Works Association (AWWA), C207-54T, "Flanges."

d. Heat Exchange Institute (HEI), "Steam Surface Condensers," (except that Paragraphs 6.2.2 up to and including 6.2.6 of the standard shall not apply to this Specification).

5.0 SUPPLEMENTAL DATA

The documents listed on the contents page as attachments are applicable to the Work, to the extent specified herein.

6.0 VENDOR DATA

6.1 Vendor data shall be furnished in accordance with the requirements indicated on the attached Vendor Data Requirements and Submittal Schedule (later).

6.2 Vendor shall furnish Certified Vendor Drawings, including a list of drawings by category, such as general arrangement, foundation data, and electrical connection. If titles of the Certified Vendor Drawings are unknown, bidder shall submit the estimated number of drawings he will submit in each category.

6.3 The following items are requested to be furnished by the Vendor. Data which are representative rather than exact shall be identified as such:

a. Completion and return of the attached Equipment Data Forms, Motor Data Form, Acoustic Data Summary Sheet, and Specification Exception Sheet.

b. General arrangement and outline drawings of the main condenser and mechanical vacuum pumps, showing all major dimensions and special foundation or support requirements.

c. Description of steam, condensate, and airflow through the condenser.

d. Curves which are clearly marked as to design point for the following:

1. Main condensers:

(a) Absolute condenser pressure versus duty kJ/hr (Btu/hr) for various inlet water temperatures for all condenser shells.

(b) Absolute condenser pressure versus circulating water inlet temperature for 0 to 110 percent of design duty kJ/hr (Btu/hr) for each shell. These curves shall be for 34^{o}C (93^{o}F) inlet water temperature.

(c) Oxygen content at hotwell pump discharge versus load.

2. Mechanical vacuum pump:

(a) Hogging time.

(b) Actual m^3/s (acfm) and Std. m^3/s (scfm) of dry air versus condenser absolute pressure.

(c) Brake horsepower versus condenser absolute pressure.

e. Description of all materials using ASTM designations.

f. Complete tabulation of size, type, and linear meters (feet) of field welding required to assemble condensers.

g. A complete description, including drawings or sketches, of the proposed method for handling high velocity fluids, specifically defining any limitations.

h. Maximum permitted forces and moments on bidder's external piping connections.

i. Proposed method of shipment including drawings.

j. Procedure for protection of shop installed tubes.

k. Any deviations from this Specification.

l. Complete description including sketches or drawings or both of the proposed method of handling main condenser air removal.

m. Field erection procedures, with drawings, showing erection sequence.

n. Days required after award of contract to submit drawings for approval.

o. Time required for delivery after drawing approval.

p. Cutoff date beyond which no more revisions can be made on the equipment specified.

q. Shop loading curve for time period applicable to the equipment specified.

r. Estimated manhours required for erection of the main condenser.

s. Bidder's proposed method of detecting leaks from each main condenser shell circulating water circuit.

t. Execution of the Specifications Exceptions form, attached hereto.

u. A detailed description of the field erection procedures, including an outline drawing showing how the shell is to be split for shipment and approximate weights of each segment.

v. DELIVERY DATES

The Vendor shall meet the following delivery requirements:

1. Drawings (sometimes called "approved for layout" or AFL) to be furnished by Vendor, showing outlines and overall dimensions and weights, suitable for use by Engineer in developing plant layouts: complete submittal by (later) .

2. Vendor Drawings (sometimes called "certified for construction" or CFC) and other technical information as called for in article 6.6: first submittals by (later) : complete drawings and information by (later) .

3. Resubmittals, by Vendor, of drawings, procedures, or similar items which are returned by the Engineer or QA Organization with a status other than "approved": 6 weeks after return by the Engineer or QA Organization.

4. First item of equipment: (later) .

5. Final item of equipment: (later) .

NOTE: Where actual required delivery dates, as agreed to by Owner and Vendor, appear on the Purchase Order or Purchase Order Supplement, they will amend the above dates. This Specification will not be amended to reflect changes in delivery dates.

w. INSTRUCTION BOOKS

1. The Vendor shall provide (No.) copies of an instruction book covering all equipment being furnished. The instruction book shall have hard front and back covers and have proper identification of the front cover as to contents. Instruction books shall be distributed prior to equipment being shipped.

2. Instruction books are not considered design manuals, and if any discrepancies arise between the Vendor's drawings and instruction books, or items omitted from the drawings which are contained in the instruction book recommendations, the Vendor shall amend the instruction books or shall modify the installation at his own expense, whichever is deemed by the Owner as providing the most proper and operative final installation.

6.4 QA/QC REQUIREMENTS

Description of quality control exercised during manufacture and list of all nondestructive tests, inspections, and factory tests shall be provided.

6.5 PERFORMANCE TEST REPORTS AND CERTIFICATIONS

The following performance reports and certifications shall be submitted to the Owner prior to acceptance of the Work:

a. Two copies of alignment data sheets for rotating equipment shall be prepared and submitted to the Engineer.

b. Rotating equipment shall be lubricated and lubrication sheets shall be prepared, issued currently, and certified by both the Vendor and Engineer.

c. Certified copies of all shop test data shall be forwarded to the Engineer for later distribution to the Owner.

d. The Vendor shall furnish procedures and instructions for all field installation and all required startup tests and instruction books for the equipment being furnished.

6.6 MATERIAL TEST REPORTS AND CERTIFICATIONS

Three certified copies of all mill test reports and results of nondestructive weld tests for the structural steel furnished will be supplied to the Owner.

6.7 SPECIAL TOOLS AND SPARE PARTS

a. Special Tools:

1. A qualified technical representative shall be provided, during installation and startup of the equipment, and will furnish all special installation test instruments and tools.

2. The Vendor shall furnish one complete set of all special tools, all in first class condition, which will be required for maintenance of the equipment covered by this Specification. Identification of all tools by name and number shall be provided, and this number shall appear on drawings and instructions to indicate the application of the tools furnished and to permit the ordering replacement.

b. Spare Parts:

Instruction books supplied by the Vendor for equipment being furnished shall include a listing of recommended spare parts.

c. The Vendor shall supply, with his proposal, pricing for 1 and 5 year supplies of spare parts.

7.0 DESIGN REQUIREMENTS

7.1 ARRANGEMENT

a. The main condenser shall be of the two pass, single shell, transverse type with a vertically divided circulating water circuit.

b. The condenser shall be designed to receive and internally distribute the following flows in addition to the main turbine exhaust flow:

1. Turbine bypass steam flow.

2. Heater drips and drains.

3. Condensate pump recirculation flow.

4. Makeup waterflow.

5. Miscellaneous drips and drains.

c. Tubes shall be sloped for drainage toward the inlet water-box.

7.2 COMPONENT CHARACTERISTICS

a. Condenser Shell(s):

1. Suitable means shall be incorporated in the design to provide for the difference in expansion between the shell and tubes, including continuous operation of the main condenser with one circulating water circuit out of service.

2. The main condenser shall be designed to fit within the space indicated on the attached "Condenser and Turbine Foundation Clearance Study" layout sketches.

3. The condensers shall be shop assembled, aligned, and matchmarked and shall have assembly clips installed prior to shipment.

4. All temporary and shipping bracing shall be painted a distinctive color. Any additional structural bracing or equipment or both required for shipping, handling, and erecting the condenser sections into place shall be provided by the Vendor.

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b. Extension Necks and Expansion Joints:

1. Extension necks shall be provided to connect each condenser shell to the turbine exhaust(s). The connections to the turbine exhausts shall be welded.

2. A rubber-belt expansion joint shall be provided in each extension neck, and shall be arranged for installation from the inside. Each joint shall be complete with stainless external water seal, supply, and overflow connections, and an internal impingement cover.

3. The extension necks shall be suitably braced, with provision for the installation and support of extraction piping and feedwater heaters, as specified elsewhere in this Specification.

4. Two 750 mm (30-inch) manholes with davits shall be provided in each main condenser neck for removal and installation of the expansion joint. Grab bars shall be provided, both inside and outside of the necks for access to the manways.

5. Areas of highest velocity and steam flow shall be clear of any internal piping and bracing.

c. Hotwells:

1. The hotwell(s) shall be of the reheating and deaerating type and shall contain coarse strainers and anti-vortex devices for condensate outlets.

2. The hotwell(s) shall provide 3 minutes of active storage, at design conditions, from normal water level to minimum water level in the hotwell(s).

3. A manhole of at least 500 mm (20 inches) diameter, quick opening type, shall be provided for hotwell access. Manholes shall be located in the hotwell(s) so that all compartments may be inspected. Grab bars shall be provided inside and outside of the hotwell to provide access to the manway.

4. Sampling connections shall be arranged to detect leaks in each condenser shell from each circulating water circuit associated therewith. Sample openings shall be located to minimize plugging due to accumulation of debris.

5. Provisions shall be made in the highest pressure condenser's hotwell for reheating condensate from the lower pressure shells to saturation temperature.

d. Waterboxes:

1. Waterboxes shall be fabricated from carbon steel, ASME SA516.

2. Waterboxes shall be bolted and gasketed to permit removal for possible retubing of the condenser.

3. Waterboxes shall be designed for a working pressure range of full vacuum to 620 kPa (90 psig).

4. Each waterbox shall be provided with at least two 600 mm (24-inch) quick opening, hinged manways. Final positioning of the manway will be subject to approval by the Engineer. Grab bars shall be provided both inside and outside of the waterbox to provide access to the manway.

5. Sectional removable platforms shall be provided for access to any area of the tube sheet which has a vertical dimension of more than 2 meters (6'-0") from the permanent safety grating or standing surface to the top tube. The platforms shall be designed to be inserted through the manholes and erected by two men. Platform quantity and location shall be such as to provide easy access to every tube. All permanent support lugs shall be provided for platform attachment. Platforms shall be provided for one set of inlet and outlet boxes for each condenser type or size. Platforms shall be fabricated from 60 mm (2 1/4 inch), Type C aluminum grating material. Safety handrails and ladders shall be provided, as approved by the Engineer.

6. Permanent safety gratings shall be provided at the bottom of any waterbox having a bottom inlet or outlet circulating water connection.

7. Lifting lugs shall be provided on each waterbox. Each lifting lug shall be designed to carry the total weight.

8. Circulating water inlet and outlet connections shall be provided with flanges, meeting the requirements of AWWA Specification C207.

e. Extraction Piping:

1. Connections shall be provided in the condenser shell to permit connection of internal and external extraction steam piping from the turbine extraction connections to externally located feedwater heaters.

2. Supports shall be provided for the Owner's extraction piping inside the condenser neck.

f. Feedwater Heater Mounting:

1. Low Pressure Heaters No. 1 and No. 2 (single shell, combined heater) shall be mounted in each main condenser neck. Each heater will be approximately (later) inches in diameter and weight approximately (later) pounds flooded.

2. Stainless steel lagging .7 mm (22 BWG) shall be provided for all neck-mounted heaters to be installed in the field. A 25 mm (1 inch) air gap shall be provided between the heater shell and the lagging.

g. Condenser Supports:

1. The condenser shell will be supported on suitable concrete piers. The Vendor shall provide one fixed foot per shell and guided slide plates for all other feet, to allow for thermal movement.

2. Condensers shall be designed to be self-supporting under all postulated loads including flooding of the shell up to the turbine exhaust connection.

h. Tubing, Tube Sheets, and Tube Support Plates:

1. Tubes will be furnished by the Owner in accordance with the attached Design Data sheets.

2. Tubes will be fabricated to ASTM A304.

3. Tubes shall be installed in the condenser in the Vendor's shop, prior to shipment. Tubes shall be attached to tube sheets by rolling.

4. Tube sheet material shall be mild carbon steel, a minimum of 40 mm (1 1/2 inches) thick.

5. Tube support plate spacing shall be such that the maximum vibratory tube deflection under the most

severe dynamic loading, based on steam flow and velocity and taking into account the weight of the tube and its contents, shall not exceed one-half of the support plate ligament dimension minus .8 mm (1/32 inch).

6. Before fabrication is begun, the Vendor shall substantiate the design used to comply with paragraph 7.2, h., 5. above, to the satisfaction of the Owner and the Engineer.

i. Vacuum pumps shall be motor driven Nash or approved equal, and shall have air removal capacity in accordance with article 2.0, c, and HEI "Standards for Steam Surface Condensers."

j. Internal Piping and Connection Baffles:

1. All internal piping provided with the condenser to handle condenser dumps shall be carbon steel A106, Grade B, Schedule 80, up to a 15 mm (0.50 inch) maximum wall.

2. All internal baffles on condenser connections shall be a minimum of 10 mm (3/8-inch) thick, attached with full penetration welds, and have a minimum open flow area of two times the connection flow area.

3. The internal piping for the makeup shall be stainless steel in accordance with ASTM A 304.

k. Cooling Water Analysis:

(See Attachment 4)

7.3 ACOUSTIC REQUIREMENTS

7.3.1 The Vendor shall submit as part of his proposal a tabulation of octave band sound power levels in accordance with 7.3.3 below for the equipment being quoted without acoustic treatment or guarantee. The proposal shall be considered incomplete without this information.

7.3.2 The Vendor shall submit as part of his proposal an additional price for a guaranteed maximum sound level of 90 dBA (90 decibels, a network weighted) when measured with a Type I precision sound level meter at slow response and at a distance of 1 meter (3 feet) in any direction from the nearest surface of the equipment. The Vendor shall also submit with his proposal a tabulation of octave band sound power levels in accordance with 7.3.3 below for the equipment in the sound attenuated condition.

7.3.3 The Vendor shall complete and submit as part of his proposal the attached Acoustic Data Summary Sheet (Attachment 10). It is preferred that the octave band levels be sound power levels in decibels with a reference power of 10 (exponent 12) watt. However, sound pressure levels in decibels with a reference pressure of 0.0002 microbars will be acceptable providing the weighting network and distance to the sound source are indicated. In the event acoustic data for the equipment quoted is not available, acoustic data for similar equipment will be acceptable. However, the equipment difference should be indicated and the Vendor's estimate of the acoustical effect of these differences should be indicated.

8.0 PERFORMANCE REQUIREMENTS

8.1 The condensers, when installed and functioning, shall meet or exceed the performance requirements listed in the attached Design Data sheets.

8.2 The flow rate, pressure, and enthalpy of flows entering the condensers, as specified in the Design Data, Attachment 1, are designated in the attached Design Data sheets. The design shall provide for minimum erosion of tubes, plates, and shells due to steam jet impact or drip action, or both, using baffles, internal piping, spray pipes, or external separators, as required by the service conditions.

8.3 Additional miscellaneous flows as described in the attached Design Data sheets.

9.0 MATERIAL REQUIREMENTS

9.1 The materials used in the construction of the pressure containing parts or structural parts associated with the strength of the completed condenser shall be selected from those listed in the Heat Exchange Institute Standards for "Steam Surface Condensers." The materials selected for the tube sheets shall also conform with those listed in the stress tables of the ASME Code, Section VIII, Division 1.

9.2 The condenser shell, hotwell, support plates, supports, and extension neck shall be fabricated from ASME SA 516 steel plates, or approved equal, and shall be of all welded construction. If pipe is used as a means of support, the pipe shall be ASME SA 106, Grade B.

9.3 All other materials selected shall conform with existing ASME material specifications or equivalent ASTM material specifications.

9.4 IMPACT STRENGTH

a. Carbon steel materials, except as noted in subparagraph b., used in the construction of pressure containing parts or for structural parts associated with pressure integrity, shall have impact energy values not less than 20.3 joules (15 ft-lb) Charpy V-notch at 27°C (80°F), which is the minimum expected circulating water temperature. Impact tested materials shall conform to the specifications designated on Table UG-84.3 of Part UG, ASME Boiler and Pressure Vessel Code.

b. Impact testing is not required for the following materials:

1. Material with a nominal section thickness of 16 mm (5/8 inch) and less.

2. Bolting, including studs, nuts, and bolts, with a nominal size of 25 mm (1 inch) and less.

3. Bar stock with a nominal cross section of 645 mm^2 (1 square inch) and less.

4. All thicknesses of pipe, tubing, and fittings with a nominal outside diameter of 150mm (6 inches) and smaller.

10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

10.1 GENERAL REQUIREMENTS

The condenser shells complete with tube sheets, hotwell, turbine exhaust connecting sections, and all structural parts associated with the structural integrity of the condenser shell shall conform with the requirements of Section VIII, Division 1, of the ASME Code insofar as these code rules are applicable. Compliance with the rules in Section VIII, Division 1, relative to the application of the ASME Code symbol stamp and the associated third-party inspection by authorized inspection agencies, such as the State jurisdiction or the National Board of Boiler and Pressure Vessel Inspectors, is not required nor intended. The condenser waterbox circuit, complete with tube sheets, shall also conform, as above, on the basis that said circuit forms a pressure chamber of a compartmented vessel.

10.2 DESIGN STRESSES

The allowable stresses for the material used in the design of the condenser shell structure shall not exceed the values listed in the stress tables in ASME Code, Section VIII, Division 1.

Materials which are not listed in these tables, i.e., not listed in either ASME or equivalent ASTM Specifications and not identified in accordance with the provision of Section VIII, Division 1, paragraph UG-10, may not be used for pressure parts or for structural parts associated with pressure integrity.

10.3 WELD JOINT EFFICIENCIES

a. Condenser shell or shell sections subjected to external pressure:

The weld joint efficiencies used in the design of the condenser shell or the shell sections, subjected to external pressure, shall comply with the applicable requirements of subparagraph UW-12. The degree of radiographic examination of weld seams as described in paragraph UW-11 is optional. Minimum examination of butt welds in condenser shell sections (shell, hotwell, and exhaust connection transition) with spot radiography in accordance with UW-11 (b) is suggested for quality control purposes.

b. Fillet welds:

The joint efficiencies used for fillet welds subject to stress due to pressure or fillet welds otherwise employed as strength welds, shall generally comply with paragraph UW-18 and specifically comply with the requirements of UW-18 (d). The geometry and size of fillet welds used in design shall conform with the illustrations in Figure UW-13.2.

10.4 BRACED AND STAYED SURFACES

Braced and stayed surfaces used in the design of the condenser shell sections (shell, hotwell, and exhaust connection transition) shall generally conform with the requirements of paragraph UG-47. The value of C used in equations (1) and (2) of paragraph UG-47 shall agree in principle with the geometries described therein for tension stays and with appropriately modified geometry when applied to compression stays. The provisions of paragraph U-2 (g) may be used in the design of braced surfaces, including rib supported surfaces. All other provisions of paragraphs UG-47 through UG-50 shall apply insofar as they are applicable.

10.5 NOZZLES AND NOZZLE REINFORCEMENTS

The design of openings in the condenser shell and waterboxes shall conform with the requirements of paragraphs UG-36 through

UG-41b as applicable. For geometries required in the design, but not described in Division 1 of Section VIII of the ASME Code, the provisions of paragraph U-2 (g) may be used and, in addition, the applicable provisions of paragraph UG-101, "Proof Tests to Establish Maximum Allowable Working Pressure," may also be used, if deemed necessary.

10.6 WELDING

a. Welds used for pressure seams or for structures designed for loads due to pressure shall conform with the applicable weld geometries and dimensions listed or described in the ASME Code, Section VIII, Division 1. Welding procedures, material combinations, and operator qualifications shall be in compliance with paragraphs UW-26, UW-28, UW-29, and all other applicable paragraphs relating to construction.

b. Welders employed for fabrication in the shop or for erection of the condenser shell structure in the field, or both, shall be qualified under the rules of Section IX of the ASME Code. Welder and welding operator performance qualification records shall be available in the Vendor's shop for review by the Owner or his Agent.

11.0 INSTALLATION REQUIREMENTS

None

12.0 PERSONNEL REQUIREMENTS

The Vendor shall employ the following qualified personnel to perform the Work.

a. All welders shall be qualified under the ASME Code, Section IX.

13.0 INSPECTIONS AND TESTS

The following inspections and tests shall be performed:

Hydrostatic Test:

a. Pressure requirements:

1. The completed condenser, especially the shell side pressure compartment, shall be subjected to a field hydrostatic test.

2. The hydraulic pressure in the condenser shell shall be limited to that resulting from the static head of water at the elevation of the turbine flange or exhaust connection.

b. Temperature requirements:

1. The test pressure, a function of static elevation for the condenser shell side, shall not be applied unless the vessel temperature is within 5.6°C (10°F) of the temperature of the test liquid, except when both the vessel temperature and the test liquid temperature are 15.6°C (60°F) or above.

2. The temperature of the test liquid used for vessels fabricated from impact tested material shall not be less than the specified minimum impact test temperature.

3. The temperature of the test liquid used for vessels fabricated from materials for which the impact properties have not been required to be ascertained and/or certified shall not be less than 15.6°C (60°F).

14.0 CLEANING, CORROSION PROTECTION, AND COATING

14.1 The inside of each condenser shell (section) shall be shot blasted and protected by a water soluable corrosion resistant coating prior to shipment. Details of the coating and method of removal are subject to approval by the Engineer.

14.2 The inside of the waterboxes shall be shot blasted and coated with coal tar epoxy.

14.3 All outside, unmachined surfaces shall be given one shop coat of red lead primer. Dry-film thickness of such paint shall be a minimum of 2 mils.

14.4 All exposed machined surfaces shall be coated and protected from corrosion during shipment and storage. Details are subject to approval by the Engineer.

15.0 MARKING AND IDENTIFICATION REQUIREMENTS

15.1 Each package, skid, box and crate shall be marked on the outside with the following information so that it is readily visible:

a. (Owner's name)
(Project identification)
(Address)
(City, state, zip code)

b. Purchase Order Number

c. Weight:

d. Equipment Nos. as applicable:

15.2 Each unit shall be identified with a tag number. The number shall be permanently imprinted with at least 5mm (3/16") high letters on a 22 gage stainless steel tag. The tag shall be attached to the enclosure with pins of a similar material.

15.3 Each unit shall have a permanently secured data plate made from at least 22 gage stainless steel, permanently imprinted with 5mm (3/16") high letters, and containing the following information:

a. Manufacturer's name and address:

b. Model Number:

c. Serial Number:

d. Date of Manufacture:

e. Duty:

f. Weight:

15.4 The data plate shall be located where it is readily visible and shall be securely attached with pins of a material similar to the plate.

15.5 Equipment item numbers shall be utilized by the Vendor in designating equipment. Numbers so assigned by the Vendor may be reassigned at the option of the Engineer.

15.6 Items furnished under these specifications, but not identified herein, shall have tags inscribed as directed by the Engineer.

16.0 PACKAGING, SHIPPING, AND STORAGE

Equipment or piping that may have been hydrostatically tested shall be checked to insure that all water has been drained from the unit prior to placing equipment in storage or on its foundation. After any equipment is in storage or on its foundation, temporary wood or steel plate covers shall be provided over flanges to prevent admittance of water to the unit. The Vendor shall be responsible for any damage to unit, equipment, and associated piping until such time as it has been accepted by the Owner.

a. Condenser shell sections shall be shipped with weather-resistant covers to prevent deterioration of tubing or washing of the corrosion-resistant internal coating.

b. Waterboxes shall be shipped bolted together in pairs <u>or</u> with plywood covers over the open (tube sheet) side.

c. The weight and lifting points or center of gravity shall be clearly and permanently marked on each item.

d. Shipment shall be by rail unless the Owner and the Vendor agree otherwise.

e. Unless the Owner and the Vendor agree otherwise, storage will be outdoors. Weather-resistant covers and adequate blocking shall be provided. Condenser neck expansion joint(s) shall be blocked to prevent cracking and covered to prevent deterioration due to weathering. Plywood decking shall be provided to completely cover exposed condenser tubes in the condenser neck.

17.0 <u>ACCEPTANCE CRITERIA</u>

17.1 MANUFACTURING ERRORS

Equipment and materials shall be complete in all respects within the limits herein specified. Manufacturing errors and omissions, required to be corrected in the field, shall be performed under the direction of and at the expense of the Vendor. If the error requires shipment back to the factory, the disassembly, handling, shipping, and reassembly shall be at the Vendor's expense.

17.2 Submittal of Vendor Data as required in article 6.0.

17.3 Submittal of performance test reports and certifications as required in Paragraph 6.5.

DESIGN DATA

A. Design Point Conditions:

1.	Average condenser pressure	kPa (in. Hg)	8.47 (2.5)
2.	Circulating water inlet	°C (°F)	33.9 (93)
3.	Circulating water flow	l/s (gpm)	12,113 (192,000)
4.	Average tubeside velocity	m/sec (ft/sec)	2.4 (8)
5.	Cleanliness factor	%	85
6.	Circ water temp rise (max)	°C (°F)	11.1 (20)
7.	Free O_2 at hotwell pump outlet	cc/l	.005
8.	Turbine exhaust steam flow	tonnes/hr (lb/hr)	912.0 (2,010,916)
9.	Turbine exhaust steam enthalpy	kJ/kg (Btu/lb)	2386.3 (1026)
10.	Low-pressure heater/drain flow	tonnes/hr (lb/hr)	182.6 (402,731)
11.	Low-pressure heater/drain enthalpy	kJ/kg (Btu/lb)	203.5 (87.5)
12.	Steam packing exhauster (SPE) drain	tonnes/hr (lb/hr)	.63 (1400)
13.	SPE drains enthalpy	kJ/kg (Btu/lb)	419 (180.2)
14.	Steam seal regulator flow	tonnes/hr (lb/hr)	.5 (1200)
15.	Steam seal regulator enthalpy	kJ/kg (Btu/lb)	3119 (1341)

DESIGN DATA
(Continued)

16.	Tube diameter and gage	mm;mm (in.;BWG)	25;.7 (1;22)
19.	Tube length	m (ft)	13.7 (45)
20.	Tube material		SA304
21.	Total heat input	kJ/hr (Btu/hr)	2.03×10^9 (1.92×10^9)

DESIGN DATA

B. Intermittent Dumps:

1. Makeup line (S.S. spray pipe):

a.	Flow	tonnes/hr	6.6
		(lb/hr)	(14,465)
b.	Enthalpy	kJ/kg	65
		(Btu/lb)	(28)
c.	Temperature	^{o}C	15.6
		(^{o}F)	(60)

2. Condensate pump recirculation:

a.	Flow	tonnes/hr	165.4
		(lb/hr)	(364,607)
b.	Enthalpy	kJ/kg	178.4
		(Btu/lb)	(76.7)
c.	Temperature	^{o}C	42.6
		(^{o}F)	(108.7)
d.	Required backpressure @ conn.	kPa	275.8
		(psia)	(40)

3. Turbine Bypass Steam (25% of throttle flow) after Throttling and Desuperheating:

a.	Flow	tonnes/hr	398
		(lb/hr)	(877,068)
b.	Enthalpy	kJ/kg	2824.1
		(Btu/lb)	(1214.2)
c.	Temperature	^{o}C	215.6
		(^{o}F)	(420)
d.	Required backpressure @ conn.	kPa	1723.7
		(psia)	(250)

DESIGN DATA
(Continued)

4. No. 7 high-pressure heater drains:

a.	Flow	tonnes/hr (lb/hr)	93.2 (205,429)
b.	Enthalpy	kJ/kg (Btu/hr)	912.4 (392.3)
c.	Temperature	^oC (^oF)	213.4 (416.1)

5. No. 6 high-pressure heater drains:

a.	Flow	tonnes/hr (lb/hr)	139.1 (306,738)
b.	Enthalpy	kJ/kg (Btu/hr)	822.7 (353.7)
c.	Temperature	^oC (^oF)	193.3 (380)

6. No. 4 low-pressure heater drains:

a.	Flow	tonnes/hr (lb/hr)	60.1 (132,612)
b.	Enthalpy	kJ/kg (Btu/hr)	495 (212.8)
c.	Temperature	^oC (^oF)	118 (244.4)

7. No. 3 low-pressure heater drain:

a.	Flow	tonnes/hr (lb/hr)	92.9 (204,926)
b.	Enthalpy	kJ/kg (Btu/hr)	420.5 (180.8)
c.	Temperature	^oC (^oF)	100.4 (212.7)

8. No. 2 low-pressure heater drain:

a.	Flow	tonnes/hr	140.6
		(lb/hr)	(309,958)
b.	Enthalpy	kJ/kg	308.2
		(Btu/hr)	(132.5)
c.	Temperature	^{o}C	73.7
		(^{o}F)	(164.6)

9. No. 1 low-pressure heater drain:

a.	Flow	tonnes/hr	182.6
		(lb/hr)	(402,731)
b.	Enthalpy	kJ/kg	203.5
		(Btu/hr)	(87.5)
c.	Temperature	^{o}C	48.6
		(^{o}F)	(119.5)

10. Miscellaneous drains, vents, and recirculations including at least the following:

    a. Main, reheat, extraction, and miscellaneous turbine drains.

    b. Deaerator and low-pressure heater vents.

    c. Steam packing exhauster recirculation.

    d. Demineralizer booster pump recirculation.

    e. Makeup demineralizer.

    f. Seal water return tank drain.

    g. Turbine exhaust hood spray water.

    h. Blowdown cooler drains.

    i. Deaerator overflow.

    j. Air preheater drains.

    k. Boiler feed pump warmup flows.

DESIGN DATA
(Continued)

l. Station flash tank drains.

m. Desuperheater spray water flows.

11. Additional miscellaneous connections and openings:

a. Extraction piping to externally mounted feedwater heaters.

b. Gland steam piping penetrations.

c. Excess relief (condensate dump) piping.

d. Condensate pump vents.

e. Vacuum pump air offtake connections.

f. Condensate pump suction piping.

g. Feedwater heater openings.

h. Instrument connections for:

(1) Makeup control.

(2) Condensate dump.

(3) Gauge glasses.

(4) Vacuum sensing diffuser connections.

(5) Hotwell temperature indication.

(6) Exhaust hood temperature indication.

(7) Test connections in extraction piping for pressure and temperature.

(8) Waterbox pressure and temperature.

i. Waterbox vents.

j. Condenser vacuum breaker connections.

k. Spare connections for steam and water piping to the condenser.

ES

ATTACHMENT 2

EQUIPMENT DATA
CONDENSER

1.	Bidder's Name		______
2.	Manufacturer's Name		______
3.	Quotation Numbers		______
4.	Effective tube length	m (ft)	______ ______
5.	Tube length required	m (ft)	______ ______
6.	Number of tubes		______ ______
7.	Surface area	m^2 (sq ft)	______ ______
8.	Number of support plates		______ ______
9.	Support plate spacing	mm (in)	______ ______
10.	Support plate thickness	mm (in)	______ ______
11.	Tube sheet thickness	mm (in)	______ ______
12.	Square feet of tube surface in air cooling section	m^2 (sq ft)	______ ______
13.	Distance between bottom tube and normal water level	mm (in.)	______ ______
14.	Circulating water temperature rise	^oC (^oF)	______ ______
15.	Water velocity in tubes	m/sec (ft/sec)	______ ______

ATTACHMENT 2
(Continued)

16.	Circulating water flow	l/s (gpm)	________ ________
17.	Circulating water pressure drop	kPa (psia)	________ ________
18.	Condensate discharge temp	^oC (^oF)	________ ________
19.	Hotwell capacity at normal water level	l (gal)	________ ________
20.	Approximate maximum steam velocity in neck	m/s (ft/sec)	________ ________
21.	Fabrication details		
	a. Tube sheet attachment to shell		________ ________
	b. Tube sheet ligament	mm (in)	________ ________
	c. Waterbox test pressure	kPa (psig)	________ ________
	d. Shell interior preservation method		________
	e. Waterbox interior preservation method		________
	f. Shell exterior preservation method		________
22.	Manholes:		
	a. Waterbox	No.	________
	b. Waterbox, size	mm (in)	________ ________
	c. Hotwell	No.	________
	d. Hotwell, Size	mm (in)	________ ________

e. Exhaust neck — No. ______

f. Exhaust neck, size — mm ______ (in) ______

23. Weights:

a. Dry — kg ______ (lb) ______

b. Flooded — kg ______ (lb) ______

c. Operating — kg ______ (lb) ______

d. Waterbox — kg ______ (lb) ______

e. Crossover box — kg ______ (lb) ______

24. Air takeoff:

a. No. ______

b. Size — mm ______ (in) ______

25. Guarantees:

Absolute pressure at design conditions — kPa ______ (in.Hga) ______

26. Maximum O_2 content in condensate leaving main condenser shell with circulating water inlet at the following temperatures:

a. 33.9°C (93°F) — cc/l ______

b. 45°C (113°F0 — cc/l ______

c. 33.9°C (93°F) — sq cm/l ______

d. 45°C (113°F) — sq cm/l ______

ATTACHMENT 2
(Continued)

		Main Condenser
27. Shell material:		
a. Type		______
b. Thickness	mm (in.)	______ ______
28. Waterbox material:		
a. Type		______
b. Thickness	mm (in.)	______ ______
29. Support plate material		______
30. Tube sheet material		______
31. Size and type of rubber used in the condenser neck expansion joints		______
32. Main condenser subassembly:		
a. Number of subassemblies		______
b. Largest item:		
(1) Dimensions		______
(2) Weight	kg (lb)	______ ______
(3) Method of transport (lifting, skidding jacking)		______

ATTACHMENT 2
(Continued)

33. State the maximum lineal feet of each type of field weld required to erect the main condenser (max shop assembly is desired): ____________

a. 7 mm (1/4 inch) ____________

b. 15 mm (1/2 inch) ____________

c. 20 mm (3/4 inch) ____________

d. 25 mm (1 inch) ____________

e. over 25 mm (1 inch) ____________

ATTACHMENT 2

EQUIPMENT DATA
MECHANICAL VACUUM PUMPS

1.	Bidder's Name		______
2.	Manufacturer's Name		______
3.	Quotation Numbers		______
4.	Number of vacuum pumps operating		______
5.	Size and type		______
6.	Suction pressure	kPa	______
		(in.Hga)	______
7.	Suction temperature	^oC	______
		(^oF)	______
8.	Design capacity of each pump:	Std. m^3/s	______
		(scfm)	______
		Act. m^3/s	______
		(acfm)	______
9.	Approximate time required to evacuate condenser to 20 in Hg vac	min	______
10.	Approximate weight of each modular unit (pump, motor, and accessories)	kg	______
		(lb)	______
11.	Maximum bhp required		______
12.	Maximum full load speed	rpm	______
13.	Sealing water required:		
	a. Pressure	kPa	______
		(psia)	______
	b. Temperature	^oC	______
		(^oF)	______
14.	Shaft seal type		______
15.	Description of fittings and accessories included		______
			______
			______

ATTACHMENT 3

CONDENSATE CHEMICAL ANALYSIS

pH at 25°C (77°F)	8.9 - 9.2
Maximum dissolved solids, ppm	25
Maximum ozygen as O_2, ppm	0.1
Morpholine, ppm	2 - 6
Hydrazine, ppm	15 - 25
Maximum chlorides as CL-, ppm	1.0
Maximum flourides as F-, ppm	1.0

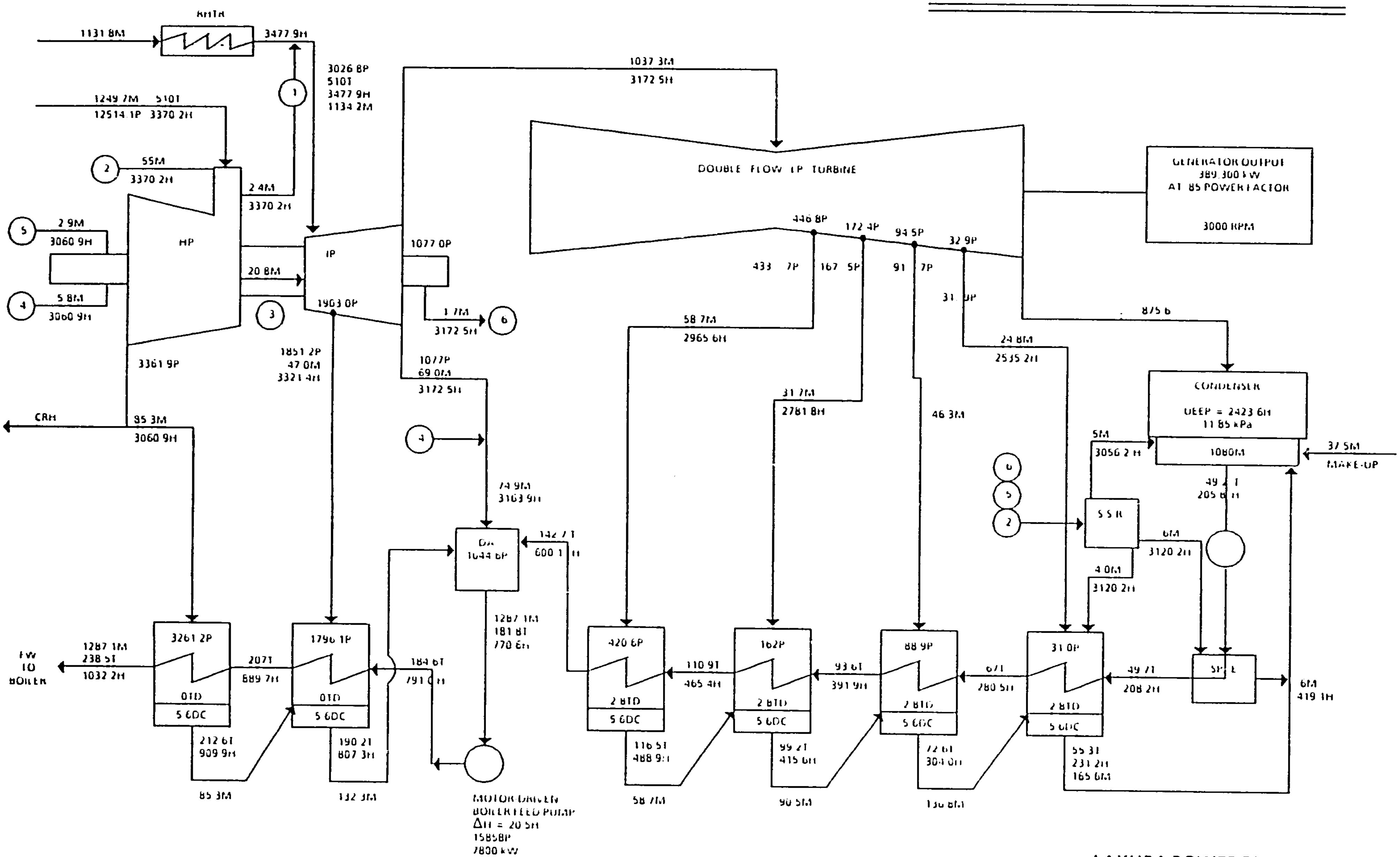
ATTACHMENT 4

TYPICAL CIRCULATING WATER ANALYSIS

Measuring Item	Unit	Value
Temperature	^oC	13-46^oC (55-115^oF)
pH		6.5-8.5
Conductivity	Micr-Mho/cm	2700
Total Solid	ppm	1500
Chloride	ppm as Cl	700
Total Hardness	ppm as $CaCO_3$	700-1000
Suspended Solids	ppm	150

ATTACHMENT 5

GUARANTEED – 11.85 kPa, 3% MU, TC2F



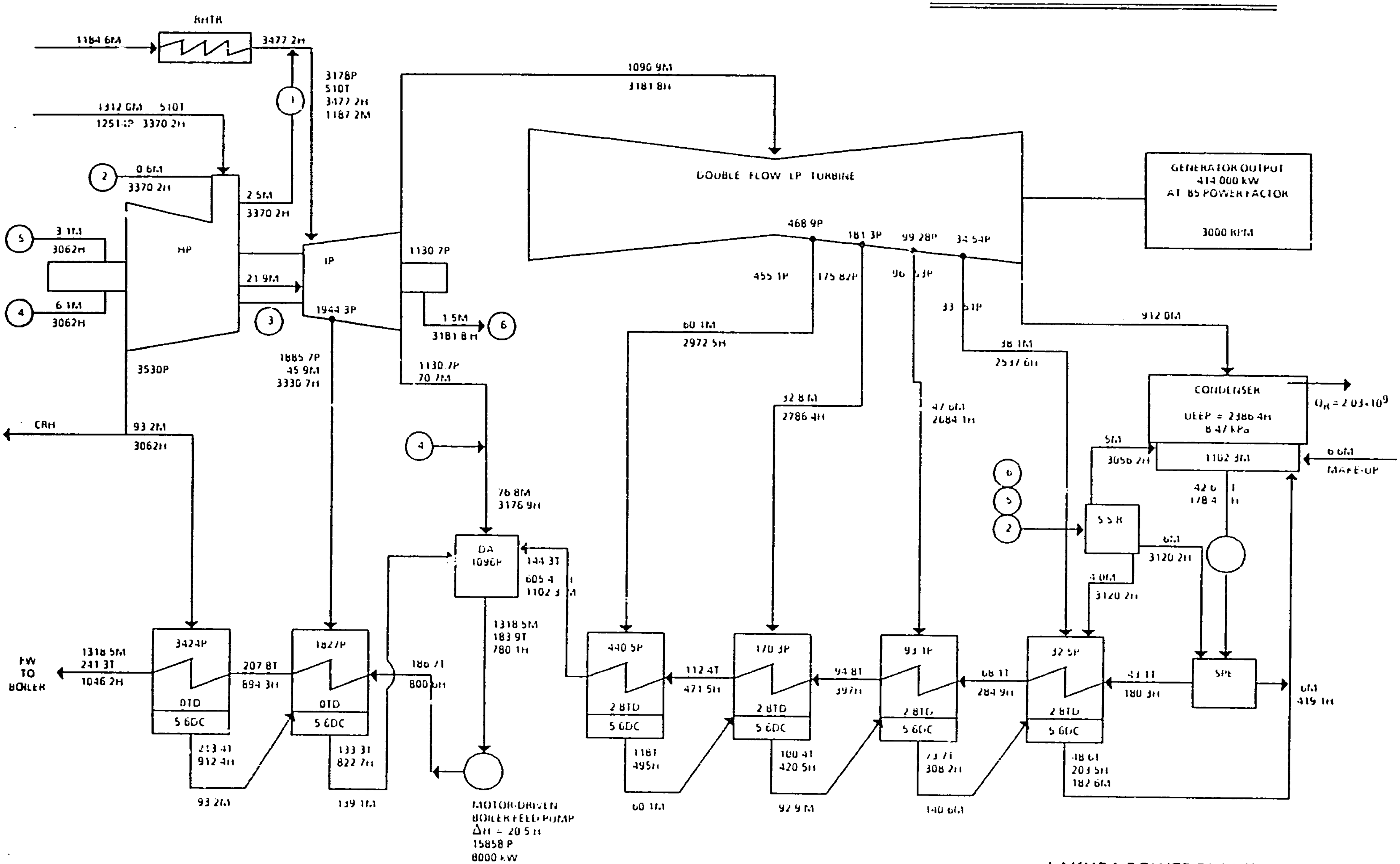
GROSS HEAT RATE = 8717 kj/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – ° C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-1

81619-4/GF #72

VWO – NP – 8.47 kPa, 0.5% MU, TC2F



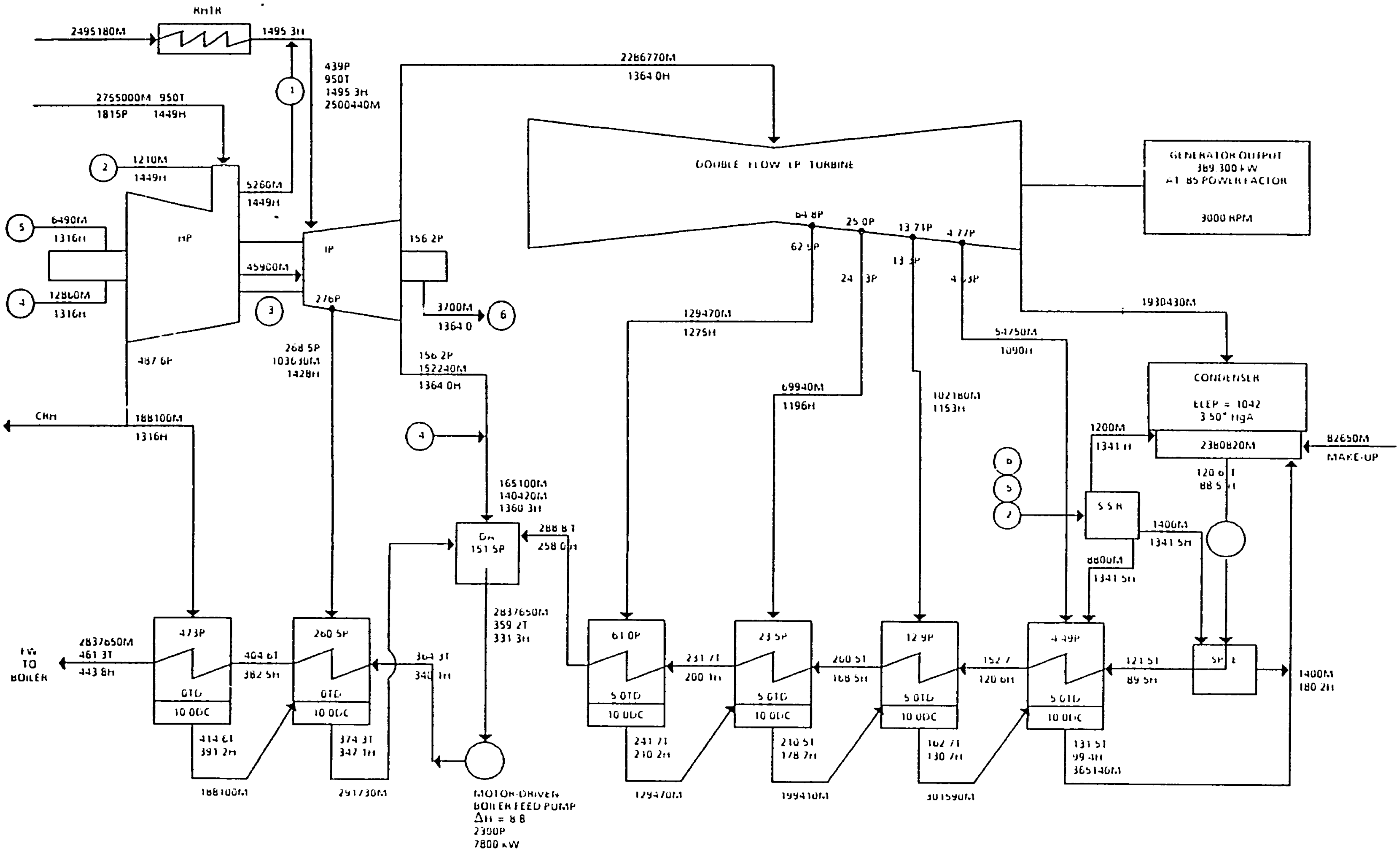
GROSS HEAT RATE = 8554 kj/kWh
(Heat Rate May Vary Depending
on T/G Vendor Selected)

M – Flow – tonnes/hr
P – Pressure – kPa
H – Enthalpy – kj/kg
T – Temperature – °C

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
SI UNITS
G/C II 11/12/85 HB-2

B1619-2/GF#72

GUARANTEED – 3.5" HgA, 3% MU, TC2F



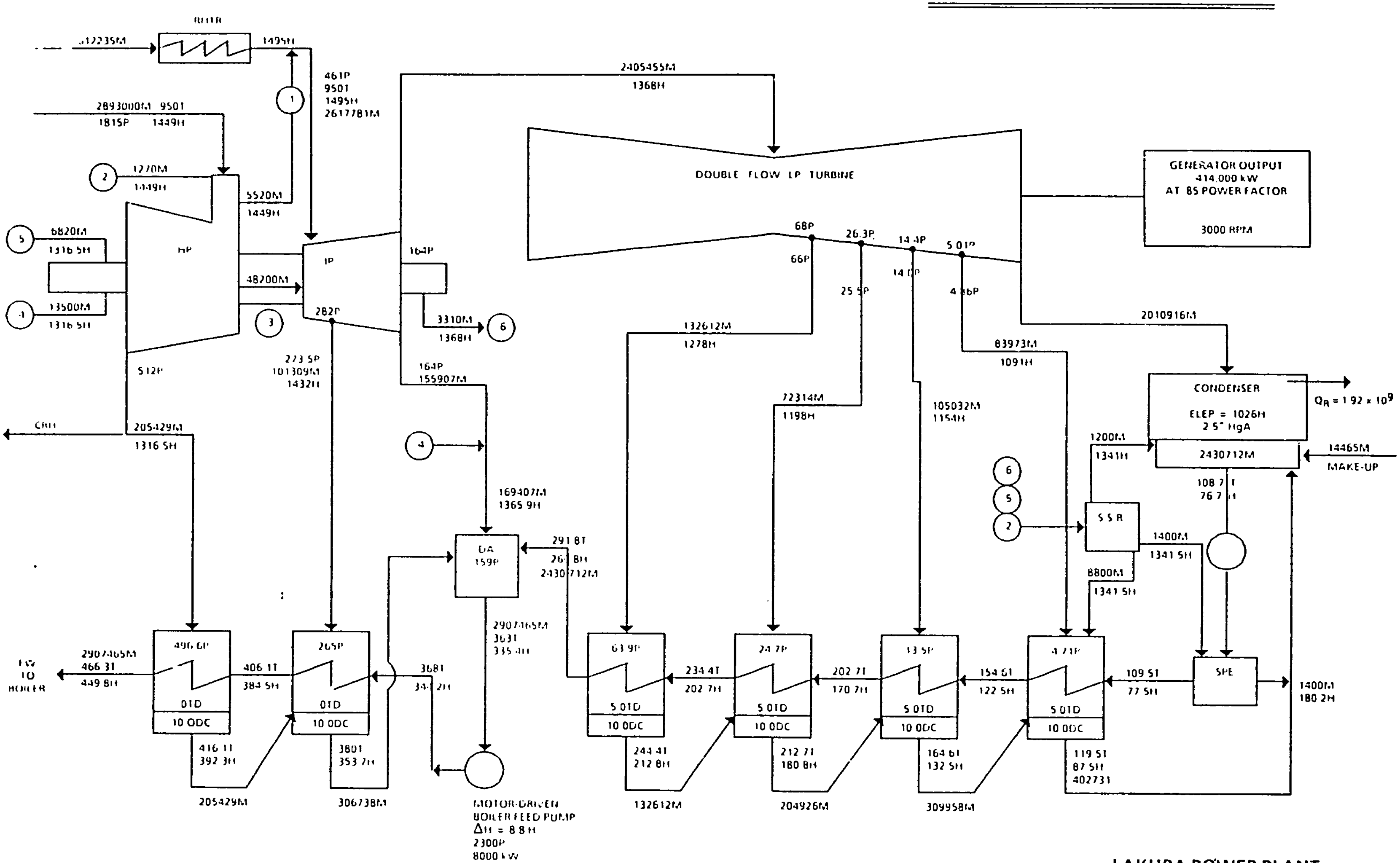
GROSS HEAT RATE = 8263 Btu/kWh
(Heat Rate may vary depending
on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – °F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANCE
ENGLISH UNITS
G/C II 11/12/85 HB-1

B1619-3/GF # 72

VWO – NP – 2.5" HgA, 0.5% MU, TC2F



GROSS HEAT RATE = 8108 Btu/kWh
(Heat Rate may vary depending on the T/G Vendor Selected)

M – Flow – lbs/hour
P – Pressure – psia
H – Enthalpy – Btu/lb
T – Temperature – ° F

LAKHRA POWER PLANT
FEASIBILITY STUDY
TYPICAL PRELIMINARY TURBINE HEAT BALANC
ENGLISH UNITS
G/C II 11/12/85 HB-2

1619-1/GF#72

ATTACHMENT 8

Refer to Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 9

Refer to Motor Data Sheets included in Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 10

ACOUSTIC DATA
SUMMARY SHEET

MECHANICAL VACUUM PUMPS

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dBA at 1 meter (3 feet)
63	______	______
125	______	______
250	______	______
500	______	______
1000	______	______
2000	______	______
4000	______	______
8000	______	______

Kind of levels given, indicate which of the following:

Sound Power Levels re 10 (exp -12) watt	______	______
Sound Pressure Levels re 2x10 (exp -4) microbars	______	______

If sound pressure levels are given, indicate both of the following:

Weighting network use A, B, C, or Linear (None)	______	______
Distance to sound source Feet or Meters	______	______

Vendor Comments: ______

______

______

______

ATTACHMENT 11

SPECIFICATION EXCEPTIONS

The Bidder certifies that the bid is complete and in absolute agreement with the requirements of this Specification, except as specifically stated below. (Use additional sheets if required.)

(BIDDER'S NAME)

(MANUFACTURER'S NAME)

(QUOTATION NUMBER)

ATTEST:

(SIGNATURE)

(TITLE)

LAKHRA POWER FEASIBILITY STUDY

SPECIFICATION M-4A

ELECTROSTATIC PRECIPITATOR

SPECIFICATION M-4A

ELECTROSTATIC PRECIPITATOR

TABLE OF CONTENTS

LAKHRA POWER FEASIBILITY STUDY
SPECIFICATION M-4A
ELECTROSTATIC PRECIPITATOR

1.0 DESCRIPTION OF WORK

The Work to be performed under this Specification shall include the design, fabrication, inspection, testing, cleaning, packaging, delivery, unloading, storing, erecting and placing into satisfactory operation, electrostatic precipitator equipment. This equipment will be installed at two 350 MW power plants for the Water and Power Development Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

Equipment, material, and services to be supplied by the Vendor shall include at least the following for each unit:

2.1 A four flow electrostatic precipitator consisting of four independent boxes capable of meeting the design requirements in Paragraph 7.0, complete with the following:

2.2 Shell and internal structural supporting steel.

2.3 Inlet and outlet plenums or nozzles with gas distribution devices, expansion joints and ductwork from the boiler air heater outlet to the I.D. fan inlets.

2.4 Hoppers, hopper heaters, nuclear type hopper level sensors, strike plates, and vibrators.

2.5 Discharge and collecting electrode system.

2.6 Rapper systems for collecting and discharge electrodes and gas distribution devices as required.

2.7 High-voltage electrical power supply and distribution equipment, complete with buswork and integral wiring.

2.8 Control panels, remote control panel inserts, and control enclosures, including instruments and controls as described herein, or as deemed necessary by the Vendor.

2.9 Access ladders and walkways integral with precipitator, both internal and external, an intermediate hopper service platform including a minimum of one stair system from grade to precipitator roof connecting all access levels.

2.10 Access doors with key interlock system.

2.11 High-voltage insulator heaters and blowers.

2.12 Monorail system for transformer-rectifier (T/R) removal/installation.

2.13 Slide plates or roller bearings to accommodate thermal expansion movement at support steel.

2.14 All necessary equipment grounding conductors and connections on the precipitator, except as noted in Paragraph 3.5.

2.15 All motors associated with the precipitator rated 150 kW (200 hp) and below and associated combination motor starters.

2.16 Support steel from grade level for the precipitator, nozzles/plenums, and ductwork from boiler air heater outlet to precipitator inlet and from precipitator outlet to I.D. fan inlet.

2.17 Unloading, storing, and erection of precipitator, ductwork, and support steel.

2.18 Precipitator automatic solid-state voltage control.

2.19 Complete electrical control room, automatic voltage control, T/R control cabinets, motor control centers, hopper heater control panels, level detector relay panels, master block of key interlock system, and hopper vibrator panels.

2.20 Cleaning and painting as described in Paragraphs 13.0 and 14.0.

2.21 Any required shop tests of component parts.

2.22 Technical assistance as required to act as consultant during installation, make necessary adjustments, initially operate equipment, and train Owner's operators.

2.23 Model study of precipitator including inlet ductwork from the air heater outlets and outlet ductwork to I.D. fan inlets.

2.24 Any special tools.

3.0 <u>WORK NOT INCLUDED</u>

3.1 Supply and installation of precipitator foundations and anchor bolts.

3.2 Supply and installation of ductwork to and from the Vendor's termination points, including expansion joints.

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3.3 Supply and installation of facilities for removing and disposing of the precipitated dust from the hoppers.

3.4 Supply and installation of grounding network and grounding cable riser adjacent to the precipitator, including grounding cable from control enclosures to riser.

3.5 Supply of alarms, instruments, and remote controls in the main control room.

3.6 Power supply for each precipitator at 400-volt, 3-phase wye, 4-wire, solidly grounded 50 hertz ac, including breakers and cable to Vendor's power supply input terminals.

3.7 Exterior lighting.

3.8 Finish painting.

3.9 The necessary thermal insulation and weatherproof siding required for precipitator, hoppers, plenums, and ductwork.

3.10 Induced draft fan and drive system.

4.0 APPLICABLE CODES AND STANDARDS

4.1 American Institute of Steel Construction (AISC)

4.1.2 "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings."

4.1.3 "Code of Standard Practice for Steel Bridges and Buildings."

4.1.4 "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

4.2 American National Standards Institute (ANSI)

4.2.1 B1.1, "Unified Inch Screw Threads."

4.2.2 B3.16 (ANSI/AFBMA 11), "Load Ratings and Fatigue Life for Roller Bearings."

4.2.3 B15.1, "Safety Standard for Mechanical Power Transmission Apparatus."

4.2.4 B18.2.1, "Square and Hex Bolts and Screws Inch Series, Including Askew Hex Cap Screws and Lag Screws."

4.2.5 B18.2.2, "Square and Hex Nuts."

4.2.6 B29.1, "Precision Power Transmission Roller Chains, Attachments, and Sprockets."

4.2.7 B16.5, "Pipe Flanges and Flanged Fittings."

4.2.8 ANSI C2, "National Electrical Safety Code."

4.2.9 ANSI C37.90, "Relays and Relay Systems Associated with Electric Power Apparatus."

4.2.10 ANSI X3.4, "Code for Information Exchange."

4.2.11 ANSI C37.90a, "Surge Withstand Capability Test."

4.2.12 ANSI C37.50, "Test Procedures for Low Voltage ac Power Circuit Breaker Used in Enclosures."

4.2.13 ANSI Z55.1, "Gray Finishes for Industrial Apparatus and Equipment."

4.2.14 ANSI Y14.15, "Standard Drafting Practices for Electrical and Electronics Diagrams (Section 15) Including Supplement Y14.15a."

4.2.15 ANSI C80.1, "For Rigid Steel Conduit Zinc Coated."

4.2.16 ANSI C80.5, "For Rigid Aluminum Conduit."

4.2.17 ANSI C37.20, C37.20a, C37.20b, C37.20c, C37.20d, "Switchgear Assemblies, Including Metal Enclosed Bus."

4.2.18 ANSI C57.12.00, "General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers."

4.2.19 ANSI C57.12.01, "General Requirements for Dry-Type Distribution and Power Transformers."

4.2.20 ANSI C50.41, "Polyphase Induction Motors for Power Generating Stations."

4.2.21 ANSI B3.15, "Load Ratings and Fatigue Life for Ball Bearirgs (AFBMA Standard 9)."

4.2.22 ANSI C37.2, Manual and Automatic Station Control, Supervisory and Associated Telemeter and Equipments."

4.2.23 ANSI C57.13, "Requirements for Instrument Transformers."

4.2.24 ANSI C97.1, "Low-Voltage AC Cartridge Fuses, 600 Volts or Less."

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4.2.25 A58.1, "American National Standard Minimum Design Loads for Buildings and Other Structures."

4.2.26 ANSI B30.11, "Monorail and Underhung Cranes."

4.3 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

4.3.1 Performance Test Code PTC 19.10, 21, 27, and 38.

4.3.2 PTC19.2, "Instruments and Apparatus for Pressure Measurements."

4.3.3 PTC 19.3, "Instruments and Apparatus for Temperature Measurements."

4.4 American Society for Testing and Materials (ASTM)

4.4.1 A-36, "Standard Specification for Structural Steel."

4.4.2 A-123, "Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip."

4.4.3 A-242, "Standard Specification for High-Strength Low Alloy Steel."

4.4.4 A-325, "High Strength Bolts for Structural Steel Joints Including Suitable Nuts and Plain Hardened Washers."

4.4.5 A-501, "Hot-Formed Welded and Seamless Carbon Steel Structural Tubing."

4.4.6 A-569, "Steel, Carbon (0.15 Maximum Percent), Hot Rolled Sheet and Strip, Commercial Quality."

4.4.7 A386-78, "Standard Specification for Zinc Coating (Hot Dip) on Assembled Steel Products."

4.5 American Welding Society (AWS)

4.5.1 A5.11, "Specification for Nickel and Nickel Alloy Covered Electrodes."

4.5.2 A5.14, "Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes."

4.5.3 D1.1, "Structural Welding Code."

4.5.4 QC1, "Standard for Qualification and Certification of Welding Inspectors."

4.6 <u>Federal Government Standards and Regulations</u>

4.6.1 U.S. Environmental Protection Agency; Code of Federal Regulations (CFR) Title 40 - Protection of Environment.

a. Part 60, "Standards of Performance for Stationary Sources;" Appendix A - "Test Methods," and Appendix B - "Performance Specifications."

4.6.2 U.S. Department of Labor; Code of Federal Regulations (CFR); Title 29 - LABOR, Chapter XVII -Occupational Safety and Health Administration.

a. Part 1910, "Occupational Safety and Health Standards."

b. Part 1926, "Safety and Health Regulations for Construction."

4.6.3 United States Department of Health, Education, and Welfare (HEW)

21CFR Subchapter J, "X-ray Radiation Safety Rules."

4.7 <u>Insulated Cable Engineer's Association</u>

4.7.1 ICEA P-46, "Power Cable Ampacities Vol. I - Copper Conductors."

4.7.2 ICEA P-54-440 2nd Edition Rev. 1 and 2, "Ampacities - Cables in Open Top Cable Trays."

4.7.3 ICEA S68-516, Rev. 1-7, "Ethylene - Propylene - Rubber - Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

4.7.4 ICEA S66-524 2nd Edition, Rev. 1, "Cross-linked Thermosetting Polyethylene - Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

4.7.5 ICEA S-61-402, 3rd Ed., Rev. 1-5, "Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

4.8 <u>Institute of Electrical and Electronic Engineers (IEEE)</u>

4.8.1 IEEE Standard 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants

4.8.2 IEEE Standard 241 - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings

4.8.3 IEEE Standard 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

4.8.4 IEEE Standard 493 - IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems

4.8.5 IEEE 383, Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations (Only Flame Test Portion)

4.8.6 IEEE 422, Guide for the Design and Installation of Cable Systems in Power Generating Stations

4.8.7 IEEE - 80, Guide for Safety in AC Substation Grounding

4.8.8 IEEE - 367, Guide for Determining the Maximum Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault

4.8.9 IEEE-112, Test Procedure for Polyphase Induction Motors and Generators

4.8.10 IEEE STD 20, Low Voltage Power Circuit Breakers Used in Enclosures (ANSI C37.13).

4.8.11 IEEE STD 142, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (ANSI C114.1).

4.8.12 IEEE STD 273, IEEE Guide for Protective Relay Applications to Power Transformers (ANSI C37.91)

4.8.13 IEEE STD 462, General Requirements for Liquid Immersed Distribution, Power, and Regulating Transformers (ANSI C57.12.00)

4.8.14 IEEE 472, Surge Withstand Capability (SWC) Tests

4.9 <u>Industrial Gas Cleaning Institute (IGCI)</u>

Publication No. E-P3.

4.10 <u>International Conference of Building Officials</u>

UBC - Uniform Building Code

4.11 <u>Instrument Society of America (ISA)</u>

4.11.1 ISA S50.1 Compatibility of Analog Signals for Electronic Industrial Process Instruments

4.11.2 ISA S20 Specification Forms For Process Measurement and Control Instruments

4.11.3 ISA RP42.1 Nomenclature For Instrument Tube Fittings

4.12 Mechanical Power Transmission Association (MPTA)

4.13 National Association of Architectural Metal Manufacturers (NAAMM)

"Bar Grating Manual"

4.14 National Electrical Manufacturers Association (NEMA)

4.14.1 NEMA AB 1, Molded Case Circuit Breakers

4.14.2 NEMA Pub. No. ICS6 Part ICS 1-109, Tests and Test Procedures

4.14.3 NEMA Pub. No. ICS6 Part ICS 6-110, Enclosures for Industrial Controls and Systems

4.14.4 NEMA Pub. No. ICS1 Part ICS1-112, Ratings, Performance, Manufacturing, and Application

4.14.5 NEMA Pub. No. ICS2 Part ICS 2-110, General Standards for Manual and Magnetic Controllers

4.14.6 NEMA Pub. No. ICS2 Part ICS 2-321, AC General-Purpose Class A Magnetic Controllers for Induction Motors Rated in Horsepower 600 Volts and less, 50 and 60 Hertz

4.14.7 NEMA Pub. No. ICS2 Part ICS 2-322, AC General-Purpose Motor Control Centers

4.14.8 NEMA ST 1, Specialty Transformers

4.14.9 NEMA VE-1, Cable Tray Systems

4.14.10 NEMA TR1, Transformer Regulator and Reactor

4.14.11 NEMA TR27, Commercial, Institutional, and Industrial Dry-Type Transformers

4.14.12 NEMA ICS 1, General Standards for Industrial Control and System

4.14.13 NEMA ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies

4.14.14 NEMA MG-1, Motors and Generators

4.14.15 NEMA MG-2, Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

4.14.16 NEMA FU-1, Low Voltage Cartridge Fuses

4.16 National Fire Protection Association (NFPA)

4.16.1 NFPA No. 70 (ANSI C-I), National Electric Codes

4.16.2 NFPA 70B, Electrical Equipment Maintenance, (ANSI 132.1)

4.17 National Micrographics Association (NMA)

NMA-MS102, Drafting Guide for Microfilm

4.18 Pipe Fabrication Institute (PFI)

ES3, "Fabricating Tolerances."

4.19 Scientific Apparatus Maker's Association (SAMA)

SAMA PMC 22.1 Functional Diagramming of Instrument and Control System

4.20 Steel Structures Painting Council (SSPC)

SSPC - Steel Structures Painting Manual Volume 2, Chapter 2 "Surface Preparation Specifications"

a. SP-6, "Commercial Blast Cleaning"

b. "Paint Specification No. 20"

4.21 Underwriters' Laboratories (UL)

a. UL 845, Motor Control Centers

b. UL 198B, Class H Fuses

c. UL 198C, High-Interrupting-Capacity Fuses Current Limiting Type Fuses

d. UL 198G, Fuses For Supplementary Overcurrent Protection

4.22 World Bank Guidelines

4.22.1 Office of Environmental Affairs the World Bank, Environmental Guidelines.

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4.23 The equipment performance test data shall be based on U.S. Government standards as established by the Environmental Protection Agency, Code of Federal Regulations 40 CFR, Part 60, "Standards of Performance for New Stationary Sources."

4.24 Equipment not covered by codes shall be designed and fabricated in accordance with the Vendor's standards and currently accepted electric utility practice.

4.25 The Vendor shall notify the Engineer of any apparent discrepancy between the codes, standards, and this Specification. Discrepancies shall be resolved by mutual agreement between the Vendor and the Owner's Engineer.

4.26 Application of codes and standards referenced herein requires the application of the latest issue date and of all addenda adopted as of the date of the purchase order. Later revisions may be involved only by mutual agreement between Purchaser and Vendor.

5.0 SUPPLEMENTAL DATA

The supplemental specifications listed in the Table of Contents as Attachments are applicable to the Work to the extent specified herein.

6.0 VENDOR DATA

6.1 Vendor shall furnish the following items with his Proposal. Data which is representative rather than exact shall be identified as such.

6.2 Completion of the Equipment Specification Exceptions form and Equipment Data forms. The reason for any exception taken shall be given and a detailed description of the alternative provided. All components, features, and design parameters specified are minimum requirements. If the Vendor's design dictates that these minimum requirements be exceeded to meet specified performance or to provide a safe, reliable operating unit, he shall include the equipment price in his bid.

6.3 Performance data for operation at conditions specified in Paragraph 7.0, and curves showing variation in efficiency during operation as follows:

a. Correction factor - gas flow rate, 20 to 110 percent of design.

b. Correction factor - inlet dust loading, from 3.50 to 16.00 grams/m^3 (1.50 to 7.00 grains/acf).

c. Correction factor - temperature, from 93 to 204°C (200 to 400° F).

d. Correction factor - sulfur content of fuel, from 3.0 to 15.0 percent.

e. Correction factor - sodium content of ash, from .40 to 3.00 percent.

f. Correction factor - moisture content of fuel from 15 to 46 percent.

These curves will be used to establish predicted performance when operating at other than design conditions.

6.4 Procedures and Information

6.4.1 Procedures and documentation standards which will be used to verify manufacturing and erection tolerances.

6.4.2 A brief description of shipping and storage preservation methods and procedure for preservative removal. The description shall also explain how preservation methods meet the intent of this Specification.

6.4.3 If any cable other than that specified in Paragraph 17.13.12.11 is used, the Vendor shall so state in his Bid.

6.4.4 Information for foundations, preliminary locations.

6.4.5 Drawings showing the sequence of precipitator erection.

6.4.6 Detailed sketches and description of discharge and collecting electrodes and their supports. Sketches of the high voltage suspension system shall be included.

6.4.7 Detailed sketches and description of each rapping system.

6.4.8 Preliminary drawings (structural, mechanical and electrical) having sufficient details, dimensions, and access to enable the Engineer to complete associated engineering studies and to establish overall space requirements and terminal connections for the equipment. Exact column locations with preliminary column base details shall be indicated.

6.4.9 Individual load tables for dead loads, dust loads (with hoppers full), seismic loads, live loads and erection stability loads. Load shall as a minimum be maximum values and not be exceeded.

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6.4.10 A detailed description of the automatic voltage control system and its operation.

6.4.11 A statement of storage and/or special handling conditions required by the equipment.

6.4.12 Vendor shall furnish data indicating rapping accelerations and directions. Instrumentation used to measure accelerations shall be fully described.

6.4.13 Vendor's recommended thermal insulation type and method of attachment.

6.4.14 Detailed description of transformer-rectifier (T/R) sets including the following information:

a. Insulating fluid manufacturer's data sheets.

b. Rectifier type, connection, surge suppression networks, design safety factors, and provisions for rectifier removal.

c. Grounding switch construction.

d. High-voltage bus and enclosure construction.

e. Testing.

6.4.15 Optional price addition for the Vendor to design and supply all grounding, power and control cables and the raceway system.

6.4.16 Motor type, voltage, frequency, horsepower and time rating, full load rpm, full load current, enclosure, and code letter for starting kVA/hp or locked rotor current code letter in accordance with NEMA MG 1-10.36.

6.4.17 Name of motor manufacturer.

6.4.18 Type of motor bearings and method of lubrication.

6.4.19 Complete electrical one-line diagram.

6.4.20 Bill of material for the electrical equipment supplied by the Vendor. (To include names of all subvendors.)

6.4.21 Electrical equipment sizes.

6.4.22 A complete load list indicating running and connected loads and the power factor.

6.4.23 Layout drawings for the electrical equipment.

6.5 Statement that the equipment supplied meets the design requirements specified in Paragraph 7.0 and the performance requirements specified in Paragraph 8.0.

6.6 One copy of the Vendor's specification for T/R sets.

6.7 Vendor's recommended maintenance schedule.

6.8 The Vendor shall submit with his Proposal an estimated manufacturing, delivery, and construction schedule based on the following dates:

a. Site available for first delivery of equipment (later).

b. Site available for erection (later) .

c. Completion required (later) .

d. Commercial operation (later) .

NOTE: Where actual required delivery dates, as agreed to by Owner and Vendor, appear on the Purchase Order or Purchase Order Supplement, they will amend the above dates. This Specification will not be amended to reflect changes in delivery dates.

6.9 The precipitator will be installed approximately as shown in the attached Drawings (later). The general arrangement of equipment is not to be construed as indicating any particular manufacturer's equipment.

6.10 Vendor may, in addition to his base bid, offer alternate designs of equipment, if, in his judgement, such alternate designs will be better and will more economically serve the Owner's requirements. Alternate bids shall be submitted in the same format and manner as the base bid, clearly marked as "Alternate."

6.11 The Vendor shall submit with his Proposal a drawing submittal schedule for approval and certified drawings based on time after award of contract.

6.12 QA/QC Requirements

The Vendor and his subvendor(s) shall have in effect in their shops at all times an inspection, testing, and documentation program that will ensure that equipment furnished under this specification meets, in all respects, the requirements specified herein. The Vendor shall submit a copy of his quality control program to the engineer.

6.13 Special Tools and Spare Parts

6.3.1 The Vendor shall supply the following:

a. One set of any special tools required to operate and maintain his equipment. All tools shall be identifed by name and number, and this number shall appear on drawings and instructions to indicate the application of the tools furnished and to permit the ordering of replacement tools.

b. The Vendor shall supply, with his proposal, pricing for 1 and 5 year supplies of spare parts.

7.0 <u>DESIGN REQUIREMENTS</u>

7.1 The equipment shall be designed for outdoor installation. Grade elevation at the precipitator location is 137 meters (450 feet) per as noted above mean sea level. Arrangement of the precipitator will be approximately as shown on the Drawings. The Vendor shall either render approval of the final arrangement, or suggest alternate arrangements that he believes will be economically desirable or will result in better gas flow and performance.

7.2 In designing the precipitator and auxiliary equipment, the Vendor shall use the following, as required, to ensure satisfactory operation at all conditions.

7.3 Ambient Air Conditions:

a.	Summer Design Dry Bulb Temperature (1 percent)*	41.7°C (107°F)
b.	Summer Design Wet Bulb Temperature (1 percent)*	28.3°C (83°F)
c.	Maximum Summer Temperature	46.8°C (116.2°F)
d.	Minimum Winter Temperature	5.7°C (42.3°F)
e.	Sand Storm Wind Velocity (typical)	44.5 m/sec (105.6 MPH)

*Percentage of the time temperature would be above this number.

7.4 Flue gas temperatures:

a.	Normal	150°C (300°F)
b.	Maximum, air heater malfunction or stopped	343°C (650°F)
c.	Minimum normal operation	150°C (300°F)

7.5 Flue gas pressures:

a.	Maximum design	+7.5 kPa (+30 in H_2O)
b.	Minimum design	-7.5 kPa (-30 in H_2O)
c.	Normal	-2.5 kPa (-10 in H_2O)

7.6 Flue gas flow:

Normal operating at 150°C (300°F)	ID Fans Test Block Flow

7.7 The precipitator equipment shall be capable of meeting its performance requirements while the steam generator is burning No. 6 furnace oil or lignite coal or both with the following as-received range of analyses:

TABLE 7.7.1
COAL/MINERAL ANALYSES

SHORT PROXIMATE

Daily Average	Typical	Range
GCV-(Dry) Btu/lb	7500	6300 - 8700
Ash-(Dry) %	36.0	26.0 - 46.0
Sulfur-(Dry) %	7.4	6.5 - 9.5
H_2O %	32.0	25 - 45
Monthly Average		
GCV-(Dry) Btu/lb	7500	6900 - 8100
Ash-(Dry) %	36.0	30.0 - 42.0
Sulfur-(Dry) %	7.4	6.8 - 8.3
H_2O %	32.0	28.0 - 40.0

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TABLE 7.7.1
COAL/MINERAL ANALYSES
(Continued)

PROXIMATE ANALYSIS
(% Dry Basis)

	Typical	Range
Ash	36.00	26.17 - 41.87
VM	34.60	32.15 - 39.58
FC	29.40	23.68 - 35.82
Sulfur	7.26	6.02 - 9.85
GCV-(Btu/lb)	7500	6060 - 8950
Equil. Moisture	38.91	33.77 - 50.06

FORMS OF SULFUR

	Typical	Range
Total %	7.71	6.02 - 9.85
Pyrite %	4.14	2.89 - 5.51
Sulfate %	0.60	0.31 - 1.56
Organic %	2.97	1.43 - 3.86

ULTIMATE ANALYSIS
(% As Rec'd or Dry)

	Typical	Range
H_2O	32.00	- - -
Ash	24.48	26.17 - 41.97
H_2	2.12	2.76 - 3.66
C	29.12	35.61 50.75
N_2	0.55	0.66 - 1.08
S	4.94	6.02 - 9.85
O_2	6.79	9.69 - 12.84
GCV-(Btu/lb)	5100	6300 - 8700

MINERAL ANALYSIS
(%)

	Typical	Range
SiO_2	39.60	32.34 - 47.68
Al_2O_3	20.17	12.12 - 26.30
TiO_2	2.02	1.33 - 3.16
CaO	3.70	2.11 - 8.39
K_2O	0.61	0.45 - 0.76
MgO	1.60	0.79 - 2.54
Na_2O	0.72	0.32 - 1.02
Fe_2O_3	24.64	17.02 - 33.60
P_2O_5	0.75	0.56 - 0.93
SO_3	5.63	2.20 - 10.55

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During combustion testing of certain samples of Lakhra lignite in-situ resistivity was measured as 1.76×10^{11} OHM-CM for a sample known as baseline and 5.48×10^{10} OHM-CM for a sample known as BT-11, Seam 1. These data indicate that fly ashes from Lakhra lignite is more difficult to collect than the high sulfur content would at first indicate. The Bidder may examine the test results at (WAPDA's Offices in Lahore, USAID's offices in Islamabad, other in USA?)/

7.8 The Vendor shall state the effect of sizing, character of fuel, character of ash, or other variations on the precipitator performance and efficiency.

7.9 During start-up, the steam generator will be fired with No. 2 fuel oil. Firing with No. 2 fuel oil could last for several hours at the beginning of each startup. During operation the steam generator may be fired with up to 20 percent of the heat input from No. 6 furnace oil. During times when no coal is available the steam generator will be fired on 100 percent No. 6 furnace oil heat input. The Vendor shall include this consideration in the precipitator design and shall advise accordingly of any operating limitations.

7.10 MECHANICAL

7.10.1 The following design requirements are based upon requirements set forth by WAPDA and the Engineer.

a.	Type ESP	Rigid Discharge Electrode or Rigid Frame
b.	Specific collecting area (minimum) $m^2/m^3/sec$ (ft^2/Macfm)	100 (508)
c.	Maximum velocity - m/sec (ft/sec)	1.37 (4.5)
d.	Minimum No. of Fields (Mechanical)	6 including 1 redundant field (see Para. 17.12.1)
e.	Maximum Coefficient of Variation at precipitator inlet and outlet and after second mechanical field	$\pm$ 15 percent
f.	Alignment tolerance on discharge electrodes	$\pm$ 6mm (1/4 inch)
g.	No. of Hoppers	1 per elec. bus section

These requirements are mandatory. The Vendor shall indicate any exceptions taken, and his reasons thereof.

7.10.2 COLLECTING PLATES AND DISCHARGE ELECTRODES

a. Collecting plates shall be 18-gauge (1.2 mm) minimum thickness. They shall have top and bottom alignment guides, stiffeners, and mountings suitable for the necessary sectionalization, rapping, and thermal expansion. Collection plate design shall be such as to minimize reentrainment of collected particulate during rapping and to minimize electrical erosion. Material of construction shall be A-36 carbon steel.

b. Discharge electrodes shall be of the rigid or rigid frame type of the manufacturer's proven design for the specified conditions of service and shall be stabilized against movement. Material of construction shall be A-36 carbon steel.

c. Mechanical terminations and connections of discharge electrodes to support frame, shall provide sufficiently positive electrical contact to prevent spit-arcing and premature failure, and shall eliminate undue mechanical stress leading to rapid metal fatigue and breakage, particularly that associated with high-tension rapping operations.

d. Insulator compartments shall have dusttight hinged doors for access. Access doors shall be key interlocked.

e. Alumina support insulators shall be used to support the high-voltage system. Handholes shall be provided for the purpose of cleaning the inside of the insulators from the top. The Vendor shall provide a 4 point suspension system for the high voltage bus sections.

f. High-tension insulator compartments shall be provided with electric heaters and shall be pressurized and ventilated by filtered and heated air furnished by electric motor driven blowers of adequate design and capacity. Filters shall preferably be of the washable type adequately sized for use in dusty atmospheres. A ring or strip heater shall be used on the outside of each insulator. Wiring to the strip heater terminals shall be nickel-plated copper with 600-volt teflon-glass insulation, or equal (NEC designation type TFE).

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7.10.3 RAPPING SYSTEM

a. Rapping equipment shall be arranged to operate in sequences that will eliminate stack puffs.

b. The rapping system for the discharge and collecting electrodes shall be of proven design for the specified conditions of service. Impact rapping shall be used.

c. Electrical failure of a rapper shall be indicated on the rapper control panel, and alarmed.

d. Provisions shall be made for the elimination of high-voltage spikes in the rapper electrical system. The Vendor shall design the electrical system to include any suppressors or other devices as required so that rapper electrical connections will not require conductors with insulation levels in excess of 600 volts.

e. Rapper control cabinets shall be located in the precipitator electrical control room near the precipitator.

f. The rapping system shall be designed so that the intensity and frequency can be adjusted.

g. Vendor shall indicate "G" forces on plates due to rapping. The "G" forces must simulate utility experience.

7.10.4 PRECIPITATOR HOPPERS

a. The hoppers shall be constructed from minimum 6mm (1/4-inch) thick A-36 carbon steel plate with a 150mm x 150mm x 25mm (6" x 6" x 1") striking anvil on all sides of the hopper extending at least 100mm (4 inches) past the insulation.

b. The number and size of hoppers shall provide a minimum of 12 hours storage of dust at design gas flow, efficiency, and maximum inlet dust loading.

c. Dust storage time shall be based upon dust level being 600mm (24 inches) below the lowest ionizing member over the hopper having the heaviest loading. Hoppers shall be arranged with necessary baffles to prevent reentrainment of dust into the gas stream once deposited.

d. The density of the dust shall be taken as 560 kg/m^3 (35 lb per cu ft) for hopper sizing and 1,440 kg/m^3 (90 lb per cu ft) for structural design.

e. The hoppers shall have a minimum valley angle of 55 degrees from the horizontal. All hopper corners shall have either 75mm (3 inch) radius fillet plates welded in each hopper internal corner or 75mm (3 inch) radius integral corners. Fillet plates shall extend full length of the corners and have closure plates at the top of the hopper.

f. Hoppers shall be provided with suitable dusttight key-interlocked access and inspection doors. External access doors shall be provided on each side of internal vertical baffle plates.

g. All hopper outlets shall be at the same elevation and shall be provided with a 300mm (12 inch), 150-pound slip-on ANSI flange to accommodate ash-handling valves. Flanges shall be shipped loose for field welding to facilitate alignment during erection.

h. Each hopper shall be provided with a 100mm (4 inch) pipe nipple fitted with a quick removable cap located near the hopper outlet to facilitate emergency probing.

i. Each hopper shall be designed to sustain its own weight, plus the weight of fly ash equal to its enclosed volume plus the weight of the ash removal piping.

j. The exterior surfaces of the hoppers shall be suitable for the application of insulation, lagging, hopper heaters and vibrators.

k. Vendor shall furnish vibrators, one for each hopper, to be controlled by the Owner's ash removal system. There shall be a "jog" pushbutton station by each hopper for manual operation of the vibrator. If an internal hopper baffle is provided, vibrator shall operate on this baffle.

7.10.5 HOPPER LEVEL INDICATION

a. The Vendor shall provide hopper level indication sensors for each hopper. Sensors shall be of the radiation type which have proven reliability for the service conditions. Radiation sources shall be furnished with safety shutters to shield maintenance personnel from harmful radiation. The Vendor shall provide necessary linkages to extend shutter operators for safe access from the hopper deck.

b. Output of sensors shall be suitable for alarming in the electrical control room and at the Owner's annunciator panel in the main control room. Alarm level shall be a minimum of .6m (2 feet) below the lowest ionizing member.

c. Provisions for key interlocking the safety shutters into position prior to opening the hopper access doors shall be provided.

7.10.6 HOPPER HEATING SYSTEM

a. The lower two-thirds of each hopper shall be heated by modular electric element type heaters. The heaters shall be capable of heating the empty hoppers to 120°C (250° F) within 8 hours at the ambient conditions specified in Paragraph 7.2. Thermostat controls shall be adjustable and able to maintain hopper and ash temperature over a range of 90°C (200° F) to 150°C (300° F) under all conditions. The heaters shall be capable of withstanding, without fatigue or failure, all vibrations and shock loads that can be experienced during operation of the precipitator and associated power station equipment.

b. The Vendor shall supply a separate dusttight and weatherproof NEMA 4 terminal box for each hopper, to be located outside the hopper insulation. Power terminal blocks shall be used for heater power supply, and thermostat wiring shall be terminated in the boxes on control terminal blocks. Control switches for hopper heating shall be located on a panel in the local precipitator electrical control room. Failure of a particular hopper heater shall be indicated on the heater control panel by an ammeter or indicator light and shall activate the annunciator.

Sufficient wattage of heaters shall be provided and they shall be evenly distributed so that at no point shall the ash temperature go below 121°C (250°F). High temperature concentrations shall be avoided to prevent buckling of metal structures.

c. Heater wiring shall be arranged to allow disconnection of individual heaters or groups of heaters at the terminal box.

7.10.7 SAFETY INTERLOCK SYSTEM

a. A complete safety key-interlock system shall be furnished to prevent opening or closing of any access doors except when the power circuit to the collectors is de-energized and the collector system grounded. Doors to be included in the key-interlock system shall include those which provide access to the electrostatic precipitator electrical equipment, rectifiers, and ductwork, except interior bolted access openings. The system shall be designed so that it will be impossible to enter an area where high voltage is a hazard without first turning off the power and grounding the high-tension elements, and so that it will be impossible to re-energize the equipment until all access doors have been closed and locked.

b. Safety interlock devices shall also be installed on all quick-opening ash hopper access doors when there is a danger of contact with hot fly ash, and on the supplied radiation type hopper level detection system.

c. Access to control panels and T/R cabinets shall be included in the system.

d. One set of interlocks and keys shall be furnished for the precipitator. No duplicate keys shall be furnished.

e. "Danger - High Voltage" signs shall be affixed at all places where access to equipment or conduit is provided for maintenance and inspection by operating personnel.

f. All access doors and hatch covers shall include provisions for padlocking in the open position to prevent accidental closing while maintenance personnel are inside.

7.11 STRUCTURAL

7.11.1 The structural support for the precipitator and inlet and outlet ductwork and plenums/nozzles shall be supplied by the Vendor. The Vendor shall supply the Engineer with the necessary information to design the foundations. Such information as a minimum shall include support (column base) locations; base and anchor details; specific load tables for dead loads, full hopper dust loads, seismic loads, live load, thermal growth forces, and magnitude and direction of support point movements. The Vendor shall provide the inlet and outlet flange expansion to the Engineer for his use in determining his breeching. Vendor shall state any additional criteria such as deflection limitations required of the foundations.

7.11.2 The precipitator shall be designed for seismic conditions in accordance with ANSI A58.1 recommendations for Seismic Zone 1.

7.11.3 The equipment shall be designed for fabrication into the largest sections allowable for shipping to facilitate field erection. The Vendor shall furnish all nuts, bolts, gaskets, and other materials necessary for complete field erection of any equipment within Vendor's scope of supply.

7.11.4 Precipitator Shell Enclosure

a. The shell, roof, and plenums shall be fabricated from 5mm (3/16 inch) minimum ASTM A-36 steel plate suitably reinforced to withstand the pressures specified and to eliminate vibrations due to the mass volume of gas passing through the precipitator. All nominally horizontal surfaces shall be sloped to ensure drainage.

b. The Vendor shall provide any perforated plates or other gas distribution devices required at the inlet and outlet of the precipitator to insure proper gas distribution.

c. The precipitator and plenums shall be equipped with necessary hinged inspection and access doors, key interlocked for safe operation and maintenance (see Paragraph 7.10.7). Inspection and access doors shall be capable of gastight sealing after repeated opening and closing. Access doors shall be the "quick-opening" type, packed with insulation, and mounted on extended frames to provide for finishing of outside insulation. Door openings shall be a minimum width of 600mm (24 inches). All access openings to the high-voltage system shall be provided with a permanently mounted flexible grounding device.

d. The precipitator shall be complete with the necessary internal walkways to facilitate inspection and maintenance. It is recommended that walkways be located at the top and bottom, before and after each mechanical field. Walkways shall be a minimum of 600mm (24 inches) wide.

e. Sufficient internal baffles shall be provided to prevent dust and gas crossflow.

f. The Vendor shall provide electrical ground pads on the precipitator housing. The pads shall be drilled and tapped for two 12.7mm (1/2 inch), 12 UNC bolts on 45mm (1 3/4 inch) centers to match Owner's ground cable lug connectors.

g. The roof of the precipitator and all equipment that penetrates the roof shall be designed and erected so that gas and dust will not leak into the enclosure from the main precipitator gas flow chamber under the design pressures.

h. The exterior surfaces shall be suitable for the application of insulation and siding.

i. The Vendor shall design and furnish monorail equipment for removal and installation of T/R sets. The minimum shall include at least a pair of end trucks, two trolleys, I-beams, motorized hoists, and required structural members.

The system shall be arranged such that materials may be easily handled between their installed position on the precipitator and grade elevation.

7.11.5 Ductwork and Expansion Joints

7.11.5.1 The Vendor shall design furnish, and erect all flue gas ductwork, hoppers, expansion joints, supports and hangers, gas distribution and mixing devices, test ports, and instrument connections required for the system. Ductwork shall include the following:

a. Ductwork from the boiler air heater outlet to the inlet of the precipitator and from the outlet of the precipitator to the inlet of the I.D. fan.

7.11.5.2 Technical Requirements

a. Design

1. Ductwork shall be designed in accordance with the following criteria:

(a) Max gas velocity for design flow at 100 percent of steam generator rated capacity:
m/s (ft/min) 18.3 (3600)

(b) Insulation load;
Kg/m^2 (lb/ft^2) 48.8 (10)

(c) Dust load, floor surface:
Kg/m^2 (lb/ft^2) 879 (180)

(d) Live load, where applicable:
Kg/m^2 (lb/ft^2) 734 (150)

(e) Min design pressure and design vacuum:
± 7.46 kPa (± 30 in H_2O)

(f) Design temperature:

Continuous Operating	Maximum Transient
149°C (300°F)	343°C (650°F)

Note: The maximum transient temperature excursion shall be assumed to have a duration of 30 minutes.

2. Inlet, outlet plenums and ductwork shall be designed to prevent any accumulation of fly ash on their slopes

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or horizontal surfaces, especially the bottom plate, from 50 to 100 percent of design gas flow. However, all inlet, outlet nozzles/plenums or manifolds, ductwork and their support and stiffening steel shall be structurally designed for an accumulation of fly ash. Horizontal surfaces and sloping surfaces up to 30 degrees shall be designed for an accumulation of 910mm (3 feet) of ash. Sloped surfaces, 30 degrees to 76 degrees, shall be structurally designed for 300mm (1 foot) of ash, using a density for the fly ash of 1442 kg/m^3 (90 lbs/cu ft).

3. Ductwork shall be designed to prevent pulsations and noise generation.

4. Ductwork shall be designed with sloped bottoms and hoppers, if required, to prevent fly ash buildup and to ensure condensate drainage. Drain ports shall be provided at suitable points to remove liquids (entrained or condensed) which have settled out of the flue gas stream, from the bottom of the ducts.

5. Maximum allowable stresses in the materials shall be in accordance with Section 1.5.1 of the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. The value of F_y for material for the design of the ductwork and internal bracing and trusses shall be 0.2 percent offset yield strength at the design temperature.

b. Fabrication and erection:

1. Ductwork shall be of all welded construction except as specified otherwise herein.

2. All ductwork materials and accessories shall be shop seal welded with field bolted fit-up except where bolted connections are indicated on the Vendor's drawings and accepted by the Engineer.

3. Where field fit-up and seal welding are required, joints shall be constructed so that the overlap shall be in the direction of the gas flow and the seal weld shall be done on the gas side.

4. The ductwork shall be fabricated in shipping units. Shipping units shall be designed and fabricated within the limits of shipping requirements, to require a minimum of field welding.

5. Internal duct bracing and trusses shall be installed in the shop at intervals of approximately 6.1m (20 feet) and shall be constructed of steel pipe with wall thickness sized for design stresses. Provisions shall be made for field connection of the bracing and trusses between ductwork sections, where required, by seal welding. The maximum L/R ratio for bracing shall be 120.

6. Gas distribution and mixing devices shall be provided with stiffeners and supports, and shall be designed to preclude vibration or flutter in the gas steam under all specified flow conditions. The devices shall be bolted to the ductwork so that they are removable.

7. External duct stiffeners shall use shapes of the same depth to facilitate installation of insulation and lagging. Fabricated shapes made from plates may be substituted for rolled shapes if the properties of the fabricated shape are equal to or better than those of the rolled shapes. The maximum span to depth ratio for external stiffeners shall be 24.

8. Access doors shall be provided to permit access to all ductwork sections, absorber module elbows, and between all major items of equipment. The doors shall not be less than 450 x 600 mm (18 x 24 inches) in size. The doors shall be accessible and provided with access ladders where required.

9. Ductwork flanged joints shall be used to join expansion joints, dampers, precipitator inlet and outlet, and induced fan inlet to the ductwork. Templates shall be used for field drilling holes to match the holes in the various pieces of equipment. The Vendor shall furnish all required ductwork templates. The flanges shall be provided with fit-up and assembly bolts and shall be seal welded. Seal welding at the expansion joints will be required only if a steel flange is provided with the expansion joint.

10. Fabrication tolerances shall be controlled to permit the ductwork to be erected within 1/8 inch of locations dimensioned on drawings. Miscellaneous steel shall be erected to AISC tolerances. At joints, each edge shall match the adjoining edge within a tolerance of 3 mm (1/8 inch). Edges and corners which do not fit up within this tolerance shall be reworked or replaced.

11. The ductwork shall be arranged as required by the precipitator system design and results of the model tests, and for accessibility for monitoring and testing, use of space, and appearance.

7.11.5.3 Expansion Joints

a. Expansion joints shall be elastomer type reinforced with fabric or wire, with a complete structural frame of the picture frame type.

b. Expansion joints shall be designed, detailed, and constructed to withstand temperatures, velocities, pressures, chemicals, and other service conditions as defined in this Specification.

c. Expansion joints shall be assigned to give the design life under deflections which may be a combination of axial motion, rotation, and lateral movement. Expansion joing deflection forces shall be computed by the Vendor. The magnitude of forces generated by expansion joint deflection may be limited by the capacity of equipment to absorb these forces, as in the case of fans or air heaters.

d. Expansion joints shall be sized and designed to meet the conditions specified herein and the arrangement of the Vendor's ductwork with respect to expansion, contraction, and offsets. Each joint shall be sized to accommodate all anticipated movements without stretching or tearing the joint.

7.11.5.4 Supports and Hangers

a. All necessary hanger assemblies and miscellaneous hanger steel shall be furnished. Hangers shall be designed for attachment to the support framework using suitable welding brackets. In such cases, the miscellaneous structural steel shall be provided by the Vendor. Special attention shall be given to hangers around transition sections, openings, and access doors. Hanger assemblies shall be designed for a clean appearance. Structural steel angle hangers and brackets shall not be used.

b. If bottom support is used, the Vendor shall furnish column stubs and Merriman Lubrite slide plates.

c. The allowable working stress in the hanger rods shall not exceed 62,050 kPa (9000 psi). Loads to the hanger rods shall take into consideration all ductwork loads including dead load, duct load, live load, wind and earthquake, and any bending stresses introduced during expansion, contraction, or offset movements of the ductwork.

d. The safety factors allowed for the design of hanger clevises and turnbuckles shall be at least those specified for the hanger rods. Turnbuckles and clevises shall be of forged steel with safe working loads and minimum dimensions as described in the AISC Manual of Steel Construction, Seventh Edition, Pages 4-126 and 4-127.

e. Constant or variable spring load hangers may be used by the Vendor; however, variable spring hangers will be allowed only with the approval of the Engineer. Spring hangers shall be VS or CS type as manufactured by Grinnel or Basic Engineering or shall be an equal hanger.

7.11.5.5 Test Ports

Test ports to obtain samples shall be provided at locations acceptable to the Engineer and in accordance with the recommendations derived from the model tests.

7.11.5.6 Instrument Connections

Instrument connections shall be provided as required to permit installation of instrumentation required to monitor and control the operation of the precipitator system.

7.11.6 Structural material specifications shall include the following:

a. Structural steel:

   1. All structural steel used in the Work and not otherwise designated shall be new and conform to ASTM A 242 or A 36.

   2. High-strength bolts shall conform to ASTM A 325.

   3. Welding electrodes shall be suitable for the type of steel to be welded.

b. Galvanized grating and grating treads shall conform to one of the following specifications:

   1. ASTM A 569, "Specification for Steel, Carbon (0.15 Maximum Percent) Hot-Rolled Sheet and Strip, Commercial Quality."

   2. "Specifications for Metal Bar Grating and Metal Bar Grating Treads" from Metal Bar Grating Manual by

National Association of Architectural Metal Manufacturers.

3. Steel grating, steel grating stair treads, and clip fasteners shall be hot dipped galvanized in accordance with ASTM A 123.

4. Cutouts and alterations shall be completed before galvanizing.

c. Handrails:

1. Handrails shall be made of ASTM A 501 material.

2. Handrails shall have one rail centerline 600mm (2 feet) above the finished floor level and a second rail centerline 1m (3 feet 5 inches) above finished floor and shall be made of 40mm (1 1/2 inch) standard pipe.

3. Posts shall be made of 40mm (1 1/2 inch) extra strong pipe and shall be spaced at not more than 2.4m (8 feet) c.c.

4. All joints shall be welded and ground to a smooth finish. Turns shall be made by the use of pipe bends.

7.11.7 The Vendor shall furnish all platforms, toeplates, walkways, stairways, and pipe handrails that are required for access to all parts of the equipment furnished by him. The limits of the Vendor's Work shall be from grade level to the top of the precipitator.

Platforms and walkways shall be provided for all specified access doors.

7.12 ELECTRICAL

7.12.1 The precipitator shall include a redundant field in the direction of gas flow such that the specified performance requirements can be satisfied with one field de-energized.

7.12.2 Electrical equipment with the exception of heaters shall be designed to operate with maximum temperature rise in accordance with applicable standards based on a 40°C ambient.

7.12.3 The power supply control panels and the transformer/rectifiers shall be equipped with a safety key-interlock system for preventing personnel from gaining access to the high-voltage elements while energized. (See Paragraph 7.10.7).

7.12.4 The Vendor shall provide the transformer/rectifier controllers with all the necessary control components completely wired, including all terminal blocks for precipitator power from the plant power supply. Units shall be of the high-speed silicon controlled rectifier type, designed to maintain the optimum precipitator voltage and current for variations in operating conditions with simultaneous supply voltage variations of plus 10 or minus 10 percent. T/R assemblies shall be designed for single-phase power input. Single-phase power groups shall be arranged and connected to minimize any load imbalance imposed on the Owner's three-phase power supply.

7.12.5 The vendor shall supply on T/R set per electrical bus section.

7.12.6 Silicon-type rectifier cells shall have a Peak Inverse Voltage (PIV) safety factor of at least 1.5. Suitable capacitors or capacitor and resistor networks shall be connected in parallel with the rectifiers to suppress low energy transients and to distribute the effects on long rectifier strings of steep voltage wave forms that may be impressed during switching or sparking. These capacitors or any other furnished electrical equipment shall be designed to contain no measurable amounts of Polychlorinated Biphenyls (PCB). Controlled avalanche-type rectifiers may be used without surge suppression networks, provided an adequate PIV safety factor is used. Rectifier assemblies shall be removable without dropping level of insulating fluid. Wires which must be removed for rectifier removal shall have vibration-resistant plug-in connectors. Bolts, nuts, or other mounting hardware which must be removed for rectifier replacement shall be of a high dielectric strength, nonconducting material.

7.12.7 If required, suitable low-loss impedance shall be included in the high-voltage circuit to limit circuit capacitance discharge current to values compatible with current rating of the rectifying elements used.

7.12.8 A sufficient amount of insulating fluid shall be furnished to fill the T/R tanks to the proper level for initial operation. Manufacturer's specifications and characteristics of this fluid shall be submitted to the Owner. This insulating fluid shall have a flashpoint greater than 300°C and be tested per ASTM D93.

7.12.9 The transformers shall include drain and sampling valves, level, pressure, and temperature gages, and grounding terminations. The rectifiers shall be easily removable for replacement. A grounding switch shall be provided which can be used to ground the precipitator. This switch shall be located in an air-filled terminal chamber attached to the T/R tank and interlocked to prevent closing onto an energized bus. A window shall be provided in the switch enclosure through which the contact position may be viewed. The design shall include a terminal box containing transformer primary connections, rectifier positive terminals, and ground terminal. A fluid containment basin shall be provided to contain leaking fluid in the event of tank failure.

7.12.10 Primary taps shall be included on the transformers, if required by the control system supplied. The transformers shall have electrostatic shielding between primary and secondary windings and shall have suitable shielding of the high-voltage coil to accomplish proper voltage division in the transformer when the unit is subjected to surge conditions encountered in electrostatic fly ash collector application. The transformer and rectifier set and cabling shall keep RFI at a low acceptable level.

7.12.11 Linear reactors shall be furnished with taps for the purpose of matching reactance to various operating conditions. It is preferred this reactor be located in an air-filed compartment attached to the T/R tank.

7.12.12 The Vendor shall provide all high-voltage power cable from the T/R sets to the T/R controllers. It is preferred that the rectifiers be connected to the electrode with conductors enclosed in weathertight ducts and that rectifying equipment be so located as to permit a minimum length of high-voltage duct. This duct shall have removable bolted covers to provide access to high-voltage conductor for connecting portable ground cables to the bus duct and for cleaning T/R set insulators. Provisions shall be made to prevent accumulation of condensation or rainwater seepage within the bus ducts. If high-voltage cable is used for connecting the electrical equipment and precipitator, it shall be of the type not requiring conduit and shall be adequately supported.

7.12.13 The electrical power available is 400V, 3 phase, 50 hertz, and equipment shall operate satisfactorily with a voltage range of 323-418 volts. A Westinghouse Current Limit-R or Tri-pac, or approved equal, molded case circuit breaker, 150,000 amperes interrupting capability, shall be furnished as a feeder disconnect for each control panel.

7.12.14 Suitable radio interference preventive equipment shall be provided in order to avoid interference with radio transmitting and receiving stations in the vicinity of the installation, or a guarantee shall be made stating that such equipment is not required.

7.12.15 All power cables shall be sized to adequately supply the loads and provide a maximum of ±3 percent voltage drop. Cable shall be based on 90°C EPR insulated with a heavy-duty chlorosulfonated polyethylene jacket and sized per ICEA ratings. Cable shall be derated for grouping, raceway type, and ambient temperature. A cable circuit list of cable sizes , circuit description, route, and lengths shall be provided to the Engineer. The Vendor shall provide all cable.

7.12.16 The raceway system shall be designed, sized, and laid out in accordance with NEC requirements.

7.12.17 All circuit interrupter devices shall be adequately sized to interrupt the available fault current. The maximum available fault current is 50,000 amperes rms symmetrical at 400 volts. The Vendor shall coordinate the protective devices so that the device closest to the fault isolates the fault. The Vendor shall furnish the Engineer all the information necessary for a short circuit and electrical system coordination study.

7.12.18 The Vendor shall furnish 380 volt combination motor starters and contactors in accordance with the attached motor starter specifications.

7.12.19 The Bidder shall furnish, with the Proposal, power one line drawings, control schematic drawings, and interconnection drawings to the Engineer.

7.12.20 All electrical control equipment cable shall be terminated at terminal blocks. The terminal blocks shall be numbered and shall agree with the schematic and wiring diagram.

7.12.21 Control voltage required shall not exceed 250V. The Vendor shall supply necessary control transformers to obtain the control voltage.

7.12.22 The Vendor shall provide a local visible circuit interrupting means in NEMA 4 enclosures located near each motor or load. This shall be molded case circuit breaker or stop L.V. pushbutton station.

7.12.23 The precipitator electrical control room shall house the combination motor starters, the power distribution panels, the automatic voltage control system, the lighting panel, the small dry type transformers, the level detector control panels, the rapping panel control panels, and the master block of the key-interlock system.

7.12.24 The Vendor shall provide the Engineer with all the information needed in accordance with the schedule and in order to enable the timely purchase and delivery of equipment to be supplied by Others.

7.12.25 Each motor (for rapper, blower, etc.) shall be connected to its supply by means of a full voltage combination motor starter which shall include a motor circuit protector and overcurrent protection. Control voltage shall be 230V, 50 hertz, grounded, obtained from an individual control transformer with a fused secondary circuit.

7.13 INSTRUMENTATION AND CONTROLS

7.13.1 Control systems provided for the precipitator control shall consist of:

a. Automatic voltage control

b. Rapper controls

c. Supervisory system for remote controls and monitoring

d. Hopper heater controls

e. Hopper high level indication.

7.13.2 A local control module for each of the T/R units shall be provided. The local control module shall provide:

a. Local controls

b. Digital displays

c. Alarms

7.13.3 Each local control module shall include manual voltage raise/lower, system auto/off/standby, manual rap and parameter settings back lighted pushbuttons.

7.13.4 Each local module shall include the following digital displays:

a. Kilowatts

b. Bushing voltage

c. Bushing current line volts

d. Line current

e. Ductwork

7.13.5 Each local control module shall include the necessary alarm indicators. These alarms shall be held until reset by the operator.

7.13.6 An electrostatically shielded isolation transformer shall be provided for the local control module power source.

7.13.7 The precipitator control system shall control the rapping drive motors for the collector and discharge electrode. The rapper controls shall be:

a. Cyclic rapping

b. Manual rapping

In the cyclic rapping mode, the rappers shall be controlled on a programmed timing cycle. The manual rapping mode shall be initiated by the operator.

7.13.8 Each rapper motor control center shall include a selector switch with Auto-Local position. In the "Auto" position the rapper shall be operated through the automatic control system. In the Local position, the rappers can be operated independently of the automatic controls.

7.13.9 A remote supervisory control and monitoring system shall allow all control functions and annuciation availabe at the local control module.

7.13.10 ALARMS AND INTERLOCKS

7.13.10.1 The following alarms shall be indicated on the local control module and on the remote supervisory monitoring system.

a. Loss of communication between the supervisory and the local control module.

b. T/R oil temperature high.

c. Rapper failure.

d. Primarv overcurrent.

e. Main breaker trip.

f. Secondary low voltage.

g. Boiler trip (contact closure supplied by the Owner.)

h. Hopper high ash level.

i. The following condition shall trip a T/R set:

1. T/R oil temperature high-high.

2. Primary overcurrent.

3. Secondary low voltage.

4. Boiler trip.

7.13.10.2 The boiler trip signal shall not trip the rapper motors.

A dry contact shall be provided for any alarm conditions as listed in Paragraph 7.9.6, for the Owner, 125 volt dc annunciator system.

7.13.11 HOPPER HEATING SYSTEM CONTROLS

7.13.11.1 Each hopper shall include an indicating type temperature controller.

7.13.11.2 Each hopper heater control system shall include a selector switch with ON-AUTO-OFF selector switch. This switch shall be mounted on a dedicated hopper heater panel.

7.13.11.3 In the AUTO mode, the hopper heater shall automatically turn ON and OFF at the predetermined temperatures.

7.13.11.4 Each hopper heater control system shall include the following status lights:

a. Red light heater ON.

b. Green light heater OFF.

c. Amber light heater malfunction.

7.13.12 CONTROL PANELS

7.13.12.1 All instrumentation, alarms, and controls required for normal operation of each precipitator shall be located within, or be mounted on, the control panel.

7.13.12.2 Control panels (cabinets and cubicles) shall be freestanding, self-supporting, of NEMA type 12 design for mounting in the electrical control room.

7.13.12.3 Control panels shall be of welded construction fabricated with flat, free from pitting, high-grade sheet steel. Joints shall be welded continuously and ground smooth so that joints are not visible or open after the final paint finish is applied. The panels shall be reinforced with suitable angles and braces, where required, for strength without affecting access to or operation of panel-mounted equipment.

7.13.12.4 Each panel shall have both front and rear access using gasketed doors with butt-type, liftoff-type, steel hinges and locking handles. The latching mechanisms shall secure the door at the lock, and at the top and bottom. Doors on all cabinets shall be keyed alike.

7.13.12.5 Filters and plenum chambers shall be provided at the top and bottom of the panels to allow air distribution for cooling purposes and shall be readily accessible for maintenance. Heat-generating equipment shall be mounted near the top of the panel, except that heavy equipment such as reactors and transformers may be floor mounted if adequate isolation and ducting are provided to vent hot air away from other equipment. Cooling fans, if required, shall be installed to direct forced air flow from bottom to top of the panel.

7.13.12.6 Panels shall contain internal mounting racks for mounting of all terminal blocks, modules, and all required power supplies. Each piece of equipment shall be mounted in the racks in such a manner that its removal and replacement can be accomplished without disturbing adjacent equipment. Ample space shall be provided for access and servicing of all equipment. A fluorescent fixture low minimum lamp socket shall be provided near the top of the panel for internal illumination with switch inside panel at a convenient location.

7.13.12.7 Panels shall be equipped with removable lifting eyes and shall have an integral lifting frame so that the panels can withstand all lifting forces without distortion.

7.13.12.8 Sufficient access channels or holes at the top and bottom shall be provided for all incoming field cable and conduit required by the system. No site wiring connections shall be necessary in the panels except termination of Vendor-supplied prefabricated cable and field cables. Ample space shall be provided to allow spreading and bending the Owner's incoming cables in a neat and orderly manner.

7.13.12.9 Terminal blocks shall be rated 600 volts stud type and include barriers between terminals, have identification marker strips, and shall be suitable for ring-tongue, wire lug connections. A sufficient number of spare terminals (not less than 15 percent shall be provided. Vendor's connections shall be, and Owner's connections will be, by compression type lugs. Terminal blocks shall be arranged such that all Owner's field wiring is terminated and identified on one side of the block and all Vendor's wiring is shown and identified on the other side. Also, Vendor's and Owner's field wiring shall not occupy the same space between adjacent parallel rows of terminal blocks. Design shall be such that no more than two lugs may be terminated under any one terminal screw.

7.13.12.10 Wherever possible terminal blocks shall be mounted in a vertical configuration. Adequate spacing shall be provided between vertical columns for routing the interconnecting cables. Where more than 50 terminal points are mounted in any vertical column, a wiring raceway shall be provided for enclosing Vendor's wires which terminate on these terminal points. Raceway shall have a minimum cross-sectional area of 161cm^2 (25 square inches for each full length column of terminal blocks. Vendor's wires to terminals shall be installed in that portion of the raceway farthest from the removable raceway cover. Intraboard wiring shall not run through these raceways.

7.13.12.11 Panel wiring shall be installed in a neat manner so as not to obstruct access to devices and shall be secured and supported to avoid straining. The Vendor shall provide control wiring and termination facilities in accordance with the following requirements:

a. All control wiring shall be 600 volt, 90°C flame-resistant, 14 gage (AWG) minimum, stranded copper wire with type SIS insulation.

b. Power terminal connectors, for wire 8 AWG and larger shall be compression type, heavy duty, cast copper, two hole flat tongue type terminals, Series 53200, as manufactured by Thomas & Betts or as approved by Owner's Engineer.

c. Control wire terminals, for 10 AWG wire, shall be terminated with preinsulated, grip-pressure type copper sleeve connectors, type PIDG, as manufactured by AMP Special Industries. A ring-tongue compression connector shall be used where a termination is required on a screw or stud type terminal and shall be used for butt type splice or pigtail connection. The correct crimping procedure and tool shall be used.

d. The color coding of control and instrument wiring shall comply with NEMA WC 30.

e. Cable grouping and conduit shall be employed for the different types of signal wiring separations. The separations are required to minimize noise introduction from one circuit into another.

f. The panel wiring shall be in accordance with the detailed point-to-point wiring diagram made by the Vendor.

g. Each terminal point and wire shall be permanently identified by the wire number corresponding to that shown on the wiring diagram. Identification shall be located so that it does not require removal during a repair.

h. Wire termination lugs shall be crimped with the lug manufacturer's approved tool that requires complete closing before it can be reopened. All tools used shall be certified in accordance with ANSI C83.79.

i. Hinge wiring shall be multistrand, extra flexible, arranged so that flexing shall take place in the longitudinal axis of the conductor (twisting), rather than across the conductor (bending).

j. The ac supply to instruments, meters, and transducers shall be connected by means of a receptacle strip terminal block so that these devices can be safely disconnected for test or calibration in the Owner's instrument shop.

k. Provision shall be made for grounding panels and instruments:

   1. Each panel shall be equipped with a copper ground bus, 25mm x 6mm (1" x 1/4") including ground clamps, extending the full length of the enclosure. The steel panel structure shall be connected to the main ground in a manner to effectively ground the entire panel.

   2. A ground lug for No. 4/0 copper cable shall be provided at both ends of each panel.

   3. All instrument cases shall be grounded to the panel by use of split lock washers on at least one mounting stud.

   4. No wires shall be grounded unless indicated on Drawing.

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l. Panel labeling and nameplates shall conform to the following requirements:

1. Nameplates shall be provided for all control units, auxiliary equipment control panels, and circuit components.

2. Nameplates on panel exteriors shall be micarta or equal having 6mm (1/4" high) black letters on a white background. The nameplates shall be attached with stainless steel screws or Goodyear Pilobond Adhesive.

3. Nameplates shall also be provided on the panel interior for identification of all panel mounted equipment. The interior nameplates carry the same specifications as the exterior nameplates.

4. Each panel shall have a large master nameplate on the front for identification with letter heights 12.7mm (1/2") minimum.

5. Switches, pushbuttons, indicating lamps, potential transformers, etc., shall be identified by nameplates. Letter height shall be 6mm (1/4") minimum. Nameplates shall be 19mm by 76mm (3/4" by 3") minimum.

6. Fuses, relays, terminal blocks, and other devices mounted inside the panels shall be identified by nameplates attached with adhesive, or by printed or stenciled inscriptions.

7. The manufacturer's name, address, type designation, identification references, and equipment ratings shall appear on a suitable nameplate securely fastened to control panels.

m. Each control panel shall be factory tested in accordance with the following provisions:

1. Wiring shall be examined for workmanship and be checked for conformance with approved wiring diagrams.

2. Screws and nuts securing wiring to terminals shall be checked for tightness.

3. Control wiring shall be tested for correctness, absence of short circuits, and continuity in accordance with ANSI C37.20, Section 5.3.4.1.

4. Wiring shall be high potential tested in accordance with NEMA ICS-1, 109.21. Precautions shall be taken to protect meters, instruments, and solid-state devices from damage caused by overvoltages.

5. A written certification of tests shall be submitted.

6. The testing will be witnessed by the Owner or the Engineer.

7.13.12.12 In the design of control panels, maximum human engineering factors shall be considered i.e.,:

a. Use of higher archive labelling.

b. Demarcation of control devices, etc.

7.13.12.13 The supervisory control and monitoring system shall include all necessary modules, relays, terminal blocks, ac outlets, etc., required for the supervisory system.

7.14 ACOUSTIC REQUIREMENTS

7.14.1 The Vendor shall submit as part of his Proposal a tabulation of octave band sound power levels in accordance with 7.14.3 below for the equipment being quoted without acoustic treatment or guarantee. The Proposal will be considered incomplete without this information.

7.14.2 The Vendor shall submit as part of his Proposal an additional price for a guaranteed maximum sound level of 90 dBA (90 decibels, A network weighted) when measured with a Type I precision sound level meter at slow response and at a distance of 1 meter (3 feet) in any direction from the nearest surface of the equipment. The Vendor shall also submit with his Proposal a tabulation of octave band sound levels in accordance with 7.14.3 below for the equipment in the sound attenuated condition.

7.14.3 The Vendor shall complete and submit as part of his Proposal the attached Acoustic Data Summary Sheet. It is preferred that the octave band levels be sound power levels in decibels with a reference power of 10 (exponent -12) watt. However, sound pressure levels in decibels with a reference pressure of 0.0002 microbars will be acceptable providing the weighting network and distance to the sound source are indicated. In the event acoustic data for similar equipment will be acceptable. However, the equipment differences should be indicated and the Vendor's estimate of the acoustical effect of these differences should be indicated.

7.14.4 The maximum sound power or sound pressure levels will be verified by measurements at the installation site at the Purchaser's discretion. The Purchaser's Engineer will perform these requested tests in accordance with standard test procedures as applicable to the particular installation or type of equipment.

7.14.5 Where no specific testing procedure is applicable, verification tests shall be conducted in accordance with the following:

7.14.5.1 Institute of Electrical and Electronics Engineers (IEEE) Standard 85, "IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery."

7.14.5.2 American National Standards Institute (ANSI) S1.2, "Method for the Physical Measurement of Sound."

7.15 MODEL STUDY

7.15.1 The Vendor shall construct a model of the flue gas system, including the precipitator and all the flue gas ductwork from the boiler air heater outlets to the I.D. fan inlet and perform a set of three dimensional flow studies. The study shall be used to minimize solids buildup, minimize pressure drop, ensure proper flow distribution and velocities, determine the turndown capability of the precipitator, and generally optimize the overall ductwork configuration. The studies shall also be used to determine the locations for accurate performance testing.

7.15.2 The entire flue gas system from the outlet of the air heaters to the I.D. fan inlets shall be included in the model study. The minimum acceptable scale for the model study shall be 1/10 of full size. The model shall be constructed of 1/4-inch thick, clear Plexiglas to the greatest extent possible. All supports, stiffeners, flow control devices, and any other items located inside the ductwork shall be modeled into the ductwork. Duplicated or redundant items in the flue gas system shall not be removed for the model study.

7.15.3 Airflow tests shall be run at 50, 75, and 100 percent of full load capacity to determine potential problems of gas distribution and ash fallout and the placement of duct hoppers.

7.15.4 All instrumentation used in the model shall be calibrated against a validated laboratory standard device. The Vendor shall use an airflow meter approved by the Engineer either upstream or downstream of the model. The airflow meter shall be capable of measuring flow from the maximum flow down to 25% of the maximum with an accuracy of $\pm$ 2 % of the measured variable.

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7.15.5 The data taken from the model shall include at least the following items for all flows:

a. Inlet flow distribution to the precipitator.

b. Outlet flow distribution of the precipitator.

c. Pressure drop in the ductwork.

d. Pressure drop across the precipitator.

e. A scale drawing of the model showing actual dimensions.

f. 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.

g. Isovelocity diagrams and histograms, indicating the coefficient of variation (velocity deviation) and mean velocity, at strategic points which shall include at least the following:

(1) Precipitator inlet.
(2) After second mechanical field.
(3) Precipitator outlet.
(4) I.D. Fan inlets.

h. A complete description of the test procedures including flow rates, pressures, sample calculations, and assumptions. Any deviations in dynamic or geometric similtude by the model from the full size installation shall be listed and justified.

i. Conclusions that show type and location of devices required for proper gas distribution and any modifications necessary to the proposed ductwork. Conclusions shall state best economic solutions to the distribution problem.

j. Recommendations for location of test ports.

k. Recommendations for location of gas flow instrumentation points. The recommendations and conclusions from the model will be used in the final design of the system.

7.15.6 The Owner or the Engineer shall have the option of observing the scale model tests. The Vendor shall notify the Engineer at least 10 days prior to the scheduled testing.

7.15.7 After award of Contract, all changes to meet the Vendor's guarantees and the requirements of this Specification shall be

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made at no additional cost to the Owner. The Vendor shall make no changes to the system design after the model study has been accepted unless approved by the Engineer. After acceptance of the system, the model shall become the property of the Owner.

7.15.8 The model study shall in no way relieve the Vendor from providing a full-scale system which meets the Vendor's guarantees and provides a uniform gas distribution. If corrections are necessary after the system is built, the Vendor shall make such corrections at his own expense.

8.0 <u>PERFORMANCE REQUIREMENTS & GUARANTEES</u>

8.1 The precipitator shall be designed to be capable of continuous performance when operating under the following maximum conditions:

8.1.1 Inlet gas flow 10 fans test block flow.

8.1.2 Inlet gas temperature 150°C (300°F).

8.1.3 Highest inlet dust loading per table in Paragraph 7.7.

8.1.4 Inlet gas pressure $\pm$7.46 kPa ($\pm$30 inH_2O).

8.1.5 The vendor shall guarantee that the precipitator shall achieve a particulate emission rate of not more than .0688 kg/X10^6 KJ (.16 lb/X10^6 Btu) 100 milligrams/m^3 (.044 grains/acf).

8.2 The vendor shall guarantee that emission performance requirements shall not be qualified by requirements for pretreatment of the coal, fly ash, or flue gas when burning the specified coals.

8.3 Vendor shall state maximum pressure drop across precipitator, including flow distribution devices and nozzles and ductwork.

9.0 <u>MATERIAL REQUIREMENTS</u>

9.1 Structural material specifications shall be in accordance with Section 7.11.5.

9.2 STRUCTURAL STEEL

9.2.1 All steel plate and structural steel stiffeners shall conform to ASTM A36.

9.2.2 Welding electrodes shall be selected suitable for the base material being welded.

10.0 FABRICATION/ASSEMBLY REQUIREMENTS

The equipment shall be fabricated and assembled in accordance with the manufacturers instructions unless specified otherwise herein.

11.0 PERSONNEL REQUIREMENTS

11.1 The service charge of qualified technical consultants shall be included in the Vendor's Proposal. The technical consultants shall be responsible for ensuring that all technical direction complies with the Owner's requirements.

11.2 The responsibilities of the technical consultants shall include overseeing the following Work:

11.2.1 Unloading and transferring the equipment to temporary field storage and to final installation.

11.2.2 Installation and assembly of all equipment supplied by the Vendor on suitable foundations supplied by the Owner.

11.2.3 Inspection of assembly, alignment, and cleanliness of all parts to insure the equipment is in operable condition.

11.2.4 Initial equipment startup.

11.2.5 Instructing the Owner's operating personnel in the:

a. Conduct of such operating tests as the Vendor may specify.

b. Initial startup procedures.

c. Vendor's recommended procedures for regular starting, operating and shutting down of all equipment supplied.

12.0 INSPECTIONS AND TESTS

12.1 General Requirements for Inspection and Testing

12.1.1 Shop Inspection:

a. The Vendor shall provide the Owner with a complete manufacturing schedule showing the dates and location of all major fabricating operations, inspection hold points, and shipping, before any production is started or material is purchased for this Specification.

b. The Owner or his representative reserves the right to inspect all phases of manufacture of the equipment includ-

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ed in this Specification. Any item found to be unsatisfactory shall be rejected or repaired at no cost to the Owner. Any inspection by the Owner or his representative will not relieve the Vendor of responsibility for conformance with stated conditions and shall not be considered as a waiver of warranty or other rights. The Vendor shall notify the Owner and/or his representative at least 2 weeks prior to the time finished assemblies are ready for inspection or prior to upcoming inspection hold points.

c. The Vendor shall advise the Owner what quality control inspections are included in the manufacturing and assembly of the equipment.

12.1.2 Shop Tests:

a. All shop tests, required for certification of equipment and material to meet requirements of all regulating agencies, shall be made at the expense of the Vendor. All equipment shall be protected against corrosion or damage of any parts during or following such tests.

b. The Owner and the Engineer shall be notified at least 1 week in advance of all shop tests.

c. Certified copies of all shop test data shall be forwarded to the Owner.

d. All equipment or piping that may have been hydrostatically tested shall be checked to insure that all water has been drained from the unit prior to placing equipment in storage or on its foundation. While any equipment is in storage or on its foundation, temporary wood or steel plate covers shall be provided over flanges to prevent admittance of water to the unit.

12.2 CONFORMANCE WITH DESIGN

The Vendor shall supply a complete set of erection tolerances. In company with the Owner and/or the Engineer, the Vendor shall thoroughly inspect the precipitator to insure that the precipitator has been erected in accordance with the Vendor's drawings. Upon correction of any deficiencies in erection, the Vendor shall notify the Owner in writing that the precipitator has been erected in accordance with the Vendor's drawings.

12.3 TRANSFORMER-RECTIFIERS

12.3.1 Transformer-rectifier assemblies shall be tested and inspected in accordance with the following:

a. Resistance measurements of all windings on the rated-voltage connection of each unit and at the tap extremes, where applicable.

b. Ratio tests on the rated-voltage connection and on all tap connections, where applicable.

c. All wiring and connections shall be visually inspected before tanking.

d. No-load loss at rated voltage on the rated voltage connection.

e. Exciting current at rated voltage on the rated voltage connection.

f. Impedance and load loss at rated current on the rated voltage connection.

g. Applied potential test of 10 kV between the low-voltage winding and ground for 1 minute.

h. Induced potential test of 1.5 times rated alternating-current voltage for 18,000 cycles, with diodes removed.

i. The complete transformer-rectifier (T/R) unit shall be connected for full-wave output and rated at 125 percent of the power supply rated peak voltage output and at rated frequency into a simulated sparking-precipitator load (resistance, capacitance if available, and a sphere-gap all in parallel). A minimum of five consecutive sparkovers shall be performed at this voltage. This test may be performed at higher frequency or with series primary resistance to limit saturation of the transformer core.

j. Before and after the overvoltage test, each leg of the rectifier shall be given a complete characteristic test to demonstrate that its characteristics have not substantially changed.

k. Corona test at 120-percent rated voltage.

l. Normal maintenance procedures.

13.0 CLEANING

13.1 Electrical equipment shall be prepared for painting in accordance with the requirements of SSPC-SP-3 or SSPC-SP-7 and by additional cleaning in accordance with SSPC-SP-1, or as otherwise required to provide a clean, dry, oilfree surface.

13.2 Mechanical equipment shall be prepared for painting in accordance with the requirements of SSPS-SP-6.

13.3 Structural steel and miscellaneous metals shall be prepared for painting in accordance with the requirements of SSPC-SP-6 to a .025 to .038mm (1.0 to 1.5 mil) blast profile.

14.0 <u>CORROSION PROTECTION AND COATING</u>

14.1 STRUCTURAL STEEL, HANDRAILS, HOPPERS, AND NOZZLES

14.1.1 All steel subject to elevated flue gas temperatures and which will be insulated and lagged; such as hoppers, plenums/nozzles and side walls shall not be painted.

14.1.2 All other steel surfaces shall be painted with Ameron Dimetcote E-ZII, Valspar MZ UNI-PAK or Carboline Carbo Zinc 11. All paint shall be applied in accordance with the manufacturer's application instructions with a minimum dry film thickness of .051 to .076mm (2 to 3 mils).

14.2 T/R tanks, rappers, and the inside and outside of insulator compartments shall be painted in accordance with the manufacturer's standards. A description of painting procedures shall be submitted to the Owner (Engineer) for approval.

14.3 The interior surfaces of control panels shall be cleaned with solvent and painted with at least one coat of primer and one coat of white enamel. Exterior surfaces shall be sandblasted all over, filled and sanded as required, and painted with at least one coat of primer and two coats of paint.

14.4 The Vendor shall give all ferrous materials not prepainted an SSPC-SP-6 commercial cleaning blast before applying the shop coat. Abrasive nonskid nosings, nonferrous metals, and collecting and discharge electrodes shall not be painted.

14.5 All machined surfaces, including shafts, bearings, and couplings shall be adequately protected against corrosion and damage during shipment and outdoor storage for a period of 1 year. Openings shall be suitably capped with metal covers where possible. All weld end preparations shall be coated with Deoxaluminate or equal, and shall be covered with metal end caps prior to shipment.

14.6 Paint shall be omitted at all areas of field welding and on all steel surfaces which will be in contact with concrete. All metal contact surfaces of connections shall be painted, including those for trusses and plate girders. Touchup painting is required after field welding.

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15.0 MARKING AND IDENTIFICATION

15.1 Each package, skid, box and crate shall be marked on the outside with the following information so that it is readily visible:

a. (Owner's name)
(Project identification)
(Address)
(City, state, zip code)

b. Purchase Order Number

c. Weight:

d. Equipment Nos. as applicable:

15.2 Each unit shall be identified with a tag number. The number shall be permanently imprinted with at least 5mm (3/16") high letters on a 22 gage stainless steel tag. The tag shall be attached to the enclosure with pins of a similar material.

15.3 Each unit shall have a permanently secured data plate made from at least 22 gage stainless steel, permanently imprinted with 5mm (3/16") high letters, and containing the following information:

a. Manufacturer's name and address:

b. Model Number:

c. Serial Number:

d. Date of Manufacture:

e. Duty:

f. Weight:

15.4 The data plate shall be located where it is readily visible and shall be securely attached with pins of a material similar to the plate.

15.5 Equipment item numbers shall be utilized by the Vendor in designating equipment. Numbers so assigned by the Vendor may be reassigned at the option of the Engineer.

15.6 Items furnished under these specifications, but not identified herein, shall have tags inscribed as directed by the Engineer.

16.0 PACKAGING

16.1 To facilitate erection, the equipment shall be packaged for shipment in the largest sections allowable.

16.2 Items subject to detrimental corrosion, either internal or external, shall be suitably protected.

16.3 All exposed nonpainted surfaces shall be adequately protected and all openings shall be suitably capped.

16.4 All items shall be shipped with the "as shipped" weight clearly marked on the shipping container.

17.0 ACCEPTANCE CRITERIA

The equipment will be accepted after successful completion of all tests specified in Paragraph 12.0

ATTACHMENT 1

Refer to Electrical Motor Specifications E-1 and E-2.

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ATTACHMENT 2

Refer to Motor Data Sheets included in Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 3

480V Combination Motor Starters Specification

Reference Standards

a. National Electrical Manufacturers Association (NEMA)

1.	AB 1	Molded Case Circuit Breakers
2.	ST 1	Specialty Transformers
3.	NEMA ICS-1	General Standards for Industrial Control and Systems
4.	NEMA ICS-2 through Rev. 3	Standards for Industrial Control Devices, Controllers, and Assemblies

b. Underwriters' Laboratories (UL) UL 845 Standard for Motor Control Centers

Submittals

a. Shop Drawings

   1. Electrical schematic diagrams.

   2. Bill of material which describes the equipment, the rating, quantity, and manufacturer's part number for each component and cell in the motor starter.

b. Manufacturer's installation instructions.

Acceptable Manufacturers

a. Acceptable Products

   1. General Electric Company

   2. Westinghouse Electric Corporation

   3. Cutler Hammer Company

   4. Brown Boveri, ITE Electrical Power Equipment

   5. Siemens-Allis

b. Substitutions: Items of same function and performance are acceptable with Owner's approval.

Components

a. General Design Requirements

1. The motor starters shall be suitable for operation on a 400 volt, 50 Hertz, three-phase, four-wire high solidly grounded system.

2. The complete motor starter shall be rated for 40°C ambient temperature.

b. Electrical Design Requirements

1. Units

(a) Units shall be arranged to be withdrawn to a disconnect position and padlocked.

(b) Only standard, current model, new equipment shall be furnished. All modifications required to meet this Contract shall be noted. Obsolete models or assemblies utilizing custom built parts are not acceptable.

(c) A permanent nameplate shall be furnished for the front of each unit.

2. Combination Starters

Combination starters shall be magnetic full votlage, three-phase, 400 volt, 50 hertz. All combination starters shall have the following features:

(a) Manual reset three pole thermal overload relays furnished with heaters. The overload relay contact shall open the main contractor circuit.

(b) Motor circuit protectors with magnetic trip only and current limiting fuser which shall have a minimum interrupting capacity at 400 volts of 100,000 amperes symmetrical. Trip range shall be provided to permit settings of 10 to 14 times motor full load current.

(c) Starters shall be sized as follows:

Motor kW (HP)	NEMA Starter Size
0-75 (0-10)	1
8.2-18.6 (11-25)	2
19.4-37.3 (26-50)	3
38-55 (51-75)	4
56-111 (76-150)	5
112-223 (151-300)	6

(d) Reversing starters shall be electrically and mechanically interlocked.

(e) Electrically held combination starters shall have the following features:

(1) Two normally open and two normally closed auxiliary contacts in addition to the normally open contact used for seal-in and undervoltage protection.

(2) 230 volt, single-phase, 50 hertz, holding coil for NEMA Sizes 1 and 2 starters.

(3) Interposing relay with 380 volt, single-phase, 50 hertz holding coil shall be provided for control circuit of all NEMA Size 3 and larger starters.

(4) A 400-230 volt control transformer 200VA minimum with one secondary fuse shall be furnished for each starter.

3. Performance Requirements

All components shall be designed and manufactured in accordance with this Specification and shall operate within their rated capacity as specified regardless of whether all necessary specific performances are set forth herein or in applicable standards.

4. Material Requirements

Materials of construction shall be the Vendor's standard which have proven satisfactory in the past and meet applicable code requirements. Only new materials and components shall be used in the manufacture of equipment to be supplied under the Specification.

5. Inspections and Tests

With all of the combination starters and circuit breakers in place, the power conductors shall successfully withstand the dielectric test for 600 volt equipment performed in accordance with NEMA ICS.1-109.21.

6. Cleaning, Corrosion Protection, and Coatings

(a) Parts shall be free from dirt, scale, and unwanted grease. The equipment shall be handled throughout production and packaging so that no foreign matter will be introduced into or onto the equipment and impair its mechanical or electrical operation.

(b) The paint finish shall be the Vendor's standard.

ATTACHMENT 4

SPECIFICATION EXCEPTIONS
ELECTROSTATIC PRECIPITATOR

The Bidder certifies that the bid is complete and in absolute agreement with the requirements of this Specification, except as specifically stated below. (Use additional sheets if required.)

____
(BIDDER'S NAME)

____
(MANUFACTURER'S NAME)

____
(QUOTATION NUMBER)

Attest: ________________________
(SIGNATURE)

____
(TITLE)

ATTACHMENT 5

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR

All data shall be for a single precfpitator.

1. Bidder's Name ____________________

2. Manufacturer's Name ____________________

3. Quotation Number ____________________

4. Number of precipitators ____________________

5. Number of fields ____________________

6. Performance and operation based on parameters in paragraph 7.0

a. Collection efficiency:

(1) W/O redundant field energized % ____________________

(2) All fields operating % ____________________

b. Dust loading:

(1) Inlet range grams/m^3 (gr/acf) ____________________

(2) Outlet range (w/o redundant field/all fields energized) Kg/Mega-Joule (lb/million Btu) __________/__________

c. Opacity (all fields operating) % ____________________

d. Coefficient of Variation % ____________________

e. Draft loss, including plenums and perforated plates, if any kPa (in H_2O) ____________________

f. Design average effective migration velocity cms ____________________

LPS/3/B1990(EDS)/D3

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EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

g.	Avg gas velocity at design flow	m/s (fps)	______
h.	Gas treatment time:		
	(1) W/O redundant field energized	sec	______
	(2) All fields energized	sec	______
i.	Hours precipitator can run at full load without emptying any hoppers (max. dust loading)	hr	______

7. Dimensions and weights:

a.	Width of precipitator	m (ft)	______
b.	Height of precipitator:		
	(1) Including hoppers	m (ft)	______
	(2) Without hoppers	m (ft)	______
c.	Depth of precipitator (flange-to-flange)	m (ft)	______
d.	Inlet gas nozzle or plenum, width x height x depth	m (in)	___ x ___ x ___
e.	Outlet gas nozzle or plenum, width x height x depth	m (in)	___ x ___ x ___
f.	Total weight of the precipitator including all equipment, recommended insulation and lagging, transitions, live loads and dead loads	kg (tons)	______

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

g. Heaviest weight to be lifted kg (tons) ____________________

8. Construction:

a. Casing:

(1) Material; thickness mm (in) __________;__________

(2) Design pressure +kPa (+ in H_2O) ____________________

-kPa - in H_2O ____________________

b. Internal gas distribution devices:

(1) Types and location ____________________

____

____

(2) Material; thickness matl; mm (in) __________;__________

c. Hoppers:

(1) Number of hoppers, deep x wide __________x__________

(2) Dimensions, depth x width x height m (ft in) ______x______x______

(3) Hopper material; thickness matl; mm (in) __________;__________

(4) Minimum hopper valley angle deg ____________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(5)	Capacity of each hopper 600mm (24 inches) below high voltage system	Rows ______ : ______ ft^3 Rows ______ : ______ ft^3
(6)	Height of 12 hour storage storage above outlet flange m (ft)	____________
(7)	Heating system - area per hopper m^2 (ft^2)	____________
(8)	Strike plates - no. per hopper and size mm (in)	____; ____ x ____ x ____
(9)	Poke holes - no. per hopper and size No; mm (in) dia	______ ; ______
(10)	Baffles:	
	(a) Number per hopper	____________
	(b) Material; thickness mm (in)	______ ; ______

d. Number and type of access doors:

(1)	Roof	____________
(2)	Casing	____________
(3)	Hopper	____________
(4)	Insulator compartments	____________
(5)	Ductwork	____________
(6)	Other (specify)	____________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

9. Precipitator design:

a. Connected power:

	w/extra field		w/o extra field	
(1) T/R's	___kVA	___kW	___kVA	___kW
(2) Rappers	___kVA	___kW	___kVA	___kW
(3) Insulator heaters	___kVA	___kW	___kVA	___kW
(4) Insulator blowers	___kVA	___kW	___kVA	___kW
(5) Hopper heaters	___kVA	___kW	___kVA	___kW
(6) Hopper vibrators	___kVA	___kW	___kVA	___kW
(7) Total	___kVA	___kW	___kVA	___kW

b. Power consumption

	w/extra field		w/o extra field	
(1) T/R's	___kVA	___kW	___kVA	___kW
(2) Rappers	___kVA	___kW	___kVA	___kW
(3) Insulator heaters	___kVA	___kW	___kVA	___kW
(4) Insulator blowers	___kVA	___kW	___kVA	___kW
(5) Hopper heaters	___kVA	___kW	___kVA	___kW
(6) Hopper Vibrators	___kVA	___kW	___kVA	___kW
(7) Total	___kVA	___kW	___kVA	___kW

c. Mechanical design:

(1) Number of mechanical fields and length of each No; m (ft in) __________;__________

(2) Space between fields m (ft in) ____________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(3) Aspect ratio:

(a) W/O redundant field energized ____________

(b) All fields energized ____________

(4) Effective cross-sectional area for gas flow m^2 (ft^2) ____________

(5) Specific collection area (w/o redundant field/ all fields energized) m^2/m^3s (ft^2/macfm) ______ / ______

d. Electrical design:

(1) Number of electrical fields and length of each No; m (ft in) ______ ; ______

(2) Number of bus sections:

(a) W/O redundant field energized ____________

(b) All fields energized ____________

(3) Ratio of bus sections to gas flow:

(a) W/O redundant field energized m^3s (10^5 acfm) ____________

(b) All fields energized m^3s (10^5 acfm) ____________

(4) Plate area per bus section m^2 (ft^2) ____________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(5) Current density based on plate area:

(a) W/O redundant field energized — mA/m^2 (mA/ft^2) ____________

(b) All fields energized — mA/m^2 (mA/ft^2) ____________

e. Collecting plates:

(1) Number of gas passages ____________

(2) Plate spacing, C-C — mm (in) ____________

(3) Plate description ____________ ____________

(4) Plate material and thickness — matl; mm (in) ______ ; ______

(5) Plate height — m (ft in) ____________

(6) Number of plates in field-length curtain ____________

(7) Is curtain assembled in shop or field? ____________

(8) Total effective collecting length in direction of gas flow:

(a) W/O redundant field energized — m (ft in) ____________

(b) All fields energized — m (ft in) ____________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(9) Total effective collecting plate area:

(a) W/O redundant field energized m^2 (ft^2) ____________________

(b) All fields energized m^2 (ft^2) ____________________

(10) Type of collecting plate rappers ____________________

(11) Number of collecting electrode rappers ____________________

(12) Number of collecting plates rapped per rapper ____________________

(13) Maximum collecting surface rapped per rapper m^2 (ft^2) ____________________

(14) Number of fields in which aligned plates can be rapped simultaneously ____________________

f. Discharge electrodes:

(1) Type (description) ____________________

____

(2) Shape and size ____________________

(3) Material ____________________

(4) Total number ____________________

(5) Spacing in direction of gas flow mm (in) ____________________

(6) Effective discharge electrode length (total) m (ft) ____________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(7) Minimum distance between CP & DE mm (in) ____________

(8) HT frame suspension - no. of points per bus section ____________

(9) Type of discharge electrode rappers ____________

(10) Number of discharge electrode rappers ____________

(11) Linear ft of discharge electrode rapped/rapper m (ft) ____________

g. Transformer-rectifiers:

(1) Manufacturer ____________

(2) Number ____________

(3) Type ____________

(4) Installed location ____________

(5) Wave form description ____________

(6) High-voltage switching (air or oil) and location ____________

(7) Insulation fluid type and manufacturer with chemical analysis ____________

(8) Insulation fluid quantity l (gal) ____________

(9) Overall transformer turns ratio ____________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(10)	Turn ratio at primary taps		________
			________
			________
(11)	Power factor at rated output		________
(12)	Conversion efficiency from SCR input to bus section connection	%	________
(13)	Secondary current form factor at average rated output current		________
(14)	Reactance of T/R sets (percent of maximum on its own base)	%	________
(15)	Impedance of T/R and inductor combined as a percent of supply voltage (on its own base)	%	________
(16)	Maximum ambient temperature for T/R Set	^{o}C	________
(17)	Guaranteed life	yrs	________
(18)	Expected life	yrs	________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

h. T/R ratings per field:

		1	2	3	4	5	6	7	8
(1) Number of T/R's									
(2) Input capacity	kVA								
(3) Primary voltage rating	V RMS								
(4) Primary current rating	A RMS								
(5) Secondary voltage rating	kV RMS								
(6) Secondary current rating	dc A RMS								
(7) Rated output current	dc mA avg								
(8) Rated output voltage	kV dc avg								
(9) Is high voltage side of the T/R sets critically damped and give percent	Yes								
	No								
	% damp								

(10) Impedence of transformer on transformer kVA rating ______________________

(11) Transformer losses kW ______________________

(12) Maximum heat dissipation from T/R Sets kW ______________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

i. Insulators:

(1) No. of insulator compartments ____________________

(2) Insulator compartment material matl; and thickness mm (in) __________;__________

(3) No. of insulator compartment blower systems ____________________

(4) Support insulators:

(a) Manufacturer ____________________

(b) Material of construction ____________________

(c) Size: height x dia. mm (in) __________x__________

(d) Minimum leakage path mm (in) ____________________

(5) Bus insulators:

(a) Manufacturer ____________________

(b) Material of construction ____________________

(c) Kilovolt rating ____________________

(d) Outdoor rating ____________________

(6) Insulator compartment heaters:

(a) Type ____________________

(b) Manufacturer ____________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(c) Temperature °C (°F) ____________

(d) Power rating W ____________

(e) Thermostat controlled?/ Range in °C (°F) ______/______

j. High voltage electric set:

(1) T/R controller type ____________

(2) Number ____________

(3) Manufacturer ____________

(4) Panel construction NEMA - ____________

(5) Max. ambient temperature of control panels °C (°F) ____________

(6) Meter ranges:

(a) Primary amps ____________

(b) Primary volts ____________

(c) Secondary amps ____________

(d) Secondary kilovolts ____________

(e) Spark rate ____________

(7) Control panel ventilation technique ____________

(8) Linear reactor:

(a) Manufacturer ____________

(b) Rating Henry ____________

Amps ____________

Voltage ____________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

(c) Type cooling Required ____________________

(d) Heat Dissipated ____________________

(e) Location ____________________

(f) Max. ambient temperature °C (°F) ____________________

(g) Heat rejection rate Kj/hr (Btu/hr) ____________________

(h) Does reactor have partial taps? ____________________

(9) Maximum power consumed by T/R Set Controller kW ____________________

k. Auxiliary control cabinets, no. and location:

(1) Rappers __________ ; __________

(2) Distribution __________ ; __________

(3) Hopper heaters __________ ; __________

(4) Other (describe) __________ ; __________

l. Surface areas:

(1) Roof m^2 (ft^2) ____________________

(2) Shell m^2 (ft^2) ____________________

(3) Hoppers m^2 (ft^2) ____________________

(4) Inlet plenum m^2 (ft^2) ____________________

(5) Outlet plenum m^2 (ft^2) ____________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

10. Precipitator accessories:

a. Hopper heaters:

(1) Type ______________________

(2) Manufacturer ______________________

(3) Rating W/m^2 (W/ft^2) ______________________

(4) No. of electric elements per hopper ______________________

(5) Supply voltage V ______________________

b. Insulator compartment blowers:

(1) Number ______________________

(2) Blower capacity m^3/s (cfm) ______________________

(3) Motor power rating kw (hp) ______________________

(4) Motor supply voltage V ______________________

c. Hopper high level probes:

(1) Type ______________________

(2) Manufacturer ______________________

(3) Number per hopper ______________________

(4) Height above outlet flange m (ft) ______________________

d. Hopper Vibrators:

(1) Manufacturer ______________________

(2) Number per hopper ______________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

e. 380V Distribution

(1) Type ________________

(2) Manufacturer ________________

(3) Bus ampere rating ________________

(4) Voltage rating ________________

(5) Number FVNR Size 1 Starters ________________

(6) Number FVNR Size 2 Starters ________________

(7) Number FVNR Size 3 Starters ________________

(8) Number FVNR Size 4 Starters ________________

(9) Number of circuit breakers by ampere rating ________________

f. Ductwork:

1. Weight of ductwork Kg (lb) ________________

2. Plate materials by ASTM No. and manufacturer's designation ________________

3. Coating, manufacturer and type (limits if more than one type) ________________

4. Plate thickness mm (in) ________________

5. Duct dimensions, LxW m (ft) ________________

6. Gas velocity:

   (a) At design flow ________________

   (b) At 25% load ________________

7. Design pressure kPa (inH_2O) ________________

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

8. Access doors:

   (a) Number ______________

   (b) Type ______________

   (c) Size ______________

   (d) Locations ______________

9. Test port locations ______________

10. Duct coatings:

   (a) Manufacturer ______________

   (b) Type ______________

   (c) Temperature limitations:

   Continuous operating ^{o}C (^{o}F) ______________

   Excursion ^{o}C (^{o}F) and time ______________

   (d) pH limitations (range) at 21.1^{o}C (70^{o}F) ______________

   (e) Coating thickness ______________

   (f) Method of installation ______________

11. Ductwork fabricator ______________

12. Describe method of ductwork support ______________

____

____

EQUIPMENT DATA
ELECTROSTATIC PRECIPITATOR
(Continued)

13. Spring hangers

(a) Type ____________

(b) Manufacturer ____________

14. Instrument tap locations ____________

15. Expansion joints:

(a) Location ____________

(b) Manufacturer ____________

(c) Size m x m (ft x ft) ____________

(d) Quantity ____________

(e) Belt material ____________

(f) Belt thickness ____________

(g) Maximum movement ____________

(h) Belt temperature rating ____________

(i) Belt pressure rating ____________

(j) Frame material ____________

(k) Baffle material ____________

(l) Unit weight Kg (lb) ____________

ATTACHMENT 6

ACOUSTIC DATA
SUMMARY SHEET

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarantee of 90 dBA at 1 meter (3 feet)
63		
125		
250		
500		
1000		
2000		
4000		
8000		

Kind of levels given, indicate which of the following:

Sound Power Levels re 10 (exp -12) watt		
Sound Pressure Levels re 2x10 (exp -4) microbars		

If sound pressure levels are given, indicate both of the following:

Weighting network use A, B, C, or Linear (None)		
Distance to sound source Feet or Meters		

Vendor Comments: ______________________________

____

____

____

LAKHRA POWER FEASIBILITY STUDY

SPECIFICATION M-4B

WET FLUE GAS DESULFURIZATION SYSTEM

LPS/2/B2459/D4

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SPECIFICATION M-4B

WET FLUE GAS DESULFURIZATION SYSTEM

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LAKHRA POWER FEASIBILITY STUDY
SPECIFICATION M-4B

WET FLUE GAS DESULFURIZATION SYSTEM

1.0 DESCRIPTION OF WORK

The Work to be performed consists of designing, furnishing, delivering to the jobsite, storage, erection and installation, performance testing, start-up, and successful commercialization of two half sized wet flue gas desulfurization system (FGD) for each of two 350 MW power plants for the Water and Power Development Authority (WAPDA) to be located in Pakistan.

2.0 WORK INCLUDED

2.1 The Work to be performed by the Vendor shall include the following:

2.1.1 Design and Engineering

a. On the gas side, the responsibility of the Vendor extends from the induced draft (I.D.) fan discharge flange, through the absorber modules, to the chimney, and includes the bypass duct.

b. On the liquid process side, the Vendor's responsibility begins with the reagent grinding system, at the reagent day bin outlet flange, and extends through the absorber module reaction tanks to the discharge at the reaction tank bleed surge tank.

2.1.2 Furnish

a. The Work furnished by the Vendor shall include all system equipment, components, and assemblies required for a complete one half sized FGD system for two units.

b. The Vendor shall employ technical representatives from the equipment subcontractors, as required, to assist in the direction of installation, erection, inspection and testing, and start-up of the subcontractor's equipment.

2.1.3 Delivery and Storage

The Vendor shall be responsible for the delivery to the jobsite of all items and equipment within his scope of supply. The Vendor shall also be responsible for storing those items which must be protected from the weather.

2.1.4 Erection and Installation

a. The Vendor shall construct the entire FGD system within the scope defined by this Specification.

b. The Vendor shall grout and prepare the foundation surfaces for structural steel and equipment.

c. The Vendor shall provide all necessary tradesmen, supervision, erection equipment, including scaffolding and staging, and all supplies and tools required to properly erect the equipment in accordance with the established project schedule.

d. The Vendor shall provide heating, ventilating, lighting, and fire protection equipment required during construction.

2.1.5 Testing

The Vendor shall perform testing in accordance with the requirements of Paragraph 13.0.

2.1.6 Start-up

The Vendor shall ensure that each piece of equipment is checked and ready for operation prior to start-up. The Vendor shall be responsible for starting the individual components of equipment prior to system start-up. Once the individual components of the system have been shown to operate successfully, the Vendor shall commence placing the entire FGD system into operation.

2.1.7 Training

The Vendor shall provide a minimum of 6 weeks of classroom training on the operation and maintenance of all the equipment supplied under this Specification and shall provide personnel for training during the first year of operation. The Vendor shall prepare the data books and operating and training manuals to be used in the training course. The training course and manuals shall include the following items:

a. System definition:

(1) System description.

(2) Component description.

(3) System chemistry.

(4) Guarantees.

b. System operation:

(1) Controls, control loops and checks, and control philosophy.

(2) Start-up.

(3) Shutdown.

(4) Normal operation.

(5) Upset emergency operation.

(6) Reagent preparation.

(7) Troubleshooting.

c. System maintenance:

(1) Preventative.

(2) Corrective.

(3) Manuals and spare parts lists.

2.1.8 <u>Model</u>

The Vendor shall design and construct a 1/10 scale model of the FGD system. The Vendor shall conduct a three-dimensional flue gas model study of the ductwork, absorber modules, and a portion of the chimney flue.

2.2 The FGD system shall consist of at least the following:

a. Absorber modules and accessories, including a complete, automatic mist eliminator wash system.

b. Complete, automatic reagent preparation system.

c. FGD system process piping, piping supports, valves, fittings, and expansion joints.

d. Process slurry and clear liquor storage and reaction tanks.

e. Mechanical agitators for all slurry tanks within the Vendor's system.

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f. Process slurry and clear liquor pumps and couplings.

g. Ductwork and expansion joints, including inlet and outlet plenums and bypass ductwork from the I.D. fan discharge flanges to the chimney inlet.

h. Flue gas dampers.

i. Control equipment.

j. Electrical equipment.

k. Motor operators for valves and dampers.

l. Structural steel framing and miscellaneous steel items for a complete FGD system. The Vendor shall provide support and access structures such as stairways, platforms, doors, etc. for all equipment, including components, an elevator, ductwork, piping, wiring, and processes within the FGD system to facilitate proper operation, inspection, maintenance, and testing.

m. Monorails and equipment hoists necessary to service the large equipment in the system.

n. Insulation and lagging for pressure vessels, tanks, process equipment ducts, and piping where necessary.

O. Absorber inlet and outlet isolation dampers.

2.3 TERMINAL POINTS

2.3.1 The terminal points and interfaces between the Vendor and the OWNER for equipment and services to be supplied by the Vendor are as follows:

a. Flue gas duct from the discharge flange of the I.D. fan to the inlet of the chimney.

b. A single point of supply for instrument and service air, supplied at the boundary of the FGD system.

c. Reagent preparation system at the discharge flange of the reagent day bins.

d. Two points of supply for makeup and service water, supplied at the boundary of the FGD system.

e. A single point of supply for gland seal water, supplied at the boundary of the FGD system.

2.3.2 Terminal points for the FGD system are shown on the attached plan and elevation Drawings (later).

3.0 WORK NOT INCLUDED

3.1 The work/items to be provided by others shall include the following:

a. I.D. fans, fan silencers, drivers, controls, and all isolation dampers for fans and absorbers.

b. Foundations and anchor bolts.

c. Makeup water Vendor's FGD system at a pressure of 345 kPA (50 psig). Gland seal water for pump seals at a pressure of 345 kPA (50 psig).

d. All permanent heating, ventilation, and air conditioning required in the FGD system enclosures.

e. All permanent fire protection equipment in the FGD system area.

f. Electrical supply equipment to include:

1. 6,900 volt switchgear.

2. 220 volt grounded, uninterruptible power supply.

g. The following electrical equipment will be furnished by others and shall be installed by the Vendor:

1. 8 kV cable.

2. 6,900 volt switchgear for motor starters.

h. Potable water supply.

i. Final painting of all exposed surfaces unless otherwise specified.

j. Compressed air will be supplied at a pressure of 620.5 kPA (90 psig), -40°C (-40°F) dewpoint.

k. Grounding.

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4.0 APPLICABLE CODES AND STANDARDS

The following codes and standards are applicable to the Work, to the extent specified herein:

4.1 American Institute of Steel Construction (AISC):

a. "Code of Standard Practice for Steel Buildings and Bridges."

b. "Manual of Steel Construction."

c. "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings."

d. "Specification for Structural Joints Using ASTM A325 or A 490 Bolts."

4.2 American Gear Manufacturers Association (AGMA):

a. 321.05, Design Practice for Helical and Herringbone Gears for Cylindrical Grinding Mills, Kilns and Dryers."

b. 421.06, "Practice for High-Speed Helical and Herringbone Gear Units."

4.3 Anti-Friction Bearing Manufacturers Association (AFBMA).

4.4 American National Standards Institute (ANSI):

a. A58.1, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures."

b. B1.1, "Unified Inch Screw Threads."

c. B3.16, (ANSI/AFBMA 11) "Load Ratings and Fatique Life for Roller Bearings."

d. B15.1, "Safety Standard for Mechanical Power Transmission Apparatus."

e. B16.1, "Cast Iron Flanges and Flanged Fittings, Class 25, 125, 250 and 800."

f. B16.3, "Malleable-Iron Threaded Fittings, Class 150 and 300."

g. B16.5, "Steel Pipe Flanges and Flanged Fittings, Including Ratings for Class 150, 300, 400, 600, 900, 1500 and 2500."

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h. B16.9, "Factory-Made Wrought Steel Buttwelding Fittings."

i. B16.10, "Face-to-Face and End-to-End Dimensions of Ferrous Valves."

j. B16.11, "Forged Steel Fittings, Socket-Welding and Threaded."

k. B16.21, "Nonmetallic Flat Gaskets for Pipe Flanges."

l. B16.25, "Buttwelding Ends."

m. B16.34, "Steel Valves, Flanged and Butt Welding End."

n. B18.2.1, "Square and Hex Bolts and Screws, Including Askew Head Bolts, Hex Cap Screws, and Lag Screws."

o. B18.2.2, "Square and Hex Nuts."

p. B20.1, "Safety Standards for Conveyors and Related Equipment."

q. B29.1, "Precision Power Transmission Roller Chains, Attachments, and Sprockets."

r. B31.1, "Power Piping."

s. B36.10, "Welded and Seamless Wrought Steel Pipe."

t. B36.19, "Stainless Steel Pipe."

u. B105.1 (ANSI/MPTA 301), "Specification for Welded Steel Conveyor Pulleys."

v. C50.41, "Polyphase Induction Motors for Power Generating Stations."

w. C80.1, "Specification for Rigid Steel Conduit, Zinc Coated"

x. MC96.1, "Temperature Measurement Thermocouples."

4.5 American Petroleum Institute (API):

a. 650, "Welded Steel Tanks for Oil Storage."

b. 2000, "Venting Atmospheric and Low-Pressure Storage Tanks."

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4.6 American Society of Mechanical Engineers Boiler and Pressure Vessel Code:

a. Section VIII, "Pressure Vessels Divisions 1 and 2."

b. Section IX, "Welding and Brazing Qualifications."

4.7 American Society for Testing and Materials (ASTM).

4.8 American Water Works Association (AWWA):

a. C203, "Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied."

b. C504, "Rubber - Seated Butterfly Valves."

c. D100, "Welded Steel Tanks for Water Storage."

4.9 American Welding Society (AWS):

a. A5.11, "Specification for Nickel and Nickel Alloy Covered Electrodes."

b. A5.14, "Specification for Nickel and Nickel Alloy Bare Welding Rods and Electrodes."

c. D1.1, "Structural Welding Code."

d. QC1, "Standard for Qualification and Certification of Welding Inspectors."

4.10 General Services Administration (GSA), Federal Specifications:

a. FF-S-325, "Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry).

b. QQ-C-576 B (1), "Copper Flat Products with Slit, Slit and Edge-rolled, Sheared, Sawed or Machined Edges, (Plate, Bar, Sheet, and Strip)."

4.11 Hydraulic Institute Standard

4.12 Insulated Cable Engineers Association (ICEA): P-32-382, "Short-Circuit Characteristics of Insulated Cable."

4.13 Manufacturers Standardization Society (MSS):

a. SP-42, "Class 150 Corrosion Resistant Gate, Globe, Angle and Check Valves with Flanged and Butt Weld Ends."

b. SP-43, "Wrought Stainless Steel Butt-Welding Fittings."

c. SP-58, "Pipe Hangers and Supports."

d. SP-61, "Pressure Testing of Steel Valves."

e. SP-69, "Pipe Hangers and Supports - Selection and Application."

f. SP-70, "Cast Iron Gate Valves, Flanged and Threaded Ends."

g. SP-84, "Steel Valves - Socket Welding and Threaded Ends."

4.14 Mechanical Power Transmission Association (MPTA).

4.15 Military Specifications:

a. MIL-C-5015 G (4), General Specification for "Connector, Electrical, Circular Threaded, and Type."

b. MIL-T-10727B, "Tin Plating, Electrodeposited or Hot-dipped, For Ferrous and Nonferrous Metals."

4.16 National Board of Fire Underwriters.

4.17 National Bureau of Standards Handbook 44, Southern Weighing and Inspection Bureau.

4.18 National Electrical Code.

4.19 National Electrical Manufacturers Association (NEMA):

a. MG 1, "Motors and Generators."

b. WC 3, (ICEA S-19-81), "Rubber-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

c. WC 7, (ICEA S-66-524) "Cross-linked-thermosetting-polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

d. WC 51, (ICEA P-54-440), "Ampacities - Cables in Open-top Cable Trays."

4.20 National Safety Standards.

4.21 Occupational Safety and Health Administration (OSHA), Part 1910, Occupational Safety and Health Standards.

4.22 Pipe Fabrication Institute (PFI): ES3, "Fabricating Tolerances."

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4.23 Rubber Manufacturers Association (RMA).

4.24 Steel Structures Painting Council (SSPC):

a. PA 1, "Shop, Field, and Maintenance Painting."

b. SP 3, "Power Tool Cleaning."

c. SP 5, "White Metal Blast Cleaning."

d. SP 6, "Commercial Blast Cleaning."

e. SP 7, "Brush-off Blast Cleaning."

4.25 Stellite R&D Department Report 9321.

4.26 Tubular Exhanger Manufacturers Association (TEMA).

4.27 Underwriters Laboratories (UL):

a. 6, "Safety Standard for Rigid Metal Electrical Conduit."

b. 50, "Safety Standard for Cabinets and Boxes."

4.28 Uniform Building Code.

4.29 World Bank Guidelines

Office of Environmental Affairs the World Bank, Environmental Guidelines.

5.0 SUPPLEMENTAL DATA

The documents listed on the contents page as attachments are applicable to the Work, to the extent specified herein.

6.0 VENDOR DATA

6.1 Vendor data shall be furnished in accordance with the requirements indicated on the attached Vendor Data Requirements and Submittal Schedule (later).

6.2 In addition to the Vendor data required by (later) form (later), the Vendor shall furnish the following information:

a. Description of fabrication details.

b. Scrubber outline drawing showing overall dimensions and location of interface points.

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c. Shop loading curve for the period applicable to fabrication of the specified equipment for the delivery dates of this Specification.

d. Time required after receipt of order to submit certified drawings for approval and performance curves as specified herein.

e. Time required for fabrication and delivery after receipt of all necessary drawings and approvals.

f. Cutoff date beyond which revisions cannot be made on equipment specified.

g. The schedule of Certified Vendor Drawings shall include a list of drawings by category, such as general arrangement, foundation data, and electrical connections. If titles of the Certified Vendor Drawings are unknown, an estimated number of drawings will be submitted in each category.

h. Delivery dates:

   1. Drawings (sometimes called "approved for layout" or AFL) to be furnished by Vendor, showing outlines and overall or approximate dimensions and weights, suitable for use by Engineer in developing plant layouts; complete submittal by (later).

   2. Vendor Drawings (sometimes called "certified for construction" or CFC) and other technical information: first submittals by (later); complete drawings and information by (later).

   3. Resubmittals, by Vendor, or drawings, procedures, or similar items which are returned by the Engineer or QA organization with a status other than "approved"; 6 weeks after return by the Engineer or QA organization.

   4. First item of equipment: (later).

   5. Final item of equipment: (later).

6.3 QA/QC REQUIREMENTS

6.3.1 The Vendor and his subcontractor(s) shall have in effect in their shops at all times an inspection, testing, and documentation program that will insure that the equipment furnished under this Specification meets, in all respects, the requirements specified herein.

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6.3.2 The Vendor shall submit a copy of his quality control manual to the Engineer.

6.4 PERFORMANCE REPORTS AND CERTIFICATIONS

The following performance reports and certifications shall be submitted to the OWNER prior to or with delivery of the Work:

6.4.1 The Vendor shall submit to the OWNER the results of tests specified in Paragraph 13.2.

6.4.2 The Vendor shall furnish a list of field test results of the equipment which must be tested during installation and initial start-up.

6.5 MATERIAL TEST REPORTS AND CERTIFICATIONS

6.5.1 Three certified copies of all mill test reports and results of nondestructive weld tests for the structural steel furnished will be supplied to the OWNER.

6.5.2 Prior to start of manufacture, the Engineer shall be given a list, with scheduled dates, of all proposed tests and inspections. The Engineer shall be notified at least 1 week in advance of those tests and inspections that he wishes to observe. Five certified copies of all factory test data shall be furnished to the Engineer.

6.6 SPECIAL TOOLS AND SPARE PARTS

6.6.1 The Vendor shall furnish one complete set of all special tools, all in first class condition, which will be required for maintenance of the equipment covered by this Specification. Identification of all tools by name and number shall be provided, and this number shall appear on drawings and instructions to indicate the application of the tools furnished and to permit the ordering of replacement tools.

6.6.2 Instruction books supplied by the Vendor for equipment being furnished shall include a listing of recommended spare parts.

6.6.3 The Vendor shall supply with his proposal, pricing for 1 and 5 year supplies of spare parts.

7.0 DESIGN REQUIREMENTS

The wet FGD system shall be designed to operate under the following requirements and to have the following features:

7.1 DESIGN CRITERIA

a. The FGD system shall be used to control sulfur dioxide emissions from one coal fired steam generator. A precipitator will be located upstream of the FGD system. Induced draft fans will discharge flue gases to the FGD system.

b. The FGD system shall be designed to provide continuous reliable service suitable for utility power plant operation. The entire FGD system shall be designed and physically arranged to facilitate operation and maintenance of all components. Sufficient access area shall be provided for all components for operation and maintenance.

c. The FGD system shall be designed for pressurized operation using dry I.D. fans upstream of the absorber modules. The FGD system shall treat 100 percent of the boiler flue gases at all loads.

d. The primary fuel for the steam generator will be lignite with a nominal sulfur content of 5.00 percent as-fired basis. The FGD system shall remove 90 percent of the sulfur dioxide from 50 percent of the flue gas based on a design sulfur dioxide production rate of 8.037 kg SO_2/GJ (18.74 lb $SO_2/10^6$ Btu) coal fired. The design sulfur dioxide removal shall be accomplished with one module out of service.

e. The Vendor shall size the FGD system and arrange the absorber modules, recycle pumps, reaction tanks, oxidation compressors, and all other equipment to allow access for maintenance, service, and equipment removal. Large equipment, such as recycle pumps and compressors, shall be located to allow access of cranes and hoists to service this equipment. The Vendor's structural steel framing shall be designed to accommodate crane hoist loadings.

f. The FGD system shall be designed to operate for 30 years under conditions specified in Paragraph 7.4.

7.2 STEAM GENERATOR OPERATING CONDITIONS

The operating conditions for the steam generator at its maximum continuous rating (MCR) are as follows:

a.	Manufacturer	(Later)	
b.	Boiler Type	Pulverized Coal	
c.	Steam Flow	1,312 (2,893,000)	tonnes/hr lb/hr
d.	Gross Heat Input	4,135 3,919	GJ/hr Million Btu/hr
e.	Coal Burn Rate	384 tons/hour 348 tonnes/hour	
f.	Excess Air Leaving Boiler	30	%
g.	Infiltration	5	% of stoichiometric
h.	Anticipated Air Heater Leakage	15	% of stoichiometric

7.3 FGD SYSTEM DESIGN PARAMETERS

7.3.1 The following flue gas parameters shall be used as the basis for design of the FGD system. These data are referenced to zero static pressure at the discharge of the I.D. fans.

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			Design Operating at MCR
a.	Dry gas mass flow	tonnes/hr (lb/hr)	later
b.	Wet gas volume flow	m^3/s (acfm)	later
c.	Temperature	^oC ^oF	150 (300)
d.	Pressure	inH_2O	0
e.	Fly ash loading	$kg/10^6kg$ $(lb/10^6\ Btu)$	.0688 (.16)
		kg/hr (lb/hr)	191 (421)
f.	SO_2 loading	kg/GJ $(lb/10^6Btu)$	8.057 (18.74)
		kg/hr (lb/hr)	2,762 (6,090)
		mg/l	6,470
g.	Chloride loading	ppm (v)	later
h.	Absolute humidity	kg (lb) H_2o/ kg (lb) dry gas	later
i.	Wet O_2 concentration	volume %	later
j.	Grade Elevation	later	above mean sea level

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7.3.2 Fuel

a. The primary fuel for the steam generator will be lignite coal from Pakistan with the following analyses of potential coal sources:

ANALYSIS OF POTENTIAL COAL SOURCES

COAL/MINERAL ANALYSES

SHORT PROXIMATE

Daily Average	Typical	Range
GCV-(Dry) Btu/lb	7500	6300 - 8700
Ash-(Dry) %	36.0	26.0 - 46.0
Sulfur-(Dry) %	7.4	6.5 - 9.5
H_2O %	32.0	25.0 - 45.0
Monthly Average		
GCV-(Dry) Btu/lb	7500	6900 - 8100
Ash-(Dry) %	36.0	30.0 - 42.0
Sulfur-(Dry) %	7.4	6.8 - 8.3
H_2O %	32.0	28.0 - 40.0

PROXIMATE ANALYSIS
(% Dry Basis)

Ash	36.00	26.17 - 41.87
VM	34.60	32.15 - 39.58
FC	29.40	23.68 - 35.82
Sulfur	7.26	6.02 - 9.85
GCV-(Btu/lb)	7500	6060 - 8950
Equil. Moisture	38.91	33.77 - 50.06

FORMS OF SULFUR

Total %	7.71	6.02 - 9.85
Pyrite %	4.14	2.89 - 5.51
Sulfate %	0.60	0.31 - 1.56
Organic %	2.97	1.43 - 3.86

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ULTIMATE ANALYSIS
(% As Rec'd or Dry)

H_2O	32.00	- -	-
Ash	24.48	26.17 -	41.97
H_2	2.12	2.76 -	3.66
C	29.12	35.61	50.75
N_2	0.55	0.66 -	1.08
S	4.94	6.02 -	9.85
O_2	6.79	9.69 -	12.84
GCV-(Btu/lb)	5100	6300 -	8700

MINERAL ANALYSIS
(%)

SiO_2	39.60	32.34 -	47.68
Al_2O_3	20.17	12.12 -	26.30
TiO_2	2.02	1.33 -	3.16
CaO	3.70	2.11 -	8.39
K_2O	0.61	0.45 -	0.76
MgO	1.60	0.79 -	2.54
Na_2O	0.72	0.32 -	1.02
Fe_2O_3	24.64	17.02 -	33.60
P_2O_5	0.75	0.56 -	0.93
SO_3	5.63	2.20 -	10.55

b. Fuel oil may be used for flame stabilization during startup and boiler boilout. Number 6 furnace oil is the 100 percent standby fuel for the steam generator.

7.3.3 Reagent

The limestone reagent available for use in the FGD system at the plant site is expected to have the following composition:

	Design Operating	Design Range
(1) $CaCO_3$, weight %	90	90-95
(2) $MgCO_3$, weight %	.56	.56-.7
(3) Inerts, weight %	8.5	4-8.5
(4) Moisture, weight %	.11	.06-.11
(5) SiO_2, weight %	.045	.005-.045

	Design Operating	Design Range
(6) Feed size, 19mm x 0 (3/4" x 0)		
(7) Bond work index	12	7-12

The FGD system shall be designed based on the limestone available $CaCO_3$ content.

7.3.4 Makeup Water

The FGD system shall be designed for zero discharge of process water. The source of the makeup water will be from treated Indus River Water or treated sanitary waste water and will have the following analysis:

a.	Temperature	18-28°C (64-82°F)
b.	pH	8-9
c.	Alkalinity as $CaCO_3$	66 mg/l
c.	Hardness as $CaCO_3$	5 mg/l
d.	Silica	5 mg/l
e.	Sulfate	100 mg/l
f.	Chloride	55 mg/l
g.	Suspended solids	1 mg/l
h.	Iron	<1 mg/l

Treated sanitary wastewater

a.	pH	6-9
b.	BOD_5	30 mg/l
c.	TSS	30 mg/l
d.	Coliform	200/100 ml

7.3.5 Gland Seal Water

Gland seal water will be of sufficient quality for gland seals and other service applications. Service water will have the same analysis as the makeup water.

7.4 FGD SYSTEM OPERATING CONDITIONS

The absorber modules, ductwork, and all auxiliary equipment shall be designed for the following operating conditions:

a.	Flue gas static pressure, kPa (inH_2O)	$\pm$2.5 ($\pm$10)
b.	Intermittant max inlet gas pressure, KPa (inH_2O)	$\pm$7.5 ($\pm$30;) yield stress not to be exceeded at this condition
c.	Max transient flue gas inlet temperature $^{\circ}C$ ($^{\circ}F$)	343 (650) 30 minutes
d.	Seismic loading	zone 1 as defined by ANSI A58.1
e.	Wind load	In accordance ANSI B58.1 with basic wind speed of 129 km/h (80 mph), Exposure C

7.5 Ambient Air Conditions

The scrubber and all auxiliary equiment shall be designed for the following ambient conditions:

a.	Summer Design Dry Bulb Temperature (1 percent)*	41.7°C D.B. (107°F D.B.)
b.	Summer Design Wet Bulb Temperature (1 percent)*	28.3°C (83°F)
c.	Maximum Summer Temperature	46.8°C (116.2°F)
d.	Minimum Winter Temperature	5.7°C (42.3°F)
e.	Sand Storm Wind Velocity (typical)	44.5 m/sec (105.6 mph)

f.	Atmospheric Pressure	100.8 kPA (29.77 inHg)
g.	Ambient Temperature Range	5°C (41.3°F) to 50°C (122°F)

*Percentage of the time temperature would be above this number.

7.6 Absorber Modules

7.6.1 The Vendor shall furnish four absorber modules, each capable of treating 35 percent of the total flue gas flow listed in paragraph 7.3.1,b. One of the absorber modules shall be a spare. Each absorber module shall be capable of completely independent operation, and shall be equipped with flue gas inlet and outlet guillotine dampers for module isolation. Each absorber module shall include at least the following components:

a. Alloy absorber section including internal supports, spray headers, spray nozzles, and access doors.

b. Mist eliminator section including an automatic cleaning system.

c. Purge system for module maintenance.

d. Reaction tank.

e. A minimum of four spray levels shall be provided for each module.

f. Each spary level shall have a dedicated slurry recycle pump.

7.6.2 Absorber Type

The preferred flue gas absorber module shall be a counter current vertical spray tower or crosscurrent horizontal spray chamber complete with an internal slurry spray system which is capable of providing intimate contact between the flue gas and the slurry droplets. Slurry shall be evenly distributed throughout the entire cross section of the absorber module. Packed bed-type absorber modules will not be accepted for limestone service.

7.6.3 Design Conditions:

The absorber modules shall be designed and constructed to meet the following conditions:

a. The minimum sulfur dioxide removal shall be 75 percent on a continuous basis.

b. The absorber module shall be gastight and watertight at all inlet gas pressure conditions varying between -7.46 to 7.46 kPa (-30 to +30 inches H_2O).

c. The maximum transient inlet flue gas pressure shall be -7.46 to 7.46 kPA (-30 to +30 inches H_2O). The yield stress of the shell material shall not be exceeded at this condition.

d. Maximum flue gas flow to each module will be $200m^3/_s$ (423,500 acfm) at 148.9°C (300°F).

e. Minimum flue gas flow to each module will be $40m^3/_s$ (84,700 acfm) at 150°C (300°F).

f. The normal operating flue gas temperature will be 150°C (300°F). However, the absorber modules shall be designed to accommodate excursion temperatures of up to 345°C (650°F) for short durations (maximum of 15 minutes).

g. Sulfur dioxide mass flow entering the FGD system will range from 27 kg/million kCal kg/hr (15 lbs/million Btu lb/hr) to 50 kg/million KCal kg/hr (28 lbs/million Btu lb/hr).

h. Fly ash mass flow entering the FGD system will range from 40 kg/million KCal kg/hr (22 lbs/million Btu lb/hr) to 87 kg/million KCal kg/hr (48 lbs/million Btu lb/hr).

i. The Vendor shall specify the maximum superficial gas velocity through the absorber at design flue gas flow.

7.6.4 Service Life

The absorber modules shall be constructed entirely of erosion/corrosion resistant (alloy) materials suitable to provide a minimum service life of 30 years in the environment expected inside the absorber under the conditions of operation indicated in this Specification.

7.6.5 Service Intended

a. The absorber modules shall be designed to eliminate problems associated with erosion, corrosion, cementation, and plugging. The Vendor shall provide all washers, cleaning systems, strainers, screens, comminutors, and other devices as required to provide this protection.

b. Each module shall be capable of completely independent operation and shall be capable of being isolated for off-line maintenance while the remaining available modules are operating.

7.6.6 Shell Construction

a. The absorber modules shall be constructed to form a watertight and gastight envelope from the module inlet to the module outlet.

b. Welded joints shall be used wherever possible. Flanged and bolted joints shall be used where necessary to preserve the integrity of the alloy material.

c. Any penetrations of the module shell required for piping connections or accessories shall be sealed to keep the module gastight.

d. The modules shall be supported on foundations and structural steel supports. A complete system of structural reinforcement shall be provided to brace the walls of the module against pressure and vacuum loads, piping forces and moments, and all other loads imposed on the module. The bracing reinforcement shall be adequate to prevent plate deflection in excess of 6 mm (1/4 inch) and module shell vibration resulting from any condition which may occur within the absorber.

e. All interior baffles, braces, and supports shall be designed so they will not trap dirt, sludge, or scale. The bottom of each module shall be sloped to prevent accumulation of sludge.

7.6.7 Expansion Provisions

The Vendor shall design the absorber modules to absorb differential expansion which may occur under extreme conditions of operating versus ambient temperatures.

7.6.8 Module Internals

a. All structural internals shall be similar in material and gage to the absorber shell. All spray pipes, mist eliminators, and other module internals shall be constructed of corrosion, erosion, and shock resistant materials. All nonmetallic internals shall be of nonflammable material with a _____ flame spread rating.

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b. Spray piping:

(1) Internal spray piping, headers, and nozzles shall be corrosion, erosion and shock resistant on both the inside and outside surfaces. Each recycle pump shall distribute slurry to a separate spray level. Slurry recycle piping shall not be manifolded on the suction or discharge side of the recycle pump.

(2) The spray nozzle grid shall be arranged so that nozzles are not directly impacting on spray system components directly below or on module side walls.

(3) Ceramic or refractory spray nozzles with full cone spray characteristics are preferred.

c. Mist eliminator:

(1) The Vendor shall supply a high efficiency mist eliminator and cleaning system near the module outlet to eliminate entrained moisture downstream of the module.

(2) The Vendor may supply his standard mist eliminator and cleaning system design if the specific design has been proven acceptable in full-scale, operating utility FGD installations.

(3) The maximum superficial flue gas velocity through a horizontal mist eliminator section shall be 3 meters (10 ft) per second based on the design flue gas flow. Higher superficial velocities for a vertically-oriented mist eliminator will be considered if certified test results and operating data from full-scale FGD installations are provided with the bid.

(4) The blades, if any, of the mist eliminator shall be interlocking, and the entire blade assembly shall be rigidly held in place. Blade designs that are structurally stable to permit high-pressure cleaning and withstand a point loading of 976 kg/m^2 (200 pounds per square foot) are preferred.

(5) The mist eliminator cleaning system shall be capable of keeping the entire active surface of the mist eliminator free of permanent solids accumulation. Top cleaning (downstream side) of mist eliminator systems shall not be used.

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7.6.9 Access

The absorber module shall include sufficient number of manholes and access doors to allow entry into all areas of the absorber, including the spray section, mist eliminator, and reheater. Access openings shall be gastight and sized to allow removal of any absorber internals such as spray headers and mist eliminator sections.

7.6.10 Provisions shall be made to completely purge the absorber module of flue gases to a man-safe condition within 30 minutes after module shutdown. During maintenance operations, the purge system shall supply a continuous flow of fresh ambient air to the module interior. The purge system shall be complete with purge and vent fans, ducts, dampers, and controls as required. Materials of construction shall be consistent with the module.

7.7 PROCESS TANKS

7.7.1 Process slurry and clear liquor storage tanks shall be designed, fabricated, and erected. The Vendor shall provide the following tanks:

a. Four reaction tanks.

b. Two reagent slurry storage tanks.

c. One mist eliminator wash tank (if required).

d. Reaction tank bleed surge tank.

e. Any other tanks required by the Vendor's design to provide a complete FGD system.

7.7.2 Sizing Criteria

a. Reaction tanks:

The tank volume shall be adequately sized for the required reaction of the sulfur dioxide with the scrubber liquid. Minimum liquid retention time shall be 10 minutes.

b. Vendor shall list the volume of the following tanks on the Attachment 1, Equipment Data Sheets:

1. Reageant Slurry Storage Tank

2. Mist eliminator Wash Tank

3. Reaction tank bleed surge tank

7.7.3 Design Requirements

a. All tanks and related appurtenances supplied under this specification shall be designed and constructed in accordance with AWWA D-100.

b. All tanks shall be of welded construction; concrete tanks are not acceptable.

c. Shell thickness for the tanks shall be as required for the application, but not less than 6mm (1/4 inch).

d. All tanks which contain slurry shall be round and shall be provided with agitators of adequate size to maintain suspension of solids. The Vendor shall provide support steel for all mixers, and an access walkway and stairs to allow inspection of agitator operation. The access walkways and platform shall be complete with grating, handrails, and kickplate. The Vendor shall determine the number and location of the agitators required to achieve the proper degree of mixing and to avoid short-circuiting flow from the tank inlet to the tank outlet connections. The Vendor shall ensure that the agitator support structure is arranged to enable agitator removal without removal of any support steel.

e. The reaction tank bottoms shall be sloped to prevent the accumulation of sludge solids and for ease of cleanout.

7.7.4 Design Loads

a. Internal hydrostatic pressure on the tank filled with the liquid to be stored.

b. Wind load of (later) kg/m^2 (pounds per square foot) on the protected area of the cylindrical surfaces.

c. Forces from piping connections.

7.7.5 Tank Appurtenances

a. All tanks shall be furnished complete with all overflows, drains, baffles, skirts, wear plates, and any other connections or appurtenances required for a complete installation.

b. All tanks shall be fitted with 100mm (4 inch) drain and overflow connections and pipes to completely drain the tank.

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c. All piping flange connections shall have a 150 pound rating.

d. Manholes:

(1) All slurry tanks shall have a flanged, circular shell manhole with an inside diameter of 60mm (24 inches).

7.8 DUCTWORK AND EXPANSION JOINTS

7.8.1 The Vendor shall design furnish, and erect all flue gas ductwork, hoppers, expansion joints, supports and hangers, gas distribution and mixing devices, test ports, and instrument connections required for the FGD system. Ductwork shall include the following:

a. Ductwork from the I.D. fan discharges to the inlet of the absorber modules. The Vendor shall make provisions for his installation of the I.D. fan outlet dampers. The I.D. fan evases shall be fabricated, furnished, and erected by the Vendor; others will design them.

b. Ductwork from the outlet of the absorber modules to the chimney inlet.

c. Bypass duct around the absorber modules.

7.8.2 Technical Requirements

a. Design:

(1) Ductwork shall be designed in accordance with the following criteria:

(a)	Max gas velocity for design flow at 100 percent of steam generator rated capacity as specified in paragraph 7.2	m/s, ft/min	21.3 (4200)
(b)	Insulation load	kg/m^2 (lb/ft^2)	4.88 (10)
(c)	Dust load, floor surface	kg/m^2 (lb/ft^2)	879 (180)

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(d) Live load, where applicable	lb/ft^2	(later)	
(e) Min design pressure and design vacuum		± 7.46 kPa (± 30 in H_2O)	
(f) Design Temperature		Continuous Operating	Maximum Transient
1. Induced draft fan outlet to absorber module inlet, and chimney before mixing °C (°F)		150 (300)	345 (650)
2. Absorber module outlet to chimney inlet before mixing, °C (°F)		54 (130)	

Note: The maximum transient temperature excursion shall be assumed to have a duration of 30 minutes.

(2) Ductwork shall be designed to prevent pulsations and noise generation.

(3) Ductwork shall be designed with sloped bottoms and hoppers, if required, to prevent fly ash buildup and to ensure condensate drainage. Drain ports shall be provided at suitable points to remove liquids (entrained or condensed) which have settled out of the flue gas stream, from the bottom of the ducts.

(4) Maximum allowable stresses in the materials shall be in accordance with Section 1.5.1 of the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. The value of F_y for material for the design of the ductwork and internal bracing and trusses shall be 0.2 percent offset yield strength at the design temperature.

(5) Ductwork material shall be alloy-acid resistant on the outlet ductwork, outlet elbows, and bypass ductwork.

b. Fabrication and erection:

(1) Ductwork shall be of all welded construction except as specified otherwise herein.

(2) All ductwork materials and accessories shall be shop seal welded with field bolted fit-up except where bolted connections are indicated on the Vendor's drawings and accepted by the Engineer.

(3) Where field fit-up and seal welding are required, joints shall be constructed so that the overlap shall be in the direction of the gas flow and the seal weld shall be done on the gas side.

(4) The ductwork shall be fabricated in shipping units. Shipping units shall be designed and fabricated, within the limits of shipping requirements, to require a minimum of field welding.

(5) Internal duct bracing and trusses shall be installed in the shop at intervals of approximately 6m (20 feet) and shall be constructed of steel pipe with wall thickness sized for design stresses. Provisions shall be made for field connection of the bracing and trusses between ductwork sections, where required, by seal welding.

(6) Gas distribution and mixing devices shall be provided with stiffeners and supports, and shall be designed to preclude vibration or flutter in the gas steam under all specified flow conditions. The devices shall be bolted to the ductwork so that they are removable.

(7) External duct stiffeners shall use shapes of the same depth to facilitate installation of insulation and lagging. Fabricated shapes made from plates may be substituted for rolled shapes if the properties of the fabricated shape are equal to or better than those of the rolled shapes.

(8) Access doors shall be provided to permit access to all ductwork sections, absorber module elbows, and between all major items of equipment. The doors shall not be less than 450 x 600mm (18 x 24 inches) in size. They shall be gastight with a bolted closure. The doors shall be accessible and provided with access ladders where required.

(9) Ductwork flanged joints shall be used to join expansion joints, dampers, absorber module inlets and outlets, chimney breeching, and induced fan outlets to the ductwork. Templates shall be used for field

drilling holes to match the holes in the various pieces of equipment. The Vendor shall furnish all required ductwork templates. The flanges shall be provided with fit-up and assembly bolts and shall be seal welded. Seal welding at the expansion joints will be required only if a steel flange is provided with the expansion joint.

(10) Fabrication tolerances shall be controlled to permit the ductwork to be erected within erection tolerances specified in paragraph 11.1.4. At joints, each edge shall match the adjoining edge within a tolerance of 3mm (1/8 inch). Edges and corners which do not fit up within this tolerance shall be reworked or replaced.

(11) The ductwork shall be arranged as required by the FGD system design and results of the model tests, and for accessibility for monitoring and testing, use of space, and appearance.

7.8.3 Expanion Joints

a. Expansion joints shall be elastomer type reinforced with fabric, with a complete structural frame of the picture frame type.

b. Expansion joints shall be designed, detailed, and constructed to withstand temperatures, velocities, pressures, chemicals, and other service conditions as defined in this Specification.

c. Expansion joints shall be assigned to give the design life under deflections which may be a combination of axial motion, rotation, and lateral movement. Expansion joint deflection forces shall be computed by the Vendor. The magnitude of forces generated by expansion joint deflection may be limited by the capacity of equipment to absorb these forces, as in the case of fans or air heaters.

d. Expansion joints shall be sized and designed to meet the conditions specified herein and the arrangement of the Vendor's ductwork with respect to expansion, contraction, and offsets. Each joint shall be sized to accommodate all anticipated movements without stretching or tearing the joint.

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7.8.4 Supports and Hangers

a. All necessary hanger assemblies and miscellaneous hanger steel shall be furnished. Hangers shall be designed for attachment to the support framework using suitable welding brackets. In such cases, the miscellaneous structural steel shall be provided by the Vendor. Special attention shall be given to hangers around transition sections, openings, and access doors. Hanger assemblies shall be designed for a clean appearance. Structural steel angle hangers and brackets shall not be used.

b. If bottom support is used, the Vendor shall furnish column stubs and Merriman Lubrite slide plates or as approved equal.

c. The allowable working stress in the hanger rods shall not exceed 62 MPa (9000 psi). Loads to the hanger rods shall take into consideration all ductwork loads including dead load, duct load, live load, wind and earthquake, and any bending stresses introduced during expansion, contraction, or offset movements of the ductwork.

d. The safety factors allowed for the design of hanger clevises and turnbuckles shall be at least those specified for the hanger rods. Turnbuckles and clevises shall be of forged steel with safe working loads and minimum dimensions as described in the AISC Manual of Steel Construction, Latest Edition, Pages 4-126 and 4-127.

e. Constant or variable spring load hangers may be used by the Vendor; however, variable spring hangers will be allowed only with the approval of the Engineer. Spring hangers shall be VS or CS type as manufactured by Grinnell or Basic Engineering or shall be an approved equal hanger.

7.8.5 Test Ports

Test ports to obtain samples shall be provided at locations acceptable to the Engineer and in accordance with the recommendations derived from the model tests.

7.8.6 Instrument Connections

Instrument connections shall be provided as required to permit installation of instrumentation required to monitor and control the operation of the FGD system.

7.9 DAMPERS

7.9.1 The Vendor shall design, fabricate, and install the flue gas dampers as specified herein, complete with all accessories, component parts, and appurtenances necessary for a complete FGD system. The following dampers shall be supplied:

a. (Later) zero-leakage, guillotine module inlet isolation dampers and drive, complete with a seal air system.

b. (Later) zero-leakage, guillotine module outlet isolation dampers and drive, complete with a seal air system.

c. (Later) zero-leakage, double-louver bypass duct isolation and control system dampers and drive, complete with a seal air system.

d. (Later) single-louver module inlet flue gas control dampers (if required by the Vendor's design).

7.9.2 Design Criteria

a. The flue gas dampers shall be suitable for the application intended and manufactured by Air Clean Damper Company, Andco, Damper Design, Mosser, or Engineer approved equal.

b. The dampers will be used to isolate equipment for on-line maintenance. The design and construction of these dampers shall provide personnel safety.

c. All of the dampers shall be self-supporting and shall be considered structural members capable of meeting at least the following criteria:

(1) Damper frames shall be channel type, either rolled structural shapes or formed plate, with bolt holes for connecting to the ductwork. Weight of the frames shall be determined on the basis of stress due to seismic loading, transit and handling abuse, system pressure, temperature, contaminants, and total damper size and weight. Stress at the weakest sections of the frame shall not exceed the levels specified in AISC Manual of Steel Construction. The frames shall be complete, self-sufficient structures not requiring additional, integral support or bracing.

(2) Each damper shall be capable of transmitting the duct load through the frame without impairing proper operation of the damper.

(3) Damper materials at elevated temperatures less than 316°C (600°F) shall be stressed no greater than 50 percent of yield at 26.7°C (80°F).

(4) The creep rates of the steel shall be based on a 600,000 hour life span.

(5) Lifting lugs shall be included in the design to ensure proper handling of the damper assembly during transport and erection.

(6) The operator motor and blower mounts, as applicable, shall be furnished and installed on the damper by the damper manufacturer. The operator torque shall not cause any component of the mount in any mode of stress to exceed 10 percent of its yield strength.

(7) The damper frames shall be designed to support the following:

(a) A fly ash load of 446 kg/m^2 (300 lbs/ft^2) on the bottom of the frame.

(b) A 907 kg (2,000 pound) concentrated load due to uneven fly ash distribution, at a point that causes maximum deflection of the frame.

(c) The seal air system, all related controls, motors, and drive mechanisms, and the entire damper unit with only one flange bolted to the ductwork.

(8) Motors shall conform to the requirements of the Attachment Motor Specification.

(9) A direct position readout shall be provided at the damper by means of a mechanical position indicator showing percent of damper opening on all dampers.

(10) Dampers shall be equipped with a permanently mounted handwheel that is automatically disengaged under all conditions of motor operation.

(11) The dampers and accessories shall comply with the latest editions of all applicable codes and standards of recognized regulatory bodies having jurisdiction at the plantsite.

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(12) After award of Contract, the Vendor shall submit for approval all calculated data necessary to ensure stability and proper function of the dampers. All compliance data shall be submitted prior to the start of fabrication. The compliance submittals shall include, but not be limited to, the following:

(a) Effects of seismic loading on each component of the assembly.

(b) Stress levels of major damper components (blades, frames, linkage, bearing mounts, actuator mounts) under system design conditons.

(c) Fatigue life calculations for the entire damper and the major components.

(d) Leakage calculations illustrating total leakage in m^3/s (acfm) through the closed damper and to atmosphere under design conditions.

(e) Blade deflection calculations.

(f) Calculations of expected pressure drop caused by the open damper.

(g) Blade buckling calculations.

(h) Torque calculations and related safety factors.

7.9.3 Guillotine Dampers

a. Guillotine dampers shall be top-entering.

b. Guillotine dampers shall have a removable bottom plate for access to the bottom frame seal.

c. Damper blade shall:

(1) Be fabricated of solid, homogenous plate and shall be as rigid as necessary to withstand the maximum differential pressures specified in Paragraph 7.5.3.

(2) Be provided with sealing strips around the periphery of the blade and on the seating surfaces of the frame. Seals shall be located on both the upstream and downstream sides of the blade. Sealing strips, seal strip bolting materials, and backing strips shall be fabricated of Inconel 625. Seal strips shall be replaceable from outside the duct.

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(3) Be designed to include provisions for thermal expansion so that the blade will not bind.

(4) The blade thickness shall not be less than 25mm (1 inch).

(5) Blades shall not require bracing fastened to the blade. Guillotine blades made of two or more plates welded together are not acceptable; damper blades which include braces welded to the blade are not acceptable.

d. The upper frame shall be designed to support the blade, drive mechanisms, and all attachments. The frame shall not sway or cause binding of the blade when subjected to wind loads as specified in Paragraph 7.5.3c and when operating at the worst flow and pressure conditions.

e. The module inlet dampers shall be insulated and lagged. Motor drives, seal air systems, and all other equipment and devices requiring regular inspection and maintenance shall clear the insulation and lagging.

f. All guillotine dampers shall have seal air systems as described in Paragraph 7.8.5.

g. The module inlet dampers shall be located at least 3m (10 feet) upstream from the module inlets to be free from moisture and the wet/dry region.

h. Damper operators shall conform to the requirements stated in Paragraph 7.8.7. Damper operators shall be designed to lift the damper blade evenly on both sides.

i. The guillotine dampers shall have roller chain drives. Each side of the damper shall have a chain on a sprocket. Each chain shall be capable of transmitting the full stall torque of the motor.

j. Jack screw operation shall not be acceptable on any guillotine damper.

k. Chains for the guillotine drives shall be manufactured by Dodge Division of Reliance Electric Company, Morse Division of Borg-Warner, or Engineer approved equal.

l. Guillotine dampers shall be guaranteed to have zero leakage of the flue gas to the atmosphere and to have zero leakage of flue gas across the blades.

7.9.4 Double Louver Dampers

a. Each double-louver isolation damper shall consist of one parallel and one opposed-blade louver damper. The opposed-blade shall be downstream of gas flow.

b. Operation of each louver in the damper unit shall be independent. Common or twin-drive units will not be allowed.

c. Each double louver shall be equipped with a seal air system as specified in Paragraph 7.8.5.

d. Damper blades shall be the double-skin, airfoil design. The blade skin shall consist of two pieces of metal formed into an airfoil shape, bolted together at the edges, and through-bolted to a round shaft. Blade skins shall be made of material compatible with the blade shaft so that blade skins and the blade shaft expand and contract at the same rate. Bolt holes through blade edges and through blade skins and shafts shall be elongated to permit slight differences in expansion and contraction caused by high and low side temperature differences. Thermal expansion and contraction shall be controlled and directed away from the drive side of the damper.

e. Blades shall be of a rigid structural design, capable of handling all thermal stresses and warping due to differential temperatures and pressures without affecting damper operation.

f. 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.

g. 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.

h. Linkage:

(1) Linkage system shall be located outside of the damper unit.

(2) Linkage system shall be fully adjustable to compensate for thermal expansion of the frame. All parts with threaded connection for adjustment shall be carbon steel. Locknuts shall be provided on the adjustable

linkage to positively hold the linkage after it has been adjusted. Design shall be such that each individual blade can be adjusted.

(3) Clevis arms shall be pinned or bolted to the stub shaft. Arms shall be keyed to the shaft for easy removal. Clevis arms shall be carbon steel and linkage pins or bolts shall be stainless steel. Pins or bolts shall incorporate a self-locking design so that operation or vibration of the unit will not cause loosening of the connections.

(4) 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.

(5) Linkage system shall have provisions for locking with a heavy-duty padlock so that the damper cannot be operated until the padlock is removed.

i. Sealing strips:

(1) Sealing strips shall be fabricated of Inconel 625.

(2) Strips shall be bolted into place with Inconel 625 bolts and nuts and backing bar. Connection shall be self-locking to prevent loosening of the connection.

(3) Seal strips shall be of a suitable length to enable easy replacement in the event of damage or failure.

(4) Blade seals shall overlap the mating edges when the damper is closed.

(5) Frame seals shall be installed on each louver damper and shall be streamlined so they do not act as dirt accumulators in the gas stream. Frame seals shall be designed to accept the expansion and contraction of the blade and shaft.

j. The dampers shall be insulated and lagged. Drive arms, seal air systems, and other equipment requiring regular inspection and maintenance shall be extended to clear the insulation and lagging.

7.9.5 Seal Air Systems

a. Each guillotine and double-louver damper shall be provided with a seal air system mounted on the damper frame.

b. The 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 calculated leakage rate through the dampers at design conditions.

c. Each fan shall be capable of maintaining a pressure between the seal chamber and the gas stream of at least 1.25 kPa (5 inches H_2O) at the design conditions.

d. Isolation valves at the discharge of each fan shall be provided. Valves shall be mild steel gate or butterfly valves.

e. Check valves at the discharge of each fan shall be provided to prevent backflow through the idle fan. Check valves shall have a replaceable soft seat and shall be designed to prevent "flutter" when in the open position.

f. An isolation valve shall be provided at the connection of the seal air duct to the seal air chamber on double-louver and guillotine dampers. The valve shall be alloy "G" or Inconel 625, gate or butterfly. An electric operator on the valve, complete with limit switches.

g. Pressure indication shall be provided on the seal air system.

h. Seal air systems, where possible, shall be mounted on the damper frame. They shall be installed so that all instrumentation can be easily observed and there is complete access to linkages, drive units, bearings, stuffing boxes, etc. The isolation valve and blower shall be mounted so that all condensation occurring between the damper and the isolation valve flows into the ductwork. If installation on the damper frame is not possible, the system shall be installed on top of adjacent ductwork.

7.9.6 Bearings and Packings

a. Damper bearings shall be the self-aligning, antifriction or sleeve type, selected on the basis of both the ambient conditions at the jobsite where the damper will be installed and on the basis of temperature transmission from the damper shaft to the bearing. The damper bearings shall be designed with a B-10 life of 100,000 hours.

b. Bearings shall be mounted in the bearing manufacturer's pillow blocks and the pillow block assemblies shall be bolted to bearing mounts welded to the damper frame. The mounts shall be located far enough outside of the frame to permit installation of insulation.

c. Each bearing and bearing mount, as well as the welds holding the mount to the frame, shall be of the strength and duty required to withstand 300 percent of the stress transmitted from the system load on the blade plus the operator output torque.

d. A packing gland shall be continuously welded to the damper frame at each shaft clearance hole in the frame and shall be fitted with packing material adequate to the atmosphere both in the gas stream and ambient. Each packing gland shall be designed and installed so that packing may be renewed without removal of bearings or linkage. Packing glands shall not contain asbestos.

7.9.7 Damper Operators

a. The damper manufacturer shall mount an electric motor operator on the damper, out of the gas stream, in his shop, prior to final inspection, testing and shipment. The operator shall be connected to outside linkages. The damper manufacturer shall mount and link the operator and operate the damper with the operator in place.

b. Damper operators shall be designed to perform with a load factor of three based upon the damper manufacturer's design torque requirements.

c. Operators shall be Limitorque type SMB, Rotork Synchroset 2 with Add-On-Pak-1, or Engineer approved equal.

d. Operator motors shall be rated for 380 volt, 3-phase, 60 Hz ac, be squirrel cage induction type with totally enclosed, nonventilated enclosures and Class B insulation, and rated for 40^{o}C ambient conditions. Motors shall be specifically designed for damper service: high starting torque, low starting current, and across-the-line starting at 90 to 110 percent voltage and ±5 percent frequency variation.

e. Space heaters shall be provided within the motor and within the limit switch component. The heaters shall be rated for 220 volts, single-phase, 50 Hz ac.

f. Motor operators for guillotine dampers shall be equipped with two train-geared limit switches or other switches providing equivalent functions.

g. Motor operators for double-louver dampers shall be equipped with four train-geared limit switches arranged as follows:

   (1) One train shall operate at the full open position.

   (2) One at the full closed position.

   (3) Two shall be adjustable for any position.

h. All motors shall conform to the attached Motor Specification.

i. The motor operator shall be wired in accordance with "Limitorque" standard arrangements, Philadelphia Gear Corporation Drawing 15-477-4292-3, or "Synchro SET 2" with "Add-On-Pak 1" standard arrangement, Rotork Drawing 2221-00, or Engineer approved equal.

j. Local manual operation shall be provided for all motor-operators with a handwheeel-to-motor turning ratio sufficient to permit operation by one man (operating force not to exceed 34 kg (75 lb). The manual operation to engage the handwheel shall disengage the motor drive. Energizing the motor, when the handwheel is engaged, shall automatically disengage the handwheel and engage the motor drive to override the handwheel operation. The handwheel shall remain engaged until motor is energized.

k. Control wiring shall be electrically isolated from the motor power supply. All control components shall be suitable for operation with 230 volt, 50 Hz, grounded service. All control contacts shall have a NEMA A300, 10 ampere rating in accordance with ANSI C19.3.

l. Motor operators shall be equipped with double torque switches or other equivalent means of protection, arranged to interrupt the current to the motor starter operating coil in case of excessive torque in either direction of damper travel. Torque settings shall be adjustable. Operators shall be adjustable for either torque or position seating and in either case, the torque switch shall provide protection against overload.

m. Gears shall be enclosed, self-locking, and precision-cut, and shall operate in a sealed grease or oil bath.

n. Gears shall be sufficient to lick the shaft when the motor is deenergized and prevent drift from torque switch spring pressure.

7.10 REAGENT PREPARATION EQUIPMENT

The Vendor shall furnish and install two (2) reagent preparation systems to go between the outlet flange of the reagent day bin and the reagent slurry storage tank. One system will be a spare. The sytems shall use limestone as the reagent. Equipment shall conform to the requirements of Paragraph 7.9.1.

7.10.1 Limestone preparation equipment shall include:

a. Two (2) gravimetric weigh feeders with drives, in accordance with the following:

(1) Each feeder shall be sized to feed 100 percent of the design limestone requirement at boiler MCR.

(2) Weigh feeders shall be as manufactured by Ramsey or Engineer appoved equal.

(3) The weigh feeders shall be capable quantitatively conveying the required flow within an accuracy of ±1.0 percent with feed density variations of ±30 percent over a flow range of 10:1.

(4) Design of feeder components shall make full allowance for handling wet and frozen limestone. Feeder shall be totally enclosed and dusttight from the limestone silo outlet to the ball mill inlet. The feeder cover shall be removable to provide access to all moving parts.

(5) Feeder shall be electrically driven.

(6) Feeder length shall be as required from the centerline of the silo outlet flange to the centerline of the inlet mill feed chute.

(7) Weigh belt:

(a) The weigh belt shall be designed so that the feed rate will not be affected by belt slippage.

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(b) Belt shall be continuous, mechanical steel splice, or Engineer approved equal.

(8) Feeder control:

(a) Head pulley shall be driven by dc motor with a SCR power supply and 380 volt, 50 hertz, 3-phase input.

(b) Weigh feeder instruments and controls shall:

1. Control the feed rate from local and remote locations.

2. Provide local readout and a 0-100 percent rate meter.

3. Be suitable for operation with 230 volt, 50 hertz, single-phase input.

4. Provide isolated input for the OWNER'S 4-20 ma dc input control signal for feed rate.

5. Provide 120 V ac powered pulse output to the OWNER'S remote mechanical totalizer.

6. Provide 4-20 ma dc output into 500 ohms for OWNER'S remote rate meter and data logger.

7. Be designed so that the feeder may be operated as a volumetric feeder.

b. Two (2) automatic wet ball grinding mills, each complete with rubber lining, drive, bearings, support steel, controls, lubrication system, and ball charge. Wet ball mills shall be in accordance with the following:

(1) Each ball mill shall be sized for 100 percent of the design requirement at boiler MCR.

(2) Wet ball mills shall be manufactured by Kennedy Van Saun Corporation or Engineer approved equal.

(3) All bearings and gears shall have at least a 30 year B-10 service life.

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(4) Ball charge shall be suitably designed, sized, and selected hardened steel balls to accomplish the desired limestone size reduction and minimize ball attrition. Balls shall be hardened to 550 to 650 Brinell.

(5) An air-clutch assembly for disengaging the mill from the motor shall be provided. The clutch shall be suitable for operation at 620 kPa (90 psig).

(6) All rotating parts which may be subjected to excessive vibration or which may impose uneven torque on motor drives due to lack of balance shall be adjusted for static and dynamic balance at the normal operating speed. All rotating parts shall be designed to safely withstand all acceleration forces which may occur.

(7) All parts subject to heavy wear shall be designed so that they can be easily replaced.

(8) The ball mill shall have horizontal shaft configuration.

(9) The discharge shall be the overflow type. An abrasion and corrosion-resistant steel liner shall be provided in the discharge trunnion. The discharge trunnion shall be fitted with a reverse helix designed so that broken balls, large rock particles, etc. cannot pass through the trunnion. (Tramp material chutes shall be provided for each mill.) A seal between the liner and the trunnion shall prevent slurry leakage.

(10) The discharge housing shall be of the manufacturer's standard design, with a maintenance door. The door shall be at least 600mm x 600mm (24" x 24") and shall be hinged, watertight, and operable without tools.

(11) Heads shall be cast steel, cast type "GM" Meehanite, or Engineer approved equal. Flanges shall be bolted. Heads shall be machined for a male-female fit with shell flanges.

(12) Trunnions:

(a) Trunnion bearing assemblies shall be self-aligning, with at least a 120 degree arc surface bearing.

(b) The bearing surface of trunnion bearing inserts shall be babbitted metal, SAE-67 bronze, or Engineer approved equal.

(c) Seals shall be capable of containing the high-pressure oil during continuous operation without leakage.

(d) Trunnion bearings shall be provided with thermocouples.

(e) Trunnions shall be cast integral with the mill head.

(13) Trunnion bearing, girth gear, and gear reducer lubrication:

(a) Each trunnion bearing assembly shall be sealed and internally lubricated.

(b) Provisions shall be made to ensure an adequate supply of forced feed cool oil to all trunnion bearings. Each trunnion pair, girth gear, and gear reducer shall have an independent lubrication system. Each bearing pair shall be equipped with a lubrication system with a high-pressure hydrostatic oil pump capable of "floating" the mill during startup and a lube oil pump for normal, continuous operation. The system shall be designed for continuous, simultaneous operation of the hydrostatic and lube oil pumps.

(c) Reducer forced lubrication systems shall be provided for gear and pinion drives.

(d) Each speed reducer lubrication system shall be sealed and force lubricated.

(e) Controls to interlock the gear lubrication system with the mill or motor starting equipment shall be provided to prevent mill operation without lubrication.

(f) A gear enclosure with covered parts for inspection shall be provided.

(g) Each lubrication system shall have full capacity ac motor-driven main oil pumps.

(h) Each lubrication system shall include all necessary equipment and accessories, including pumps, dual changeable filters, dual coolers, dual reservoirs, sight-flow indicators, valves, pressure-relief valves, pressure switches, necessary instrumentation, and all integral piping and other appurtenances required to form a complete lubrication system.

(i) Oil piping shall be as follows:

1. Piping shall be arranged to permit removal of oil equipment components without dismantling the piping.

2. For all piping systems smaller than 20mm (3/4 inch), stainless tubing and stainless steel Swagelok fittings shall be used.

3. Piping 20mm (3/4 inch) and larger shall be stainless steel, welded or flanged, prefabricated, and assembled so that no field welding is required for assembly.

4. Oil piping shall be adequately supported to prevent mechanical failure due to thermal stresses, vibration, and other causes.

5. Piping shall include flexible connections where required. Oil return lines shall be designed with as much slope as possible, but not less than 15mm (1/2 inch) per foot.

6. Field piping between lube oil system and bearings shall be provided. Piping at bearings and the lube oil system shall be brought to a single return connection.

(j) The quantity and pressure of oil for the bearings and gears shall conform to the mill manufacturer's requirements.

(k) Full capacity oil coolers shall be designed to cool all the required oil to the desired temperature when supplied with the proper amount of cooling water at 35°C (95°F), based on a fouling factor of 0.001. The cooling water temperature shall rise at least 5.6°C (10°F). The oil cooler shall be designed so that it can be

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disassembled for internal cleaning and reassembled without welding. Tubes shall be at least 20 gage (BWG) 90-10 copper-nickel. Tube sheets shall be nonferrous. A drain and vent connection shall be provided for each cooler. Connections for cooling water shall be brought to a single supply and a single return.

(l) The oil reservoir shall be equipped with a level indicator and temperature-controlled electric heaters. Heaters shall be rated for 380 volt, 3-phase, 50 hertz ac. Drain and fill piping shall be connected to a location where the lube oil system can be conveniently drained, flushed, and refilled.

(m) Provisions for field flushing shall be included.

(n) Lubrication system controls:

The following lubrication system controls shall be furnished for each ball mill:

1. Pressure switches:

a. One pressure switch with adjustable set point and adjustable differential, to start the idle lubricating oil pump on decreasing lube oil pressure. Switch contacts shall be DPDT.

b. One pressure switch with adjustable set point and adjustable differential, to start the idle hydrostatic oil pump on decreasing hydrostatic oil pressure. Switch contacts shall be DPDT.

c. One pressure switch with adjustable set point to serve as a permissive to start the hydrostatic oil pump if lubricating oil pressure is acceptable. Switch contacts shall be DPDT.

d. Hydrostatic oil pressure switches at each bearing to serve as permissives to engage the mill clutch, trip, and alarm.

e. Lube oil pressure switches at each bearing to serve as permissives to start the mill motor, trip, and alarm.

f. Differential pressure switches across each oil filter to alarm if the filter is plugged.

2. Flow switches:

   a. Lubricating oil flow switches at each bearing to serve as permissives to start mill motor, trip, and alarm.

   b. Hydrostatic oil flow switches at each bearing to serve as permissives to start mill motor, trip, and alarm.

3. Temperature switches:

   a. Temperature switches to alarm if lubricating oil temperature is high or low.

   b. Temperature switches to alarm if hydrostatic oil temperature is high or low.

4. Thermocouples:

   a. Pipe type thermocouples at the lubricating and hydrostatic oil cooler discharges for remote indication of oil temperatures.

   b. Thermocouples to monitor temperatures at three locations cn each main bearing and at one location on each gear reducer bearing.

5. Lube oil temperature control systems to automatically maintain lube oil temperature at set point.

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6. Lubrication system wiring and conduit shall be as follows:

   a. All electrical devices installed on the skid (pressure switches, temperature switches, etc.) shall be wired to the terminal box with terminal blocks.

   b. Wiring on skid-mounted equipment shall be the manufacturer's standard subject to approval by the Engineer.

   c. Identification numbers shall be provided on each point of all terminal blocks. Identification shall be black lettering on a white surface.

7. Bearing caps with covered ports shall be provided for trunnion inspection.

8. Reserve oil capacity shall be no less than 3 month's normal oil consumption.

(14) Girth gear and pinions:

(a) Pinions shall be of forged steel. The pinion shaft shall be forged integral with the pinion.

(b) Pinion shaft bearings shall be self-aligning, antifriction (spherical roller) bearings. They shall be symmetrically constructed so they can be reversed in their mountings to expose a new wearing surface.

(c) Pinions and girth gear shall be reversible.

(d) Pinions and girth shall conform to AGMA 321.05.

(e) The enclosure for pinions and girth gear shall be dusttight.

(f) Pinions and girth gear shall be located on discharge ends of the mills. The pinions and speed reducer shall be installed on the inboard side of the gear.

(g) Thermocouples shall be installed in each bearing.

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(15) Speed reducers for gear and pinion drives:

(a) Parallel shaft, enclosed-type, helical gear reducers with roller bearings and dual lip seals in accordance with AGMA 151.02, 271.03, and 420.03 shall be provided.

(b) The speed reducers shall be sized for a service factor of 1.75 based on the mill design horsepower, but shall not be smaller than that required for the motor starting torque.

(c) Bearings shall have at least a AFBMA 30,000 hour B-10 life.

(d) Chain drives shall not be used.

(e) Unused shaft extensions shall be covered.

(f) The reducer and motor support frame shall:

1. Be fabricated of structural steel and heavy plate extending the full length of the reducer and drive. (Coordination with the motor manufacturer is required.)

2. Be designed to adequately support equipment under all operating conditions without grout fill inside the frame.

3. Require grout under the basic frame only. The frame shall not be covered with a thin steel plate which requires grouting under the plate.

(g) The reducer shall be dowelled to the frame in the shop; the driver will be dowelled in the field by others.

(h) All bolts or screws for attaching the reducer and motor drive to the support frame shall be furnished.

(i) Heavy-duty, high-torque flexible couplings shall be provided on the reducer input and output shafts.

(16) Liners:

(a) The mill shell shall be lined with vulcanized rubber sheeting suitable for cushioning metal liners and sealing the mill shell.

(b) Liners shall be of high quality corrosion and abrasion-resistant molded rubber.

(c) Liners shall be as manufactured by B. F. Goodrich or Engineer approved equal.

(d) Liner anchors shall be watertight, corrosion resistant stainless steel throughout.

(e) Mill shell design shall allow for replacement of the rubber liners with metal liners without any significant modifications to the equipment. Liner bolt holes shall be drilled to accommodate metal liner anchor bolts and fitted with bushings to support the anchor bolts for the rubber liners.

(17) The Vendor shall provide all instrumentation necessary for measurement and indication of motor stator temperature.

(18) Mill shall have two manholes, 180 degrees apart. Openings shall be reinforced, watertight, and large enough to pass all waring parts or 600 x 600mm (24" x 24"), whichever is larger. Bolts and nuts shall be corrosion-resistant stainless steel.

(19) Mill shell shall be of steel plate.

(20) Ball loading chutes and means for adding balls shall be provided.

(21) Sole plates:

(a) Sole plates which are separate from the equipment shall be provided to permit all bearing housings, gear reducers, motors, and accessories to be removed and replaced without regrouting and to permit realignment by shimming and redoweling.

(b) Sole plates shall be separately anchored to the concrete foundation and shall be provided with jacking screws to facilitate alignment.

(c) Sole plates shall be fully machined on the top surface and shall have a thickness of at least 1/24 of the greatest dimension of the sole plate.

(d) Sole plates shall be cast iron or steel, with static loads not exceeding 13,789 kPa (2,000 psi) on the grout, and dynamic plus static loads not exceeding 20,684 kPa (3,000 psi).

(22) All welding and welding procedures shall conform to AWS D1.1.

c. Classifiers:

(1) The Vendor shall provide radial manifold classifier assemblies complete with cyclone classifiers, overflow and underflow launders, valves, pressure gages, vents, and all internal piping. A heavy-duty rubber lining shall be provided in all parts of the system exposed to slurry except the cyclones. Cyclone linings shall be ceramic and shall be easy to replace. Each classifier assembly shall have three flanged connections:

(a) A feed connection.

(b) An overflow connection.

(c) An underflow connection.

(2) One spare cyclone shall be provided in each classifier assembly.

(3) Classifiers shall have no moving parts.

(4) Sufficient access stairways and platforms to each classifier assembly shall be provided.

d. Distributors:

Product distributors each consisting of three compartments, and complete with distributor mechanism and air cylinder shall be provided. Each product distributor shall be fabricated from 6mm (1/4 inch) thick mild steel plate.

e. Mill slurry sumps:

The Vendor shall provide two mill slurry sumps fabricated from 6mm (1/4 inch) thick mild steel plate, each complete with an overflow connection, a flanged discharge connection, a screened inlet, and a sump agitator.

f. Mill slurry pumps:

(1) The Vendor shall supply four rubber-lined, centrifugal mill slurry pumps complete with drives. Each pump shall be of sufficient capacity to handle the maximum output of one ball mill based on the reagent requirement with the boiler at MCR. Two pumps will be spares, one for each ball mill.

(2) The pumps shall conform to the requirements in Paragraph 7.10.

g. Interconnecting piping:

(1) The Vendor shall provide all interconnecting piping, chutes, fittings, and valves for a complete reagent preparation installation.

(2) Piping shall be at least schedule 80 carbon steel and shall conform to Paragraph 7.13.

h. Instruments and controls in accordance with Paragraph 7.21.

i. A control panel including graphic display in accordance with Paragraph 7.21.13.

7.11 SLURRY PUMPS

7.11.1 The Vendor shall design, fabricate, and deliver rubber-lined slurry pumps as specified herein, complete with all component parts and appurtenances necessary for a complete and well-integrated system. The following equipment shall be supplied as minimum:

a. Four (4) reagent slurry feed pumps and drives. Two pumps shall be provided per slurry storage tank; one pump will be a spare.

b. Sixteen (16) absorber module recycle pumps and drives. Four (4) pumps shall be provided per reaction tank; one pump and slurry header per tank will be a spare. All recycle pumps shall feed slurry to a separate spray level. Recycle pumps shall not be manifolded on the suction or discharge side.

c. Eight (8) reaction tank bleed pumps and drives. Two bleed pumps shall be provided per reaction tank; one pump per tank will be a spare. These pumps shall pump the bleed slurry to the reaction tank bleed surge tank.

d. Two (2) pumps shall be provided to pump the reaction tank bleed slurry from the reaction tank bleed surge tank, to the waste disposal pond. One (1) pump shall be a spare.

e. Sump pumps and drives shall be provided to handle process spills, leaks, equipment drain, and equipment washings in the sump locations in the FGD system. Two sump pumps shall be provided per sump; one pump per sump will be a spare.

f. Slide rails and baseplates as required.

g. Bearing casing thermocouples, oil temperature thermocouples, and bearing material thermocouples.

h. Pump lubrication system including instrumentation and controls.

7.11.2 Rubber lined pumps shall be as manufactured by ASH Pump, Warman, or Engineer approved equal.

7.11.3 Pumps shall be horizontal shaft, vertically split, centrifugal, end suction single stage, with replaceable rubber liners and impellers. Sump pumps may be either horizontal or vertical, centrifugal, wet-pit duplex type.

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7.11.4 The pumps shall be constructed in accordance with applicable ANSI standards, except where otherwise stated. If any of the provisions of this Specification depart from the manufacturer's usual construction in such a manner as to substantially increase the cost of the equipment, without, in his opinion, providing a corresponding increase in quality, or if he considers that his usual construction would provide better quality than the construction specified herein, this fact, with documented justification shall be brought to the attention of the Engineer.

7.11.5 Spares and parts for all pumps of the same size shall be interchangeable. This applies to such components as shaft sections, bearings, seals shaft sleeves, impellers (runners), couplings, drive belts, liners, and bowl assemblies (where applicable).

7.11.6 Pumps shall be mechanically balanced statically.

7.11.7 The slurry flow velocity at the suction inlet and pump discharge shall not exceed 6m/s (20 feet per second) at design conditions.

7.11.8 Pumps shall be of a design that has operational experience in full scale utility FGD systems with performance acceptable to the Engineer.

7.11.9 Pumps shall be provided with eyebolts to permit equipment removal. Pump removal shall be made without disturbing the piping or motor.

7.11.10 Motors shall be in accordance with the attached Motor Specification.

7.11.11 <u>Drives</u>

a. For motors up to 300 kW (400 horsepower), matched multiple V-belt drives with a side-by-side motor and pump arrangement shall be used. The motor shall be placed on slide rails.

b. For motors over 300 kW (400 horsepower), gear drives shall be used. Heavy-duty, common baseplates and a fan cooled oil cooler shall be used in conjunction with the gear drives.

c. Matched multiple V-belt drive (MVD) sets shall be rated at not less than 140 percent of the motor horsepower.

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d. Drives shall be provided with guards:

(1) Complying with all applicable safety requirements.

(2) Arranged to facilitate disassembly.

(3) Rigidly fastened to the baseplate.

(4) With solid metal cover on pump side and open mesh on outboard end for matched MVD sets.

e. Drives shall prevent any external thrust from being transmitted to the motor shaft under normal operating conditions.

7.11.12 Pump Casings

a. The pump casing shall be split vertically into the suction inlet assembly and the pump assembly designed for ease of disassembly.

b. Suction and discharge connections shall be standard 150 pound ANSI flat-faced flanges with a rubber lining extending over the flange.

c. Rubber liners shall be replaceable and metal inserts shall be molded in to hold the liners in place without the use of adhesives.

d. Casing bolts shall be stainless steel and of the through-bolt design.

e. Casing shall be located in a bottom horizontal discharge to facilitate draining.

f. No casing drain or vent connections shall be made in the casing.

g. The entire pump casing, including the suction flange, shall be capable of withstanding, without deformation, a pressure equal to 1.5 times the maximum discharge pressure which would occur when the pump is operating at rated conditions.

h. The entire pump casing, including the suction flange, shall be capable of withstanding, without permanent deformation, a pressure equal to 1.25 times the maximum discharge pressure which would occur when operating at the rated pump speed (rpm) but with a pump discharge valve closed.

7.11.13 Impellers

a. Impellers shall be closed type with repelling vanes constructed of molded rubber on a rigid, metal skeleton which screws onto the shaft in the direction opposite to the shaft rotation.

b. Impellers shall be statically balanced.

c. Impeller tip speeds shall be a maximum of 26.4 m/s (5,200 feet per minute), measured from the outermost part of the impeller.

d. A method to quickly release the impeller from the shaft, without the use of come-alongs, shall be incorporated into the design.

7.11.14 Shaft

a. The shaft within the pump shall be completely encased along its entire length by the impeller and the shaft sleeve to prevent corrosion.

b. A slip-fit shaft sleeve of 420 stainless steel, through-hardened to a minimum Brinell of 550 shall be provided.

c. The pump shall be free from excessive vibration at all discharge rates between 10 percent and 120 percent of the design flow.

d. The critical speed of the rotor shall be at least 40 percent higher than the running speed.

7.11.15 Bearings

a. Bearings shall be heavy-duty grease lubricated, tapered, roller bearings.

b. Inboard and outboard pump bearings shall have a minimum B-10 life of 50,000 hours.

c. Bearing seals shall be a double-rotating, metal piston, ring seal and grease purged labyrinth, or an Engineer approved seal arrangement.

d. Bearings shall limit maximum shaft deflection at the stuffing box to 0.05mm (0.002 inch).

e. Temperature measuring devices shall be provided for each bearing.

7.11.16 Stuffing Boxes

a. Packed stuffing boxes with lantern ring seals utilizing clear water injection to the seals shall be used.

b. Stuffing boxes shall be designed to facilitate adjustment, disassembly, and repacking.

c. A splash guard shall be provided to prevent slinging of seal water.

d. Packing material shall be subject to approval of the Engineer.

7.11.17 Frames and Baseplates

a. Support frames shall be as follows:

(1) Fabricated of structural steel and heavy plate extending the full length of pump and driver, and rigid enough to maintain alignment of all machinery.

(2) Designed to adequately support equipment under all operating conditions without grout fill inside of the frame.

(3) Frame shall not be covered with a thin steel plate which requires grouting under the plate, but the frame shall be filled with concrete as required for drainage. Grout shall be required under the basic frame only.

b. Baseplates are required for gear drive arrangements and shall be common for the pump and motor.

7.12 WATER PUMPS

7.12.1 The Vendor shall design, fabricate, and deliver clear water, centrifugal pumps as specified herein, complete with all component parts and appurtenances necessary for a complete and well-integrated system. The following equipment shall be supplied:

a. Two (2) mist eliminator wash pumps and drives. Each pump shall be sized for the maximum instantaneous demand to clean the mist eliminators. One pump will be a spare.

b. Two (2) gland seal water pumps and drives. Each pump shall be sized for the maximum seal water requirement of the complete FGD system. One pump will be a spare.

c. Two (2) makeup water pumps and drives. Each pump shall be sized for the maximum makeup water and service water requirement of the FGD system. One pump will be a spare.

d. Any other clear water pumps required by the Vendor's design, necessary for a complete system.

e. Slide rails and baseplates as required.

7.12.2 Metal pumps shall be as manufactured by ASH Pump, Ingersoll-Rand, Worthington, or equal.

7.12.3 Pumps shall be horizontal shaft, vertically split centrifugal, end suction, single stage type.

7.12.4 The pumps shall be designed to have a head capacity curve which rises steadily to shutoff. At shutoff, the pump TDH shall be not less than 120 percent of the head at the design condition.

7.12.5 Pumps for a given service shall have identical characteristics and be capable of operating in parallel.

7.12.6 The pump assembly shall be designed for a maximum vibration of .08mm (3 mils) at any point.

7.12.7 The pumps and appurtenances shall be constructed in accordance to ANSI standards.

7.12.8 Parts and spares for all pumps of the same size shall be completely interchangeable.

7.12.9 Pumps shall be mechanically balanced statically.

7.12.10 Pumps shall be provided with eyebolts to permit equipment removal.

7.12.11 Motors shall conform to the attached Motor Specification.

7.12.12 <u>Drives</u>

a. For motors up to 300 kW (400 horsepower), matched multiple V-belt drives with a side-by-side motor and pump arrangement shall be used.

b. Matched multiple V-belt drive sets shall be rated at not less than 140 percent of the motor horsepower.

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c. Drives shall be provided with guards.

(1) Complying with all applicable safety requirements.

(2) Arranged to facilitate disassembly.

(3) Rigidly fastened to the baseplate.

(4) With solid metal cover on pump side and open mesh on outboard end.

d. Drives shall prevent any external thrust from being transmitted to the motor shaft under normal operating conditions.

7.12.13 Pump casing shall be:

a. Split vertically into the suction inlet assembly and pump assembly and designed to facilitate disassembly.

b. Suction and discharge flanges shall be standard 150 pound ANSI flat-faced flanges.

7.12.14 Casing bolts shall be stainless steel with through-bolt design.

7.12.15 The casing shall be oriented in a bottom horizontal discharge to facilitate draining.

7.12.16 The entire pump casing, including the suction flange, shall be capable of withstanding, without deformation, a pressure equal to 1.5 times the maximum dischage pressure which would occur when the pump is operating at rated conditions.

7.12.17 The entire pump casing, including the suction flange, shall be capable of withstanding, without permanent deformation, a pressure equal to 1.25 times the maximum discharge pressure which would occur when operating at the rated pump speed (rpm) but with a pump discharge valve closed.

7.12.18 Impellers shall be statically balanced.

7.12.19 The impeller shall be locked to the shaft to preclude loosening during accidental reverse rotation.

7.12.20 Shaft sleeves are required. They shall be locked to the shaft to preclude loosening during accidental reverse rotation.

7.12.21 Pumps with stuffing boxes shall have split glands. Graphited braided asbestos packing shall be provided whenever it is suitable for the service; otherwise packing shall be the manufacturer's standard.

7.12.22 When mechanical seals are specified, throttle bushings and spacer couplings allowing seal replacement shall be furnished. Mechanical seals shall be John Crane, Borg-Warner, Dura Seal, or equal. Each seal shall be carefully selected to give long service life with the pumped fluid.

7.12.23 Antifriction bearings shall have an AFBMA B-10 life of 100,000 hours. A shaft mounted flinger shall be provided to deflect water. Radial and axial forces of horizontal pumps shall not be transmitted to the motor.

7.13 OXIDIZING AIR COMPRESSORS

7.13.1 The Vendor shall design, fabricate, and install two (2) oxidizing air compressors to oxidize calcium solids in the four (4) reaction tanks. Each compressor shall be sized to provide 100 percent of the total oxidizing air requirement of the system.

7.13.2 Compressors shall be complete with drive motors, speed changing equipment, shaft couplings, baseplates, relief valves, inlet filter-silencers, discharge silencers, lube oil units, and all other equipment and material required to provide a complete unit.

7.13.3 Oxidation compressors shall be suitable for the application intended as manufactured by Allis-Chalmers, Ingersoll-Rand, Joy, or Engineer approved equal.

7.13.4 The compressor shall be a multistage, centrifugal compressor either on a single horizontal shaft driven through a speed increasing gear or of the integral gear type. Each unit shall include inter- and aftercoolers, a lube oil system, controls, and accessories, all factory mounted on steel fabricated supports, piped and wired to the maximum practical extent.

7.13.5 The peak-to-peak amplitude of vibration of the pinion shafts shall not exceed the following limits:

	r/min	Peak-to-Peak Amplitude, mm (Inch)
a.	3,600	.056 (0.0022)
b.	6,000	.043 (0.0017)
c.	10,000	.030 (0.0012)
d.	15,000	.022 (0.0009)
e.	20,000	.018 (0.0007)

	r/min	Peak-to-Peak Amplitude, mm (Inch)
f.	30,000	.015 (0.0006)
g.	40,000	.013 (0.0005)

Note: The values of vibration for speeds between the values shown shall be obtained by extrapolation.

7.13.6 The first "actual" lateral critical speed of stiff-shaft compressors and gears shall be at least 20 percent over the maximum continuous speed. Flexible-shaft compressors and gears shall operate with the first actual critical speed at least 15 percent below any operating speed. Where operating conditions may require reduced operating speeds, careful consideration shall be given to the location of the first critical speed. The Vendor shall make a lateral critical speed analysis and determine that the critical speeds of the driver are compatible with the critical speeds of the compressor and that the combination is suitable for the operating speed range.

7.13.7 Flanged Connections

a. Flanged connections shall conform to ANSI B16.1 or B16.5 as applicable, except that cast iron flanges shall be flat faced. Face and drilling requirements also apply to studded connections for which studs shall be furnished. Flat faced flanges are acceptable on steel cases. Flanges thicker or of larger outside diameter than required by the standard are acceptable. If the Vendor uses flanges or connections other than those covered by ANSI, all required mating parts must be supplied by the Vendor and details of the connections must be approved by the Engineer.

b. Connections welded to the case shall meet the material requirements of the case rather than the connected auxiliary piping.

c. Connections shall be provided for the following items:

(1) Pressure and temperature gage connections at each nozzle.

(2) Casing drains at the lowest point of each stage, or other low points of horizontally split casings.

(3) Lube oil.

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7.13.8 Impellers

a. Impellers shall be semi-open or closed and shall have either backward leaning or radial-type blading.

b. Renewable labyrinths shall be provided at all internal close clearance points to minimize internal leakage. Preferably, these labyrinths shall be easy to replace.

7.13.9 Shafts

a. Shafts shall be of one-piece, heat-treated forged steel, suitably ground.

b. Shaft seals shall be provided to prevent leakage out of or into the compressor over the range of specified operating conditions and during periods of idleness. Seal operation shall be suitable for variations in suction conditions that may prevail during startup and shutdown, or changes in atmospheric conditions.

c. The first critical speed of the shaft shall be 30% above running speed.

7.13.10 Couplings

a. The Vendor shall furnish all steel flexible-type couplings. Spacer-type couplings shall be supplied where necessary to permit normal compressor, gear, and driver maintenance without the need for moving either the compressor, gear, or the driver.

b. Limited end float couplings shall be used with electric motor drivers. The compressor or gear thrust bearing shall carry the residual motor thrust and coupling engagement axial loads when limited end float couplings are used.

c. Removable all-metal coupling guards shall be furnished.

7.13.11 Gears

a. Gear units shall conform to AGMA 421.06 and to related AGMA standards referenced therein, except as modified, supplemented, and optioned herein.

b. In no case shall the gear service factor be less than required by AGMA 421.06.

c. The gear casing shall be split on the horizontal center line of the motors with an oiltight metal-to-metal joint that prevents the escape of oil or vapors. Joint compounds may be used.

d. The gear casing upper half shall be doweled to the lower half. It shall be possible to lift the upper half without disturbing the alignment of the compressor or the oil piping.

e. Removable inspection covers shall be provided in the gear casing for direct visual inspection of the full face width of pinion and gear.

f. A suitably located, dry-type filter breather shall be provided on the gear casing vent. The breather shall be designed to keep moisture, vapor, dirt, etc., from entering the gear casing.

g. Each bull gear and pinion shall be supported on two bearings. Overhung designs are not acceptable. The gear unit shall be pressure lubricated, including spray nozzles for the teeth.

7.13.12 Shaft seals shall be of the nonrubbing labyrinth type and made of a nonsparking material that will cause minimum scoring of the shaft in the event of accidental rubbing. The seals shall be renewable.

7.13.13 Bearings shall be suitable for lubrication from a lube oil system common with the driven equipment. The bearing design, both radial and thrust, shall be selected by the Vendor.

7.13.14 The Vendor shall furnish an air filter-silencer for the compressor suction line and a silencer for the blow-off control valve. The air filter-silencer shall have a minimum of two stages and shall be capable of operation under reverse flow on surge condition without damage to the filtering elements. The first stage element shall be fully replaceable and the remaining filter media shall be cleanable.

7.13.15 <u>Coolers</u>

a. The Vendor shall furnish intercoolers for the most efficiency commensurate with a low installation cost and an aftercooler to produce the final air temperature of 43.3^{o}C (110^{o}F).

b. The coolers shall be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII and TEMA and shall be the shell and tube type with a fixed tube sheet, straight tubes, and removable covers. Tubes shall be not smaller than 15.8mm (5/8 inch) od, 18 gage (AWG).

7.13.16 A liquid-gas separator shall be provided after each intercooler to remove moisture and foreign material from the airstream prior to entering the next stage of compression. The separators shall be of the inertial or impingement type to remove 100 percent of the entrained moisture.

7.13.17 <u>Lubrication System</u>

a. The Vendor shall furnish a lubrication system for the compressors, gears, and drive motors. The lubrication system shall be self-contained and shall include a shaft-driven oil pump, heat exchanger, strainers, duplex filters, pressure relief valves, thermometers, pressure gages, oil drain sight flow glasses, a reservoir, and an auxiliary lube oil pump.

b. The lubricating system shall include adjustable pressure switches to automatically start and stop the auxiliary pump when the oil pressure drops below a predetermined pressure setting and to prevent the motor drivers from starting when there is no pressure to the bearings. Means of testing for the automatic starting feature of the auxiliary pump shall be provided.

c. All temperature and pressure switches necessary to actuate annunciator shall be furnished.

d. The lubricating system shall be designed to provide a continuous supply of oil to the bearings if the compressor rotates in the reverse direction.

7.13.18 The compressor and driving equipment shall be mounted preferably on one continuous baseplate. The baseplate shall be continuously supported and of welded steel construction and designed to minimize misalignment after installation.

7.13.19 Motors shall conform to the attached Motor Specification.

7.13.20 The Vendor shall provide the services of the manufacturer's field service personnel during erection and preparation for initial operation.

7.14 PIPING

7.14.1 The Vendor shall design, fabricate, install, and erect all piping, fittings, and valves within the scope of this Specification. The scope of supply shall include at least the following:

a. All piping specified for the equipment and as required for a complete FGD system within the FGD system boundaries.

b. All miscellaneous piping required for operation, including at least pilot lines, vents, drains and connecting lines to and from control valves, regulators, gages, gas analyzers, flowmeters, transmitters, equipment bearings and glands, and gage panels.

c. All tubing and tubing cable, supports, junction boxes, chemical feeders, and similar items as specified and as required for a complete installation.

d. Weld backing rings, consumable welding inserts, gaskets, and flange bolting material for all piping and pipe fabrication furnished under this Specification, including connections to equipment and piping furnished by the OWNER.

e. All temporary piping, fittings, connections, blind flanges, special flanges, blanks, and spacers required for hydrostatic testing, cleaning, blowing, and flushing the piping systems in the field.

f. All pipe supports, hangers, guides, restraints, vibration eliminators, anchors, and miscellaneous supporting steel as shown on the Drawings and as specified herein.

g. Flow nozzles, nipples, and welding adaptors in the pipe, including boring the pipe for flow nozzles in accordance with the requirements of the nozzle manufacturer.

7.14.2 Piping design and materials shall conform with the requirements and recommendations of ANSI B31.1.

7.14.3 Piping shall be properly sized for the design flow rates of the liquid to be transported. All slurry piping shall be sized to maintain a minimum velocity of 2m (6 feet) per second at minimum flow rates to prevent solids from settling in the lines, and a maximum velocity of 3m (10 feet) per second at maximum flow rates to minimize erosion. All slurry piping shall be 25mm (1 inch) and larger.

7.14.4 Flushing:

a. All piping, valves, and pumps in slurry service shall include provisions for automatic water flushing. All flush water piping control and isolating valves, and controls required for flushing operations shall be furnished. Sufficient flush water shall be introduced to the pipe to completely flush the volume of the pipe line twice.

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b. If substantial flush water is required to flush the absorber recycle piping, this line may be drained instead of being flushed. If this is the case, automatic flush valves with a timer shall be incorporated into the system control logic to prevent draining the recycle line during a momentary outage or trip of the pump.

7.14.5 Absorber recycle piping and pumps shall not be manifolded together. Each absorber recycle pump shall serve a dedicated absorber spray level.

7.14.6 Flanged or welded nozzles, branch connections, welding outlets, adapters, and taps shall be true and faced at right angles to the axis of the pipe to ensure accurate fit. Connections shall not extend inside the pipe.

7.14.7 Adhesive joints in fiberglass piping systems shall not be made under ambient conditions in which temperatures are below or above the manufacturer's recommendations.

7.14.8 Mitered fittings shall not be field fabricated unless specifically approved by the Engineer.

7.14.9 Branch connections shall be in accordance with the latest revision of ANSI B31.1.

7.14.10 Socket welding and threaded connections on carbon steel pipe lines shall be made by forged outlet fittings, Bonney Forge or Engineer approved equal. Fittings shall be of sufficient weight to satisfy reinforcement requirements and their pressure-temperature ratings shall be compatible with the pipes to which they are attached. The holes in pipe headers made for these connections shall be drilled to the same size as the fittings' inside diameters. All burrs shall be removed and threaded fittings shall be retapped after welding.

7.14.11 All necessary provisions for expansion shall be made. Where pumps take suction from a tank, the suction line shall include either an elbow or expansion joint to facilitate pump removal.

7.14.12 Pipe runs shall be vertical and horizontal.

7.14.13 Piping shall be designed to withstand surges in pressure and vibration caused by starting and stopping pumps.

7.14.14 Gland seal water piping shall be complete with site flow indicators and pressure gages at each equipment connection.

7.14.15 Connections for instruments and sampling and similar small connections shall be of the same material as the pipe and shall be extended to accessible locations. Connections shall be furnished with valves and shall be capped.

7.14.16 Fiberglass reinforced plastic piping and components shall be joined and installed in accordance with the manufacturer's instructions.

7.14.17 All piping shall be fabricated and delivered in such manner as to require minimum Work in the field. The piping system shall be fabricated into the largest subassemblies that can be safely and economically shipped to the jobsite and reasonably handled in erection.

7.14.18 Each pipe line or portion thereof shall be fabricated in accordance with the applicable portion of Paragraph 9.11 which includes detailed data for pipe, fittings, flanges, nozzles, and branch connections.

7.14.19 Surface Defects:

a. Care shall be taken in the handling and fabricating of piping in order to prevent surface damage.

b. Surface defects which are classified as injurious in accordance with applicable codes shall be repaired in accordance with those codes.

7.14.20 Dimensional Requirements

a. Dimensional tolerances of fabricated piping assemblies shall not exceed PFI ES-3. Accumulated tolerances between fixed points shall not total more than 9.5mm (± 3/8 inch) in any direction.

b. Minimum wall thickness for fabricated assemblies, as finally fabricated, shall be in accordance with applicable codes.

7.14.21 Alignment

The inside diameters of piping components to be joined by welding shall be aligned in accordance with the applicable codes.

7.14.22 Bending

a. All pipes requiring bending shall meet the requirements of the applicable codes after bending.

b. When bending electric fusion-welded pipe, the longitudinal weld shall be located in the neutral axis of the bend.

c. Bending of carbon steel shall be performed by either the hot or the cold method, whichever is more practicable.

d. Bends shall be used only where specified on the Drawings or after approval by the Engineer of a written request.

e. Prior to bending, pipe shall be sandfilled, where required, and firmly tamped in accordance with standard accepted shop practice to prevent flattening. Iron free sand shall be used for austenitic stainless steel piping. To prevent excessive wall thinning when hot bending, gas-purged bending shall be used where sand is not required.

f. Bends shall be free of sand or debris of any kind, both inside and outside. Bends shall be wire brushed on the outside and aluminum-oxide grit blasted on the inside to ensure cleanliness.

g. When hot bending is used, the pipe shall be heated by any method which ensures close control and uniformity of temperature. Heating of pipe shall be gradual to avoid hot spots. No spot or heat shrinking shall be used.

h. Piping shall be degreased prior to subjecting it to elevated temperatures before, during, or after bending to prevent carburization.

7.14.23 Transition Joints

Shop-fabricated transition pieces shall be used where ferritic steel-austenitic stainless steel weld joints are required to weld valves and equipment to the pipe. The minimum length of the transition piece shall be 180mm (7 inches) unless otherwise shown on the Drawings.

7.14.24 Fittings

Fittings shall be furnished as specified in Paragraph 9.11.

7.14.25 Flanges

a. Flanges shall be furnished as specified in Paragraph 9.11 unless the Drawings indicate otherwise.

b. To prevent galvanic corrosion between dissimilar metals, insulation flanges shall be provided where shown on the Drawings.

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c. Bolt holes shall straddle the principal horizontal and vertical centerlines of piping and equipment unless the Drawings show otherwise.

d. Slip-on flanges, where permitted, shall be fully welded at the hub and pipe end.

e. Bolts and gaskets shall be furnished for all flanged joints, including connections to equipment furnished by others. Special bolts, such as those required for wafer-type butterfly valves, shall also be furnished.

f. Where tongue-and-groove flanges are specified, the female facing shall be on the valves or equipment. Where a flanged valve connects to equipment, the female facing shall be on the equipment.

7.14.26 Branch Connections

1. Branch connections shall be furnished as specified in Paragraph 9.11 unless the Drawings indicate otherwise.

2. Holes for branch connections 50mm (2 inches) and smaller shall be machine drilled. For branch connections 65mm (2-1/2 inches) and larger, the holes shall be machine drilled or torch cut by automatic equipment. Rough burning is not allowed. There shall be no burrs, wire edges, or other irregularities on the inside of the pipe or along the edge of the hole.

3. Branch connections shall be reinforced in accordance with ANSI B31.1.

4. Additional reinforcement against external forces (expansion relief valve thrust, deadweight seismic consideration, and differential settling) shall be provided where specified. The Vendor shall design reinforcements for loads specified by the Engineer.

7.14.27 Welding

General welding requirements are as follows:

a. Welding procedures, welders, and welding operators shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. For all shop-fabricated, carbon alloy steel, and austenitic stainless steel piping, the welding processes shall comply with the requirements of the ASME Code (Section IX) and ANSI B31.1.

b. Joint preparation shall be in accordance with ANSI B16.25 for field welds and welds to equipment or items supplied by others.

c. Unless otherwise specified herein, the requirements of Chapter V of ANSI B31.1 shall govern the welding of ferrous metals.

d. Surfaces of parts to be joined by welding shall be cleaned to remove oil, grease, paints, scale, rust, and moisture. Each weld pass shall be cleaned and shall be free of slag before the next pass is deposited.

e. Where backing rings are tack welded to the pipe, the tack welding shall be on the upstream side in at least four places.

f. In the welding of a pipe having a wall thickness 20mm (3/4 inch) or greater, ever effort shall be made to deposit at least one-third of the weld metal in an uninterrupted operation. If the welding is interrupted before one-third of the weld metal is deposited or the weld is 15mm (1/2 inch) thick, the weld shall be covered with adequate insulating material to insure slow cooling to ambient temperature. The partially completed weld shall be examined by magnetic particle or liquid penetrant methods before resuming welding.

g. Welding filler metal and welding flux shall be stored in a manner to ensure that no moisture accumulates in the weld rod. Low hydrogen type electrodes shall be stored in enclosures with the temperature regulated as recommended by the electrode manufacturer. All electrodes shall be properly identified.

h. Heat shall not be applied to correct weld distortion and dimensional deviation in austenitic stainless steel material.

7.14.28 Weld Defect Repairs

Welds which do not meet the acceptance standards of each applicable nondestructive examination described in Chapter VI of ANSI B31.1 shall be repaired using the qualified welding procedures applicable to the original weld.

7.14.29 Pipe Supports

a. All engineered materials and equipment shall be in accordance with the requirements of the ANSI B31.1, MSS SP-58, MSS SP-69, and pipe manufacturer's recommendations for pipe supports.

b. Supporting steel shall be in accordance with AISC Specification for Design, Fabrication and Erection of Structural Steel for Buildings. Supports shall be located, where possible, on system support beams or columns of 200mm (8 inch) size or larger. Supports shall also be located near concentrated piping loads (such as valves) and near changes in direction of the piping. Supports shall not be attached to system support structural angles, diagonal bracing, or truss members.

c. The design load for each restraint, including its support steel and associated hardware, shall be the greater of the following summations:

   (1) deadload + thermal.

   (2) deadload + hydrostatic.

d. Deflection of carbon steel pipe between supports shall be limited to 3mm (1/8 inch) with normal operating loads in the piping, and 10mm (3/8 inch) with maximum loading. Deflection and support spacing of FRP piping systems shall be in accordance with the manufacturer's instructions.

e. Variable support hangers shall be of the coil spring design.

f. All materials shall be suitable for the temperature conditions to which they may be subjected.

g. Rod hangers or constraints shall not be subjected to compressive loads.

h. Supports shall be designed so that they cannot become disengaged by movements of the supported pipe.

i. All support rods shall be carbon steel.

7.14.30 <u>Tubing</u>

a. Copper tubing 20mm (3/4 inch) and smaller for use with flareless bite tubing fittings shall be light drawn temper tubing conforming to ASTM B75, except copper tubing in tubing cables shall be fully annealed soft temper tubing conforming to ASTM B68 or B75.

b. Copper tubing one inch and larger, and short instrument drop runs of 20mm (3/4 inch) and 15mm (1/2 inch) tubing, for use with braze joint fittings shall be ASTM B88 Type K drawn temper. The tubing shall be in lengths of at least 10 feet and shall be capped at both ends.

c. Copper tubing shall be oxygen free or phosphorus deoxidized copper. Oxygen bearing tough pitch copper tubing shall not be substituted.

d. Stainless steel tubing shall conform to ASTM A213 and shall be fully annealed seamless Type 316 with carbon content greater than 0.04 percent. Stainless steel tubing for use with tubing fittings shall not exceed Rockwell B80 hardness.

e. Wall thickness for tubing 20mm (3/4 inch) and smaller shall not be less than the following. The thicknesses indicated are the minimum acceptable and heavier wall tubing shall be used where required by pressure and temperature conditions or as specified otherwise.

Outside Diameter of Tubing, mm (in).			Wall Thickness, mm (in.) Copper, ASTM B68, B75		Wall Thickness, mm (in.) Stainless Steel	
(1)	7	(1/4)	.8	(0.030)	1.7	(0.065)
(2)	10	(3/8	1.2	(0.049	1.7	(0.065)
(3)	15	(1/2)	1.7	(0.065)	2.1	(0.083)
(4)	17	(5/8)	2.1	(0.083)	2.4	(0.095)
(5)	20	(3/4)	2.8	(0.109)	2.8	(0.109)

f. Wall thickness of Type K drawn temper copper tubing shall be in accordance with ASTM B88.

7.14.31 Plumbing and drainage shall meet the following requirements:

a. All storm waste and vent piping underground within the buildings shall be extra heavy cast iron solid pipe with extra heavy cast iron hub and spigot soil fittings in accordance with ASTM A-74.

b. All waste, vent and storm lines above ground shall be galvanized steel pipe, Schedule 40 ASTM A-120 with galvanized cast iron drainage fittings, except vent lines which shall have galvanized malleable iron fittings.

c. All vent piping passing through the roof shall be extra heavy cast iron soil pipe from below the roof; vent piping

40mm (1-1/2") and smaller shall be increased in size below the roof. The connections between screwed vent piping and cast iron soil pipe shall be by means of Manhoff hub or similar fitting. Each vent as it passes through the roof shall be provided with a vent connection and with .45 kg (16 oz.) copper flashing.

d. Fire standpipe piping inside the building shall be steel pipe, Schedule 40, with malleable threaded or flanged fittings.

e. Acid resisting piping, where indicated on the plans, shall be duriron pipe and fittings (ASTM A-518) or approval equal.

f. No plumbing work shall be done except by a duly licensed master plumber or journeyman plumber working for and under the personal supervision of a master plumber.

g. The Work described in this Specification and shown on the Vendor's drawings shall comply with all laws, ordinances and regulations of the state authorities and any local laws and codes.

7.14.32 The potable water system shall meet the following requirements:

a. The Vendor shall connect to the OWNER'S potable water system at the terminal point indicated herein. Connection at interface shall include a system cut-off valve, strainer, pressure reducing valve to deliver 448 kPa (65 psig), and reducing valve isolation valves.

b. Potable water piping shall be Type "L" hard temper ASTM H 23.1, with cast brass fittings and 95-5 percent tin-antimony soldered joints.

c. The potable water system shall be sized to provide a minimum of 172 kPa (25 psig) residual pressure at the most remote fixture or equipment supply connection.

d. Safety shower and eyewash unit shall be provided for emergency use in any area where sulphuric acid may be present and any area which may have a substance that is hazardous to human health. The emergency shower and eyewash shall be a Speakman SE-236 and SE-410.

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7.15 VALVES AND VALVE OPERATORS

7.15.1 The Vendor shall furnish and install all valves and valve operators required for a complete FGD system.

7.15.2 Isolation valves shall be provided to permit any piece of equipment to be removed from service for maintenance without affecting operation of the remainder of the system.

7.15.3 Valves:

a. Valve construction shall be in accordance with the requirements of the American National Standards Institute (ANSI) or the Manufacturers Standardization Society (MSS) where applicable standards exist. In case of conflict, the ANSI rules shall govern.

b. Valves furnished for slurry isolation service shall be either knife gate or plug valves.

c. Valves furnished for clear liquid isolation service shall be either knife gate, plug, butterfly, or check valves.

d. Valves furnished for modulating control services of clear liquid shall be either pinch or globe valves.

e. Modulating control valves shall not be used in slurry service.

f. All valves furnished for isolation service shall be furnished with manual and electrical motor valve actuators.

g. All valves furnished for modulating control service shall be furnished with manual and pneumatic actuators.

h. Where required by the service, valves shall be rubber lined or of suitable corrosion-erosion resistant materials acceptable to the Engineer.

i. Valves and accessories shall be capable of continuous satisfactory operation under their respective design conditions with a reasonable operating margin and without undue strain, corrosion, deterioration, leakage, vibration, or other operating deficiencies.

j. Each control valve station shall include inlet and outlet shutoff valves and a bypass valve. Shutoff and bypass valves shall be manually operated unless they must be automatically operated to satisfy control system requirements.

k. End to end dimensions shall conform to ANSI B16.10.

l. Valve designs shall minimize disc vibration, spin, and chatter under all conditions.

m. The minimum wall thickness of pressure retaining parts shall be in accordance with ANSI B16.5, Tables 15, 18, 24, 27, 30, or 32 for the respective pressure classes.

n. Valves shall be provided with a means to relieve confined fluid.

o. All valves shall be full ported unless otherwise specified.

p. Replaceable valve parts shall be replaceable with the valve installed.

q. Steel body gate, globe, and check valves shall meet the following requirements:

   (1) Steel body valves shall have carbon steel or stainless steel bodies as required for the service.

   (2) Positive backseating stem and bonnet construction shall be furnished. Gate valves shall have renewable seats. All other valves shall have integral type seats.

   (3) A gland follower with bolting for compression adjustment and fastening shall be furnished. The design shall prevent binding between the stem and follower during adjustment and shall provide adequate space for replacing the packing without removing the actuator when the follower is slipped up the stem.

   (4) Packing shall be high quality, selected to minimize friction and the necessity for gland take up, and to provide maximum protection against leakage and corrosion to valve parts. The packing(s) selected shall be certified to contain less than 200 ppm leachable chlorides. The bidder shall list on the Equipment Data form a schedule of the packing he will use in each valve.

(5) Valves 100mm(4 inches) and smaller shall be lift check or swing check; valves larger than 100mm (4 inches) shall be the hinged check type, except valves larger than 200mm (8 inches) may be tilting disc type.

(6) Tilt disc check valves may be of the split body or bonnet entrance type, and hinge covers may be used on valve exterior.

(7) The swing check type valve shall be the type which allows servicing through the bonnet opening; the type with an internal hinge or the type with the hinge pin penetrating the body and cap is acceptable.

r. Butterfly valves shall meet the following requirements:

(1) The valve body shall be of the wafer type designed for installation between two ANSI 125 pound flanges.

(2) The valve disc shall rotate approximately 90 degrees from the full open to the tight shutoff position.

(3) The rubber seat shall be a spool type rubber ring vulcanized or bonded to the valve body and extending over the flange contact faces to serve as a piping gasket or a metal reinforced rubber ring retained by the mating pipe flange.

(4) The seating surfaces on the disc shall be ground and polished.

(5) The valve shaft or shafts shall be designed for the torques and forces encountered in opening and closing the valve in service. The shaft design torque shall be determined in accordance with Appendix A of AWWA C504. All disc-to-shaft securing fasteners shall be stainless steel.

(6) Shaft seals shall be of the self-adjusting, split "V" type, accessible for replacement without disassembling the valves.

s. Plug valves shall meet the following requirements:

(1) Plug valves shall be DeZurik eccentric plug type, Tufline tapered plug valves, or Engineer approved equal.

(2) All valve bodies shall conform to the requirements of ANSI for dimensions, material thickness, material specifications, and their respective pressure classes. Valve body ends shall be flanged in accordance with ANSI standards.

(3) Plug valves used in low pH or abrasive applications shall have stainless steel bearings and a neoprene lined body and plug. Manually operated plug valves shall have gear operators and handwheels.

t. Knife gate valves shall meet the following requirements:

(1) Slide gate valves shall be DeZurik C knife gate valves, Hilton-HZ wafer valves, or Engineer approved equal.

(2) All wetted parts shall be of 316 stainless steel, as a minimum.

(3) Flax packing and a neoprene resilient seat shall be provided for each valve.

u. Pinch valves shall meet the following requirements:

(1) Pinch valves shall be constructed by RKL Controls, Inc. or Engineer approved equal.

(2) Each valve shall have a pure gum rubber or synthetic rubber body acceptable to the Engineer. The body shall be totally enclosed in a cast iron or aluminum housing.

(3) The pinch mechanism shall be designed not to cut the rubber liner when the operator is over-torqued.

v. Solenoid valves shall meet the following requirements:

(1) Solenoid valves shall be as manufactured by the Automatic Switch Company or Engineer approved equal.

(2) Solenoid-operated air pilot valves shall be yoke or diaphragm mounted wherever applicable, complete with interconnecting piping between the solenoid valve, diaphragm, and positioner. Interconnecting piping shall be brass pipe or copper tubing.

(3) Solenoid valves shall have brass bodies and soft seats to ensure tight shutoff.

(4) Solenoids shall be high-temperature epoxy-glass insulated, shall be capable of being continuously energized at 220 volts ac in a 60°C (140°F) F ambient temperature, and shall have 450mm (18 inch) long leads.

(5) Solenoids located indoors shall be enclosed in NEMA 12 general purpose enclosures; those located outdoors shall be enclosed in NEMA 4 enclosures. Conduit hubs shall be 15mm (1/2 inch).

7.15.4 Electric Motor Valve Actuators

a. Electric motor valve actuators shall meet the following requirements:

(1) Electric motor valve actuator shall be Limitorque Corporation, Model SMB or SB, as manufactured by Philadelphia Gear Corporation, or Rotork Inc. Model Syncro Set, or equal.

(2) The motors shall be designed and manufactured with workmanship of first quality in accordance with accepted current standards for electric utility equipment. The recommendations of NEMA MG 1, Sections 1, 2, 10, 11, 12, 14, and 18 shall be adhered to as applicable.

(3) The complete motor-operated valve actuator shall be designed for outdoor (weatherproof) installation unless specified otherwise. The motor shall be of high torque design, capable of opening or closing the valve against maximum differential pressure when the valve is 15% above or below the specified applied nominal voltage of 400 V ac or 125 V dc.

(4) All motors shall be suitable for 400 V ac, 50 hertz, 3-phase operation unless specifically requested for 125 V dc operation. All 380 V ac motors shall be furnished with a 220 V ac, single-phase space heater unless specified otherwise. All motors shall have Class B insulation unless specified otherwise.

(5) Motor bearings shall be the permanently lubricated type of anti-friction design.

(6) The motor-operated valve actuator shall include the motor, operator unit gearing, limit switch drive or gearing, sixteen limit switches, one double-torque

limit switch, stem nut and stem cover for rising stem valves or bored and key-wayed drive sleeve for non-rising stem valves, declutch lever and auxiliary manual handwheel, clutch, and gear train independent of the motor gear train as a self-contained self-locking unit.

(7) The power gearing shall consist of generated helical gears of heat treated steel, if required, a steel worm and worm gear of alloy bronze, and anti-friction ball/roller bearings with permanent lubrication throughout.

(8) The valve actuator shall have a stem nut and lock nut compatible with the material of the valve stem. Nut arrangement shall be of the two-piece type to simplify field replacement. The stem nut shall be removable from the actuator without removing the actuator from the valve or any gearing within the actuator.

(9) A handwheel shall be provided for MANUAL operation only and shall not rotate or be capable of rotating when the unit is operating electrically. To switch from motor operation to handwheel operation, a positive declutching lever shall disengage the motor and motor gearing mechanically but not electrically. When in the manual operating position, the unit shall remain in this position until the motor is energized at which time the valve actuator shall automatically return to electric operation and remain in the motor position until the handwheel operation is selected. The handwheel shall operate in a clockwise direction to close the valve. Manual valve actuators shall be sized for opening and closing with a force not exceeding 36 kg (80 pounds) applied at the rim.

(10) The valve control shall have a built-in lost motion device that travels at least 135^{o} before impacting a hammer blow to start the valve in motion in either the closing or opening direction, and allows the motor to attain full speed before load is encountered. A lost motion device shall <u>not</u> be provided for valves used in inching, throttling, regulating, or modulating service.

(11) A local mechanical valve position indicator, graduated in percent of valve opening, shall be installed on each unit.

b. Torque switches shall meet the following requirements:

(1) Each valve control shall be furnished with a double torque switch which shall be adjustable and responsive to the load encountered in either direction of travel. The switch shall have two electrically independent contacts, one to open on excess torque during valve closing and one to open on excess torque during valve opening.

(2) The closing torque switch shall be employed in the case of a wedged gate valve or globe valve to control predetermined seating thrusts. Travel and thrusts shall be independent of wear in the valve disc or seat rings. The maximum possible closing and opening torque settings shall be as near to the pullout torque of the motor as possible without damaging the electrical or mechanical equipment.

c. Limit switches shall meet the following requirements:

(1) Limit switches and gearing shall be an integral part of the valve control. The limit switch gearing shall be of the intermittent type or other positive drive, and totally enclosed and lubricated.

(2) Limit switches shall be adjustable to any point between fully open and fully closed valve positions. Each group of four limit switches shall have two normally opened and two normally closed contacts.

(3) Limit switch compartment shall have a 220 V ac heater installed of sufficient wattage to prevent condensation.

7.15.5 Pneumatic Valve Actuators

a. Pneumatic valve actuators shall meet the following requirements:

(1) The actuator stem connection length shall be adjustable in the field.

(2) The Vendor shall recommend the use of a hydraulic snubber for any specific valve application where a snubber is necessary for smooth control performance.

(3) The inside of the actuator casing shall be cleaned and painted with the manufacturer's standard primer and finish paint.

(4) The topworks shall be of the yoke mounted design, except where space may be a consideration. In this case, topworks may be close-coupled to the valve.

(5) Pneumatic actuators shall be supplied with nameplates (metal screw or tack welded) which indicate the diaphragm air pressures at fully open and fully closed positions.

(6) Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions, or the maximum differential pressure specified. Unless otherwise specified, the operator shall be selected to provide a minimum allowance of 9 kg/linear cm (50 lb/linear inch) of seating surface to assure tight seating. The spring diaphragm actuator shall be designed to provide the specified shutoff leakage rate limit with no more than 80% of available air supply pressure or at least 34.5 kPa (5 psi) less than the design supply pressure, whichever pressure is less. The diaphragm case shall have a minimum design rating of 207 kPa (30 psig) regardless of the application.

(7) All valves shall be furnished with a handwheel of the enclosed gear type to suitably seal out dirt and other foreign material, and require no more than 36 kg (80 pounds) of handwheel effort. The handwheel shall be of the declutchable type to permit automatic operation of the valve with the power actuator and shall include a suitably hardened male drive shaft for attachment of an air wrench to effect powered operation.

b. Limit switches:

Limit switches shall be of the snap acting type, DPDT, and the contact rating shall be 10 A at 220 V, 50 Hz, and 1/2 A inductive at 125 V dc. Contacts shall be provided for both the fully open and fully closed positions. The limit switches shall be National Acme, Snaplock, series SL, or equal. They shall be installed in a manner that will not interfere with the normal operation of the valve. The range of adjustment shall be up to 1/2 of the valve stroke. Mounting of the limit switches on the valve shall be rigid to preclude misalignment and false indication of position when conduit is later connected to the switch enclosure.

c. Controllers:

The controllers shall be mounted in dusttight and weatherproof cases having windows for observation of pressure gages. Pneumatic controllers shall be equipped with gages to show the values of the supply and control pressures. The controller shall have adjustable set point, proportional band, and any other function mechanisms such as reset, rate, anti-reset windup, etc.

7.16 SLURRY AGITATORS

7.16.1 The Vendor shall design, fabricate, and install slurry agitators of sufficient quantity and size to properly agitate the slurry solids in the following applications:

a. Reagent slurry storage tank.

b. Absorber reaction tank.

c. Slurry surge tank.

d. All other slurry tanks required by the Vendor's system.

7.16.2 One spare agitator of each type and model shall be supplied as a warehouse spare.

7.16.3 The services of the manufacturer's field service personnel shall be provided during erection and preparation for initial operation.

7.16.4 Each agitator shall consist of the following components:

a. Rubber covers shaft and impeller.

b. Motor.

c. Couplings, gear reducers, and all required guards.

d. Mounting base.

e. Auxillary piping as required for cooling.

f. Other equipment and material as required to provide a complete unit.

7.16.5 The agitator vendor shall conduct a pilot test to confirm the agitator design criteria and determine the optimum location of the agitator.

7.16.6 Agitators shall:

a. Be as manufactured by Mixing Equipment Company, Chemineer, Philadelphia Gear, or Engineer approved equal.

b. Keep all solids suspended and off the bottom of the tank.

c. Be designed for continuous operation.

d. Be designed to maintain a uniform solids suspension in at least 50 percent of the tank height.

e. Be capable of resuspending settled solids.

f. Be designed to maintain solids suspension when liquid level is no more than 25 percent of tank height.

7.16.7 All wetted components of the agitators shall be rubber lined and spark tested. Soft natural rubber for abrasion resistance shall be minimum of 3mm (1/8 inch) on shaft and 6mm (1/4 inch) on impeller with 6mm (1/4 inch) build-up on feeding edges and areas of high wear.

7.16.8 Top entering agitators are preferred; however, if side entering agitators are used, the agitators shall be provided with mechanical seals and stuffing boxes with connections for flush water. Seals and stuffing boxes shall be replaceable without draining the contents of the tank.

7.16.9 Impellers and impeller shafts shall meet the following requirements.

a. Impeller thrust shall not be transmitted to the speed-reducing equipment or motor.

b. Flow patterns from the impeller and tank baffling shall be capable of maintaining solids in suspension with and without recirculating flow from the tank. The flow pattern shall also be capable of resuspending solids after a short shutdown such as a power failure.

c. The impeller and shaft shall be easily removable without disturbing the speed reducers or the motor.

d. Impellers shall not be integrally welded to the shaft.

e. Shaft runout at the seal face or stuffing box shall not exceed .05mm (0.002 inch) during operation at design conditions.

f. The first critical speed of the shaft shall be greater than 130 percent of maximum operating speed.

7.16.10 Reducing drive gears shall be designed in accordance with American Gear Manufacturers Association. Motors shall be flexible coupled to the gear reducers. All exposed rotating drive equipment shall have guards meeting the requirements of OSHA. The gears shall be accessible without disassembling the inner parts of the drive. The gear drive service factor shall be 2.0 based on the motor nameplate horsepower.

7.16.11 The drive shall have antifriction bearings throughout and shall be designed to absorb the maximum possible loads from fluid agitation, including torque, thrust, and unbalanced hydraulic load. Bearings shall have a minimum B-10 life of 30,000 hours.

7.16.12 Lubrication of the agitator speed reducer shall be by means of oil bath or oil spray to ensure constant flow of oil to all gear surfaces. A positive gear shall be provided to prevent oil leakage down the output shaft.

7.16.13 The speed reducer shall be equipped with a change gear feature to permit easy replacement or speed change.

7.16.14 Agitator motors shall be in accordance with the attached Motor Specification.

7.16.15 The motor gear reducer, and agitator shall be supplied on a common base fabricated of steel or cast iron of rigid construction to maintain alignment of all components.

7.17 ELEVATOR

7.17.1 The Vendor shall furnish and install one elevator for the FGD system complete with structural steel, hoist beams, machine room, hoistway and penthouse frames, hoistway liner, all machinery, hoistway doors, and all items, controls, and accessories specified herein. Elevator shall be Otis MR4535 or an Engineer approved equal, standard package type including options and modifications as herein specified.

7.17.2 The elevator shall be installed with the FGD equipment to serve all main platform levels and ground level.

7.17.3 The Vendor shall furnish enclosure siding for the machine room, hoistway and penthouse, elevator landing platforms, and hoistway liner panel.

7.17.4 Separate landing plaftorm shall be provided at each landing. Weatherproof landing platforms shall exterd 1.8m (6 feet) from the front of elevator and be at least as wide as the elevator.

7.17.5 The elevator machine room shall be located in a space provided below and at the rail of the hoistway.

7.17.6 The elevator travel shall be from the ground floor landing with pit depth as required, to a top landing and penthouse elevation to be determined by the height of the absorber enclosure.

7.17.7 Safe lifting capacity, in addition to the weight of the car, shall be 2,041 kg (4,500 pounds). The speed, at this load shall be 1.8 m/sec (350 feet per minute).

7.17.8 Elevator operation shall be by selective, automatic control from a flush-mounted panel located inside the car.

7.17.9 Limit switches shall be provided in the elevator shaft. Limit switches shall be designed to cut off current and prevent further movement of the car in either direction, in case the car, for any reason, should travel more than a predetermined distance beyond terminal floors.

7.17.10 The car platform shall be 2.1m (7'-0") wide by 1.5m (5'-0") deep. The car plaftorm shall be constructed of structural steel shapes, riveted, bolted, or welded together.

7.17.11 Car enclosure shall conform to regulations of the ANSI safety code for steel or wood cars.

7.17.12 Car doors shall be horizontally-split, power-operated, sliding, two-speed, 1.2m (4'-0") wide x 2.1m (7'-0") high with retractable safety shoes. Car doors shall be hollow metal (stainless steel) flush panel construction not less than 25mm (1 inch) in thickness filled with sound-deadening filler.

7.17.13 <u>Guides</u>

a. Guides for car and counterweights shall be planed steel tees, erected plumb, and secured to the building with heavy steel brackets. They shall have the following weights:

(1) Car guides shall weigh at least 22.3 kg/m (15 pounds per linear foot).

(2) Counterweight guides shall weigh at least 11.9 kg/m (8 pounds per linear foot).

b. Guides ends shall be tongued and grooved, forming matched joints with all connections made with splice plates.

c. Automatic guide lubricators with proper means for regulating oil flow shall be furnished and installed on both the car and counterweight guides, or passenger elevator-type shoes or roller guides shall be furnished.

7.17.14 Machine

a. The machine shall be the single worm-geared type with motor, brake, gears, and drive equipment mounted in proper alignment on a cast iron or steel base plate.

b. The steel worm shall be provided with ball thrust bearings designed to take end thrust of worm in both directions.

c. Machine shall have a spring applied electrically released brake, designed for instant and automatic application in event of power failure.

7.17.15 Ropes and compensating chains of proper size and number shall be supplied to ensure best wearing qualities. They shall at least comply with the safety requirements for elevators of the ANSI Safety Code.

7.17.16 The elevator shall be suitably counterbalanced for smooth economical operation.

7.17.17 The Vendor shall include the following electrical lighting and wiring:

a. All electrical control and lighting equipment shall be mounted and wired, ready for connection to an external 400 volt, 3-phase power supply and 220 volt lighting supply.

b. Traveling cables between the car and hoistway shall be flexible, type EO, with supporting filler of stranded steel wire, and hung so as to relieve strain in the copper conductors and insulation.

7.18 HOIST AND TROLLEY

7.18.1 The Vendor shall supply a complete hoist and trolley system as required for maintenance of the following major equipment:

a. The reagent preparation grinding mills in the additive preparation area.

b. The recycle pumps and oxidation compressors in the absorber area.

7.18.2 The capacity of the hoist shall be that required to lift the heaviest piece of equipment, plus rigging, during service or maintenance; minimum capacity shall be 4.5 tonnes (5 tons).

7.18.3 The hoist shall be the underhung, electrically motorized traveling type.

7.18.4 The length of the trolley shall be that required to service the specified equipment plus the length needed to hoist equipment to the adjacent laydown area.

7.18.5 The height of the trolley shall be that needed to lift equipment over adjacent operating equipment and set it down in the laydown area.

7.19 INSULATION AND LAGGING

7.19.1 The Vendor shall design, furnish and install all insulation work required for the satisfactory performance of all piping systems and equipment furnished under this Specification. The Work shall include the flashing of all roof and wall penetrations and the insulation of the following items for the purpose of heat conservation, personnel protection, antisweat, and freeze protection:

a. All hot gas ducts from the ID fan discharge to the chimney inlet.

b. Pressure vessels, tanks, and process equipment, including pumps, heat exchangers, and heaters, as required by the Vendor's design.

c. Piping and tubing lines.

7.19.2 All materials required for support and fastening of the insulation and lagging shall be furnished and installed by the Vendor. This shall include structural steel, insulation pins, clips, welding studs, screws, rivets, bands, tie wires, or any other required means.

7.19.3 Before applying insulation, the Vendor shall verify that the pipeline has been completely installed, all heat tracing has been installed, and each item has been tested and is ready for insulation application. Also, the surface to be insulated shall be thoroughly cleaned of scale, dirt, and other matter and shall be dry when insulated.

7.19.4 The Vendor shall follow the material manufacturer's recommendations and instructions for mixing, storing, and applying their products. The Vendor shall be responsible for protecting the insulation from weather from the time of delivery to the time of installation and weatherproofing installed insulation with permanent finish.

7.19.5 The Vendor shall provide all temporary safety and weather protection for the insulation material and erection personnel. The affected area shall be restored to its original condition after the completion of the Work. All surfaces adjacent to the work area shall be protected by the Vendor to prevent damage.

7.19.6 All costs of removing and reinstalling items to permit or expedite the insulation Work shall be borne by the Vendor. Any completed or in-progress construction work which may or may not be part of this Specification and which is damaged by the Vendor during the insulation work shall be repaired, replaced, or restored to its original condition by the Vendor at the Vendor's expense.

7.19.7 All stiffeners or flanges of casings and ducts shall be covered with insulation. Outstanding legs of any metal parts extending beyond the outside of the insulation face shall be covered with insulation of not less than 25mm (1 inch) thickness.

7.19.8 When completed, all insulation shall be weather protected. The insulation and lagging shall accommodate all thermal movement without noticeable distortion or loss of insulating capability and shall remain free of hotspots, blisters, or discoloration.

7.19.9 Lagged surfaces in areas where it is necessary to support the weight of personnel shall be designed for a minimum of 610 kg/m^2 (125 pounds per square foot) live load. Lagged surfaces in all other areas shall be designed for a minimum of 293 kg/m^2 (60 pounds per square foot) live load normal to the lagging surface.

7.19.10 Insulation Method:

a. Ductwork:

(1) All insulated ducts shall be covered with a 50mm (2 inch) thickness of insulation. Insulation specified as 50mm (2 inch) or greater thickness shall be installed in two layers with staggered joint construction. All joints shall be butted tightly to eliminate voids between adjacent blocks or sidewalls. All insulation shall be covered with tne specified wire mesh and held in position with No. 9 pins and speed clip insulation fasteners. The pins shall be welded to the structure on 300 x 300mm (12 inch by 12 inch) vertical and horizontal centers. When the insulation must be installed at the level of the stiffeners, it shall be supported with a layer of wire mesh. Thermal barriers shall be installed on vertical runs at a maximum spacing of every 3m (10 feet) and at the top of the vertical run.

(2) Insulated ductwork shall be lagged with .13mm (.051 inch) thick stucco embossed aluminum. The lagging on horizontal surfaces shall be sloped 200mm per meter (2 1/4 inches per foot) for water drainage. Lagging and overlaps shall not be less than 76mm (3 inches) in the direction of drainage. Adjacent panel sides shall be overlapped a minimum of one rib flute. Sidewall lagging ribs shall run vertically and all ribs and valleys shall be lined up on adjacent sheets at the splices, flashing, and expansion joints.

b. Access insulation:

(1) All equipment access openings, inspection openings, manways, and removable heads which must be removed periodically for maintenance or repairs and which are not furnished as a preinsulated unit shall be insulated in such a manner that they can be opened or removed without difficulty or interference with the surrounding insulation.

(2) The lagging on the access openings shall be flashed, counterflashed, and weatherstripped to provide a weatherproof seal for the insulation.

7.20 EQUIPMENT ENCLOSURES AND ACCESS

7.20.1 Equipment Enclosures

7.20.2 A control room and motor control center enclosure shall be provided for the Reagent Preparation Facility.

7.20.3 A control room and motor control center enclosure shall be provided for the Absorber Area.

7.20.4 Equipment Access

a. All supporting steel, grating, checkerplate, handrails, and kickplates for walkways, stairs, and platforms shall be provided as required to make a complete access system to all equipment requiring inspection, service, periodic maintenance or testing.

b. Regularly attended areas for equipment requiring access during operation and for normal day-to-day inspection and maintenance shall have access operating platforms which are fully accessible by stairs. No ladders or strips ladders for these access platforms will be permitted.

c. Maintenance areas that require access only monthly or annually (i.e., duct access doors, fan and fan motors, safety valves) shall have access platforms of adequate size to permit two people to work, 1.1 square meters (12 square feet) minimum, with walkways or ladders to reach the platforms.

d. A sufficient number of access doors and platforms to facilitate entry to all parts of the absorber modules and FGD System shall be provided. All absorber modules shall be connected by walkways at no less than (later) elevations.

e. All access doors shall be at least 600mm (24 inches) in diameter, gastight, and quick opening.

f. Platforms shall have direct access to the elevator, unless platforms are so close together that the 3.6m (12 foot) minimum elevator door spacing does not permit elevator opening at each separate level.

g. Headroom shall be 2.1m (7'-0") clear. Adequate allowance shall be made for installation of piping, conduit, and lighting fixtures.

h. Access component design criteria:

(1) Walkways:

(a) Walkways shall be at least .9m (3'-0") wide. Walkways for minimal access areas may be .6m (2'-0"). Main access walkways shall be at least 1m (3'-6") wide.

(b) Handrails and kickplates shall be installed along both sides.

(2) Platforms:

(a) Platforms shall be at least 1m (3'-6") wide.

(b) Handrails and kickplates shall be installed around the perimeter.

(3) Access stairs:

(a) Shall be at least .9m (3'-0") wide.

(b) Shall have handrails along both sides.

(c) Shall be open riser type.

(d) Treads shall be vertically spaced approximately 200mm (8 inches).

(4) Ladders:

(a) Shall be at least 460mm (1'-6") wide.

(b) Rung diameter shall be 190mm (3/4 inch).

(c) Rungs shall be spaced on 300mm (12 inch) centers.

(d) Shall have side rails at least 9.5mm x 63.5mm (3/8" x 2 1/2").

(e) Exterior ladders shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

7.21 STRUCTURAL AND MISCELLANEOUS STEEL

7.21.1 The Vendor shall provide and erect the following:

a. Structural and miscellaneous steel required to frame and support the FGD System components and ductwork.

b. Structural steel frame, lagging girts, landings, sills, and grouting for the elevator and elevator machine room.

c. Steel girts, purlins, braces, and framing required for the equipment enclosures and accessories.

7.21.2 Unless otherwise specified, all structural steel shall conform to ASTM A36, as designated in the AISC Manual of Steel Construction, Part I. High-strength structural steels as listed in AISC may be used, subject to approval of the Engineer, if they conform to the appropriate ASTM specification.

7.21.3 Structural steel includes all columns, beams, trusses, baseplates, girts, secondary bracings, purlins, girders, and hangers of structural steel.

7.21.4 Miscellaneous steel includes all steel other than structural steel such as edge plates, handrails, stairs, grating, ladders, and plate.

7.21.5 All galvanized materials indicated or specified shall be hot-dip galvanized in accordance with ASTM A123 or A153.

7.21.6 Design stresses under all static and dynamic loads shall not exceed those permissible by the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings.

7.21.7 Design criteria shall be in accordance with UBC and ANSI A58.1 unless otherwise specified.

7.21.8 All structural components shall be designed for wind loads in accordance with UBC. The wind pressure shall be ___ pounds per square foot with design wind pressures determined from Table 23-F in the UBC.

7.21.9 The entire structure, along with all components, shall be designed in strict accordance with UBC earthquake regulations for structures located in Seismic Zone 1. The term "W" as used in the calculations for seismic loading shall be interpreted as the normal operating weight of the unit including all dead loads. Platform live loads may be excluded.

7.21.10 The structural steel frame will be required to take all loads of those pipes, conduits, and cable trays furnished by Vendor. All pipes, conduits, and cable trays shall include adequate hangers and bracing.

7.21.11 The structural steel frame shall be designed to take all piping loads of those pipes within the absorber enclosure. Pipe loads will be provided after award of Contract. All steel beams shall be designed to carry an additional (in addition to equipment, wind, seismic, etc.) 907 kg (2,000 pound) load at the midspan of beam. This is to ensure that the structure will carry pipe loads not known prior to steel design. Pipe hangers and braces shall connect directly to the structural steel wherever convenient. Secondary framing members customarily furnished by hanger suppliers as part of the hanger arrangement will be provided by others.

7.21.12 Structural steel shall be designed to carry loads imposed by equipment maintenance and service requirements.

7.21.13 A hoist and trolley system above the recycle pumps, compressors, and the ball mills shall be provided. Capacity, location, and elevation of the hoist and trolley shall be as required to maintain and service this equipment.

7.21.14 Walkways, platforms, and stairs shall be designed for live loads of 150 Kg/m^2 (100 pounds per square foot) plus concentrated equipment loads. Stair live load shall be 186 Kg/m^2 (125 pounds per square foot) and shall be designed to carry the live load or a moving concentrated load of 454 Kg (1,000 pounds), whichever is greater.

7.21.15 Shear bars shall be provided on the column baseplates to transfer lateral loads into the concrete foundation. The top of concrete foundations for the main FGD enclosure columns shall be .3m (1'-0") below the finished floor. Concrete foundations for flues and ductwork exterior of the absorber enclosure shall be .3m (1'-0") above the finish grade. No moments shall be transferred to foundations.

7.21.16 Wind bracing shall be located to maintain clear accessways, conveyor belts, and laydown areas required to service equipment.

7.21.17 All exterior structural steel shall be arranged to facilitate painting and cleaning.

7.21.18 Girts and Opening Frames

a. The Vendor shall furnish and install all necessary columns, girts, roof purlins, etc., as required to support and construct the absorber modules and ductwork. The structural steel column arrangement shall be such that when the steel girts and metal panel walls are applied to the outside face of the columns, all platforms and walkways will be totally enclosed with sufficent walkway space provided between the wall and all parts of the modules, holding tanks, and recirculation pumps where access is required.

b. Lintels, mullions, girts, jambs, curb angles, rake angles, and parapet steel shall be considered architecturally exposed structural steel as defined by the AISC Code of Standard Practice, Section 10.

c. The maximum horizontal spacing of girts for support of metal-wall panels shall be 2.1m (7'-0") center-to-center and girts shall be supported on the outside face of the columns.

d. Lowest girt on the absorber enclosure shall be located approximately 3m (10'-0") above grade with support and at the base of the concrete stem wall. A girt system the full height of all enclosures shall be provided.

e. Closed ends or miter-cut girts shall be provided at corners.

f. Channel subframing shall be provided for all wall and roof penetrations required for equipment furnished and installed under this Contract (this includes framing for duct penetrations, doors, windows, louvers, etc).

g. Girts and support hangers shall be designed to support the metal wall system and the specified wind load. The channel girt shall be placed toe down to avoid collecting dust.

h. A header beam and girt shall be provided above overhead doors to carry door load and metal panel wall.

i. Framing shall be provided for 1m (3'-6") high parapets around absorber enclosure perimeter including the channel backup at the roof counterflashing.

7.21.19 Roof Purlins

a. Roof purlins shall be spaced so that the roof span will not exceed 1.8m (6'-0").

b. Roof purlins shall be designed for a roof dead load of 30 Kg/m^2 (20 pounds per square foot) and a live load of 45 Kg/m^2 (30 pounds per square foot).

c. Maximum service load deflections shall be L/240.

d. Roof purlins shall be designed for external suction pressure over the entire roof and localized pressures in accordance with the requirements of ANSI A58.1 using a 50 year recurrence interval.

e. The elevation of the roof purlins shall be such that a minimum of 2.1m (7 feet) of head room is provided over all walkways and points of required access with the roof having a minimum slope of 6mm (1/4 inch) per foot.

f. Stairs for access to the roof and elevator roof penthouse shall have a rectangular enclosure above the roof and shall be complete with girts, purlins, and door openings.

7.21.20 Miscellaneous Steel

a. Handrails shall be 40mm (1 1/2 inch) nominal 48mm (1.9 inch) outside dimension round black standard weight pipe conforming to ASTM A53 Type E or S, Grade B; ASTM A106, Grade B; or ASTM A120 (with minimum yield strength of 227,528 kPa (33,000 psi) with two horizontal pipe runs at 58mm (1'-11") and 1m (3'-6") above the top of the walking grating. Handrails shall be galvanized in accordance with ASTM A123. Accessories shall also be galvanized.

b. Kickplates shall be 6mm (1/4 inch) thick steel plate and galvanized.

c. Steel floor grating shall be as follows:

(1) Grating shall be one-piece, resistance-welded steel construction without notching of bearing or crossbars before welding.

(2) Main bars shall be 5mm (3/16 inch) thick, spaced not more than 30mm (1 3/16 inches) on centers. Serrate main bars shall be used outdoors.

(3) Crossbars shall be spaced at 100mm (4 inches) on centers and shall be one of the following shapes:

   (a) Hexagonal with 3mm (5/16 inch) diameter of inscribed circle.

   (b) Rectangular 13mm x 5mm (1/2 inch x 3/16 inch).

   (c) Square 6mm (1/4 inch) with spiral twist.

   (d) Round 8mm (21/64 inch) diameter.

(4) Grating materials shall be of welding quality and conform to the following standards:

   (a) Crossbar - ASTM A569 - Grade 1010.

   (b) Main Bars - ASTM A569 - Grade 1015.

(5) Grating shall be manufactured by one of the following:

   (a) Blaw Knox, Pittsburgh, PA.

   (b) I.K.G. Industries.

   (c) Dravo Corporation, Pittsburgh, PA.

   (d) Borden, Elizabeth, NJ.

   (e) Engineer approved equal.

d. Stairs shall be as follows:

   (1) Open riser type with grating treads and grating landings conforming to Paragraph 7.19.4, h and with main bars 25mm x 5mm (1 inch x 3/16 inch) (serrate main bars shall be used outdoors).

   (2) Stairs shall be supported with carrier plates 64mm x 5mm (2 1/2 inch x 3/16 inch) x tread width, tack welded to all bearing bars with 5mm (3/16 inch) fillet welds (one side only) to the front two and the rear bearing bars, or they shall be supported with a 35mm x 22mm x3mm (1 3/8 inch x 7/8 inch x 1/8 inch) minimum size angle welded to the front and rear bearing bar (one side only).

   (3) Subframing shall be provided so the grating span on landings does not exceed 1m (3'-6").

(4) Nosing shall be provided on all treads and at the head of all stairs. For interior stairs, cast abrasive nosings similar to Feralun nosing as manufactured by American Abrasive Metal Company, Irvington, New Jersey shall be used. For exterior stairs, standard checkerplate galvanized nosings shall be used.

(5) The Vendor shall provide an extra 2 percent of the total of each size and type of stair tread with nosing used. Damaged stair treads and nosings shall be replaced during construction to maintain safe stairways. Unused stair treads shall become the property of the OWNER.

e. Checkerplate shall be 6mm (1/4 inch) minimum thickness with surface deformation of the four-way type. All checkerplate shall be hot-dip galvanized. Minimum size pieces shall be used to prevent warpage during galvanizing or pieces shall be stiffened to prevent warpage.

f. Concrete and masonry anchors:

(1) Concrete and masonry anchors shall be the manually expanded anchor type.

(2) Anchor sizes shall be sufficient to carry the load and shall be installed according to the manufacturer's printed instructions.

(3) Anchors shall be manufactured by Phillips Drill Company, Inc. Michigan City, Indiana or Engineer approved equal.

(a) For concrete anchors, Phillips "Red Head Wedge Anchors" shall be used.

(b) For masonry anchors, Phillips "Red Head Sleeve Anchors" shall be used.

7.22 INSTRUMENTATION AND CONTROLS

7.22.1 The FGD control system shall be a complete, integrated, semi-automatic system designed to operate continuously at high efficiency and with a minimum of operator attention. Its primary function is to assure the safe and reliable operation of the FGD system and its associated systems. The control system will be used to provide the necessary interlocks, sequence of operation, modulating control, operator interface, data logging, monitoring, and communication with all systems peripheral to the FGD system.

7.22.2 Functional Requirements

Individual absorber modules shall be placed in and taken out of service from the absorber control panel. A complete control system shall be provided to perform the following functions:

a. The following digital control loops shall be controlled and monitored from the absorber control panel:

   (1) Absorber module startup and shutdown. The control system for placing a module and its associated equipment in service shall operate in one of two modes: remote manual or semiautomatic. In the remote manual mode, the absorber inlet and outlet dampers and bypass dampers, motor operated valves, pumps, and all other associated equipment shall be opened or closed, started or stopped from individual switches or pushbuttons located on the absorber control panel. In the semiautomatic mode, an absorber module and all associated equipment shall be automatically placed in or taken out of service when the module start or stop pushbutton is actuated. In both the remote manual and semiautomatic modes of operation, proper interlocks shall be provided to assure that the proper sequence of startup or shutdown actions is followed.

   (2) Mist eliminator spray control. Mist eliminators shall be sequenced to spray automatically as required to prevent accumulation of scale deposits.

b. The following analog control loops shall be controlled and monitored from the absorber control panel:

   (1) Additive feed. A three-element control system shall control the rate of additive feed to each individual module to maintain its sulfur dioxide removal rate and pH at preset constant values. The three controlling elements will be module gas flow, inlet gas sulfur dioxide content, and slurry pH.

   (2) Slurry bleed off. The rate of slurry bleed off from each individual module shall be controlled to maintain solids percentage at preset constant values.

   (3) Subloops. Subloop controls shall control reaction tank level, mist eliminator tank level, if required,

mist eliminator wash header pressure, and other tank level and header pressure controls requiring operator supervision from the absorber control room.

7.22.3 The Vendor shall have complete system responsibility for proper design and operation of the installed system. The Vendor's services shall include at least the following:

a. System design in accordance with all applicable codes and standards specified herein.

b. Engineering and design interface with the boiler control vendors.

c. Calibration, setting, adjustment, and testing of all equipment supplied.

d. Programming.

7.22.4 The Vendor shall furnish at least the following equipment:

a. Complete semi-automatic control system.

b. Operator control stations.

c. Drive unit regulators.

d. Field-mounted equipment:

(1) Control valves.

(2) Control valve motor to pneumatic converters.

(3) Control drives, drive arms, and linkages.

(4) Electronic transmitters.

(5) pH cells and converters.

(6) Nuclear density transmitters.

(7) Thermocouples.

(8) Resistance temperature detectors (RTD's).

(9) Pressure switches.

(10) Temperature switches.

(11) SO_2 analyzers.

(12) Temperature and pressure gages.

(13) Redundant equipment for parameters critical to the process control.

e. Control boards for the main FGD control room and the reagent preparation control room with the following components:

(1) Control switch modules.

(2) Indicators.

(3) Recorders.

(4) Annunciators.

(5) Prefabricated cables.

(6) Integrators.

(7) Indicating lights.

(8) Ammeters.

(9) Semigraphic panels, showing all major components of the FGD system.

f. A gas-side control and status panel shall be provided in the main turbine-generator control room. Individual absorber module status shall be provided. Override control shall be provided for the FGD system bypass damper in the event of an emergency fuel or fan trip.

7.22.5 The FGD control system shall include at least the following control functions:

a. Transferring reagent slurry from the reagent slurry feed piping to the absorber module reaction tanks.

b. Controlling the absorber module liquid recycle flow in the modules and reaction tanks.

c. Controlling the density in the recycle loop by constant flow bleed to the waste disposal system.

d. Controlling the seal water pressure.

e. Transferring the reaction tank slurry bleed to the reaction tank bleed surge tank.

f. Controlling flue gas bypass damper.

g. Controlling the mist eliminator wash cycle.

h. Controlling makeup water flow.

7.22.6 The FGD control system interlocks shall prevent the operator from starting any pump and motor or opening any dampers and valves, unless all the permissives associated with the particular equipment are satisfied.

7.22.7 The normal shutdown sequence shall be interlocked with appropriate time delays incorporated so that flushing the slurry lines and the equipment will be initiated. The normal time delay controlled shutdown shall be bypassed on any emergency shutdown.

7.22.8 The control system and instrumentation shall automatically maintain all levels, flows, pressures, densities, pH concentrations, and temperatures.

7.22.9 All tanks and reservoirs shall alarm on high and low level. The levels shall allow an operator sufficient reaction time to correct the problem.

7.22.10 Abnormal operation of a system component or individual piece of equipment shall cause automatic and safe shutdown of any malfunctioning part of the system without interfering with the power plant electrical generation capabilities, and prevent damage to the equipment due to overload, line pluggage, or other malfunctions.

7.22.11 <u>Modes of Operation</u>

a. The FGD control system shall be capable of operating in either the semiautomatic mode, the manual mode, or a combination of both modes.

b. In the semiautomatic mode, the control system shall automatically place a control loop or major piece of equipment in service, or remove it from service, when the operator initiates the start or stop pushbutton. The control system shall superimpose automatic start and stop timed sequencing on the manual control mode. All the interlocking and tripping functions that are integral to the manual mode shall remain integral to the semiautomatic mode.

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c. In the manual mode, the operator must initiate each start and stop in the start and stop sequence. The control system shall monitor the operator's progress and prevent him from departing from the proper operating sequence. All the safety interlocks and tripping functions shall be incorporated into the manual control mode.

d. If the control system fails, the operator shall be able to operate the FGD system manually from the FGD control board.

e. Local control shall be provided for individual pieces of equipment. Local controls shall consist of emergency stop and jog switches and status lights. However, for recycle pumps, the local controls will have start, stop, and lockout switches and no interlocks shall be bypassed. The switches shall be General Electric SB-1 switches.

7.22.12 Alarms

Annunciator systems will be used to indicate and record all malfunctions occurring in the FGD system during operation.

7.22.13 Graphic Display Panels

a. Graphic display panels shall be provided in all control rooms to illustrate the status of equipment within the appropriate control jurisdiction. The graphic panels shall be freestanding.

b. The graphic display panel in the main FGD control room shall show all major components of the FGD system arranged in proper schematic order, from and including the silos up to the sludge stabilization area. The panel shall have status indicating lights for pumps, mills, and isolating and bypass dampers, plus any other device required to display the overall status of the entire system.

c. The graphic layout shall be subject to approval by the Engineer.

7.22.14 Control Board Requirements

a. The FGD control board and the electrical equipment and termination cabinet shall be complete assemblies ready for installation on sills. The size and makeup of shipping assemblies shall be subject to the approval of the Engineer.

b. The FGD control board shall be of the console type. The electrical equipment and termination cabinet shall be vertical freestanding type.

c. The Vendor shall drill and cut panels and provide all necessary mounting details. The Vendor shall mount on the board and within the termination cabinet all items of equipment and miscellaneous devices called for on the Drawings and in this Specification.

d. All equipment mounted on the control board and within termination cabinet shall be located so as to be accessible.

e. Each item of equipment shall be removable and accessible for field termination of cables where applicable, without removal of other items.

f. The FGD control board and the electrical equipment and termination cabinet shall be completely assembled and wired at the factory, ready for installation when received at the site. They shall be suitably braced to prevent distortion and damage during shipping and handling.

g. The electrical equipment and termination cabinet shall contain all required control relays, timers, protective relays, interlock wiring, fuses, and terminal blocks. The cabinet shall be divided by a splitter plate separating the front and rear of the cabinet. The front of the cabinet shall be dedicated to control devices and wiring, and the rear of the cabinet shall be dedicated to field wiring terminal blocks.

7.22.15 Wiring

a. Unless the approved drawings show otherwise, the general factory installed wiring in the control panel shall be 14 gage (AWG), stranded, tinned copper switchboard wire, 600 volt, non-flame propagation NEC Type SIS. Unshielded instrumentation wiring and control wiring fused for not more than 5 amperes at 220 volts ac or 125 volts dc, shall be at least 16 gage (AWG) stranded tinned copper, 600 volt, NEC Type SIS. Wiring mounted to swing panels or subject to movement shall be grouped into bundles, have extra-flexible conductors, and have a spiral wound guard over wire bundles.

b. Shielded instrumentation wiring shall be at least 18 gage (AWG), stranded, tinned copper, shielded twisted pair, 2 inch maximum lay, 100% coverage aluminum mylar shield, 300 volt, of flame retardant construction with an 18 gage (AWG) tinned copper drain wire.

c. Thermocouple wires and special shielded cables entering the control panel shall be run directly to the associated instruments or devices without intermediate termination within the panel.

d. All instruments and devices, except those noted herein, shall be wired to terminal blocks. All contacts, used or spare, shall be wired to terminal blocks.

e. Wires shall not be spliced.

f. All connections to devices with terminal screws shall be terminated with AMP Incorporated "Diamond-Grip" preinsulated, ring-tongue terminals or Engineer approved equal. Suitable tools shall be used when removing insulation to preclude nicking and damaging the conductors. The size of the connector shall be identifiable on the terminal after it is complete.

g. All solenoid and relay coil circuits shall be designed so that any ground or short of the coil shall not prevent the solenoid or relay coil from dropping out.

h. All housings of electrical or electrically operated instruments shall be separately grounded in a manner subject to approval by the Engineer. The removal of a housing shall not interrupt the grounding of any other housing.

i. Wiring shall be neatly arranged and secured to the panel or supported by suitable brackets as required. Bundled groups of wires shall be tied with Panduit Corporation "Lok-Strap" releasable cable ties or Engineer approved equal. If advantageous, wiring may be installed in a Panduit Corporation Type E wiring duct or Engineer approved equal having snap covers.

j. All equipment shall be completely assembled and wired at the factory, ready for installation when received at the site.

k. If any board-mounted item is not available for installation to meet scheduled shipment of the board, wiring of the item shall be completed. The wire ends shall be exactly formed to the configuration required, with terminals and identifying sleeves applied, and ready for connection. The Vendor shall obtain a written approval from the Engineer before shipment of the FGD Control Board if it has any shortages of equipment.

7.22.16 Terminal Blocks

a. All field wiring, except as noted herein, shall terminate on GE Type CR151, or Engineer approved equal, terminal blocks. Terminal blocks for signal inputs shall be CR151A2 Series with No. 8-32 screws to recieve a 16 gage (AWG) ring-end terminal. Terminal blocks for coil inputs or contact outputs shall be GE Type EB-25 or Engineer approved equal, with No. 10-32 screws to receive 12 gage (AWG) ring-end terminals. Terminals to power inputs shall be studs adequately sized for the full current requirements.

b. Terminal blocks shall be barrier type with fluted washer head binding screws and shall be suitably identified with identification as shown on the Vendor's diagrams.

c. Terminal blocks shall be suitably mounted and readily accessible, at least .3m (12 inches) above the floor.

d. Terminal blocks shall, in general, be arranged in a series of rows at approximately 152mm (6 inches) on center. No devices or other material shall obstruct access to the terminal blocks for connection of terminals or for installation of control cables. The Vendor's drawings shall show the arrangement of the blocks.

e. Spacing and location of terminal blocks for connections shall be subject to approval by the Engineer.

f. No terminal block shall carry more than two conductors on either side of any terminal.

g. The Vendor shall provide at least 20 percent spare terminal points.

h. Any shielded cables terminating on terminal blocks and shown grounded on the wiring diagrams shall be connected to shield terminals on the terminal blocks, unless terminated in a special connector. The shields for internal wiring shall be grounded at one point in accordance with the Engineer's instructions.

i. Provisions shall be made for terminating the Owner's incoming cables, including spare conductors, on adjacent points on the terminal blocks.

7.22.17 Grounded Bus

a. A 51mm x 6mm (2" x 1/4") flat bar copper ground bus shall be installed running the full length of the control panel. The bus shall be drilled at each end for NEMA 2 hole drilling pattern. All instruments and devices requiring grounding, as shown on diagrams, shall be connected to the ground bus by copper conductors via compression type lugs.

b. Grounding provisions shall be subject to the approval of the Engineer.

c. The ground bus splice points shall not be coincident with the bolts which support the ground bus. Connections to the ground bus shall be such that it is not necessary to open the ground bus nor any other connection to the bus to remove any connection. Bolted connections to the ground bus shall be separate from the support and joint bolts.

7.22.18 Interior Lighting and Receptacles

a. The control boards shall be provided with continuous strip, fluorescent illumination. Ballast shall be of a low noise and high power factor. The fluorescent tubes shall be the same length.

b. Convenience outlets shall be spaced approximately 1.5m (5 feet) apart in the rear of the boards. Outlets shall be Hubbell 7580G in Type FS condulet.

c. The interior lighting circuit shall have three-way and four-way toggle switches located inside, near each door for on-off control.

d. Wiring shall be extended to suitable terminal block points for connection of the Owner's 220 volt, 50 hertz supply circuit, including equipment grounding connectors and boxes.

7.22.19 Ventilation

a. The Vendor shall satisfactorily ventilate the control panel by using louvers and fans to ensure that all components, devices, subassemblies and electronic equipment will operate continuously within the temperature and accuracy limits as specified or as guaranteed.

b. Fans shall be Kooltronic Model KD651B including Kooltronic Guards No. 650G.

c. Induction type fan motors requiring an external capacitor shall not be permitted unless the capacitor is integral to the motor housing.

d. Vent fans shall have a toggle switch for on-off control.

e. The area above the rear access doors shall be louvered to facilitate the ventilation.

f. Suitable means of fire/high panel temperature detection with audible alarm and annunciation shall be provided by the Vendor.

7.22.20 Instrument Requirements

All of the following instrumentation and all instrumentation critical to the control of the FGD system, as recommended by the Vendor and approved by the Engineer, shall be provided with a completely redundant system:

a. Local controllers:

(1) Local controllers shall be pneumatic and shall be provided as required by the Vendor's design. Controllers shall be mounted in dusttight and weatherproof cases having windows for observation of pressure gages. Pneumatic controllers shall be equipped with gages to indicate the supply and control pressures. Controllers shall have adjustable set point and proportional band. Reset action shall be provided and all required equipment shall be mounted inside the controller case. Reset action shall be adjustable.

(2) All pneumatic controllers shall be equipped with booster relays mounted within the controller cases as required. All pneumatic controllers shall be equipped with reducing valves and filters for their air supplies. If the controller is yoke mounted on the valve, the air supply reducing valve and filter shall also be mounted on the valve and may be used to supply all of the control air requirements of the controller and valve positioner.

b. Transmitters:

(1) Transmitters shall be electronic and furnished as required by the design of the control and instrument systems furnished. Transmitters shall be equipped with mounting brackets suitable for attachment to a mounting rack structure by bolting or welding. Transmitters of the motion balance type shall be provided with indicating scales and an enclosure with a minimum classification of NEMA 12.

(2) All transmitters shall be connected to their systems by piping, and any flexible connectors required by the transmitter design shall be furnished. All connections for primary piping shall be provided with NPT female threaded connections not smaller than 6mm (1/4 inch). All connections for electric wiring shall be provided with holes or knockouts for electrical conduit connections not smaller than 13mm (1/2 inch) nominal size. Electrical connections to locally mounted transmitters will normally use a short length of liquidtight flexible conduit.

(3) The signal output for electronic transmitters shall be 4-20 mA dc.

(4) The makes and types of all transmitters furnished shall be approved by the Engineer.

c. Flow measuring devices:

(1) Flow measurements of clear fluids shall be made using orifice plates, venturi tubes, or rotameters as required by the Vendor's design.

(2) Slurry flow measurements shall be made using magnetic flowmeters as manufactured by the Fischer and Porter Company or Engineer approved equal.

d. Density measuring devices:

(1) Density measuring devices shall be furnished as required by the absorber manufacturer's design. The density measuring devices shall be gamma source and detection units complete with separately mounted electronic units. The electronic units shall include local indicating lights and relays for use with the alarm system. All density measuring devices shall be installed in vertical lines.

(2) The equipment shall be as manufactured by Texas Nuclear, Kay-Ray Inc., or Engineer approved equal.

e. pH measurement:

Recorders, monitors, and pH cells shall be furnished complete, in number and location as required by the absorber manufacturer's design. Adequate redundancy for reliable operation and sufficient retransmission capability for control and monitoring shall be provided. The pH cell assemblies shall be designed for operation with a minimum of operator attention and cleaning. The pH equipment manufacturer and model numbers shall be subject to acceptance by the Engineer. The pH cells shall be located in auxiliary measuring vessels which can be isolated.

f. Flow indicators:

Local flow indicators shall be provided as required by the absorber manufacturer's design. Flow indicators shall be as manufactured by Wallace & Tiernan or Engineer approved equal.

g. Flow switches:

(1) Flow switches shall be provided as required by the Vendor's design. Flow switches for clear fluids shall be of the indicating type as manufactured by Universal Filters, Inc., or Engineer approved equal.

(2) Flow switches for slurry flows shall incorporate magnetic flowmeters and electronic trips.

h. Limit switches:

(1) Limit switches, except those integrally mounted on electric motor operated valves, shall be equivalent to National Acme Company "Snaplock" Series D2400X-ST (EA-170-14100). Switches shall have at least two normally open and two normally closed contacts.

(2) Limit switches shall be constructed to withstand the temperatures encountered in the actual service. Enclosed construction shall be furnished where required for hazardous areas in accordance with the National Electrical Code.

i. Pressure switches:

(1) Pressure switches shall be selected as follows:

(a) General static pressure switches shall be Custom Component Dual-Snap or equal.

(b) Differential pressure switches for high differential pressure ranges shall be Custom Component Dual-Snap or equal.

(c) Differential pressure switches for low differential pressure ranges shall be equivalent to those manufactured by Barton Instrument Corporation.

(d) Differential pressure applications requiring both indication and pressure switch contacts shall be implemented equivalent to those manufactured by Barton Instrument Corporation, regardless of the range.

(2) Pressure switches shall be enclosured where required in hazardous areas in accordance with the National Electrical Code. Each pressure switch shall be specifically selected for the service in which it is used. The acceptability of each switch with respect to range, over-pressure capability, repeatability, and deadband shall be demonstrated to the Engineer.

j. Temperature switches:

Temperature switches shall be equivalent to Allen-Bradley Bulletin 837 with NEMA 4 enclosures. Special standard length armored capillary tubes shall be furnished where required. Thermowells shall be furnished as required. Each temperature switch shall be specifically selected for the service in which it is used. The acceptability of each switch with respect to range, repeatability, and deadband shall be demonstrated to the Engineer. Enclosed construction shall be furnished where required for hazardous areas in accordance with the National Electrical Code.

k. Level switches:

Level switches shall be equivalent to Magnetrol having float and body construction appropriate to the service conditions of the systems to which they are connected. Switch elements shall be of the vibration resistant mercury bottle type magnetically coupled to the float. Two switch elements shall be available at each level point monitored. Each switch element shall be reversible for normally closed or normally open operation or shall be double throw construction. Switch element leads shall be of high temperature construction and terminated on terminal blocks within the switch housing. Switch housings shall be splashproof construction, unless otherwise specified. Enclosed construction shall be furnished where required for hazardous areas in accordance with the National Electrical Code.

l. Solenoid valves:

Solenoid valves shall be equivalent to those manufactured by Automatic Switch Company. Valves shall be selected to incorporate body construction, trim materials, and internal arrangements suitable to the application and shall be acceptable to the Engineer. Solenoid enclosures shall be NEMA 4 unless otherwise specified. Solenoid coils shall be Class H high temperature construction and shall be suitable for continuous duty. Enclosed construction shall be furnished where required for hazardous areas in accordance with the National Electrical Code.

m. Pressure gages:

Gages for control air supply and signal pressures integral to the instrument shall be in accordance with the control manufacturer's standards. All other gages shall be as specified herein. Gages shall be equivalent to Ashcroft "Duragauge". Dial size shall be 114mm (4 1/2 inch) minimum. Readability must be considered in final selection of dial size and larger dials shall be furnished if required. Dials shall be engraved with service legends, or separate nameplates of engraved laminated phenolic shall be attached to the gage faces to identify the service. Legends shall be as directed by the Engineer. All gages, except on control air service, shall have stainless steel movements and nylon bearings. Gages for panel mounting shall be Type 1377. Gages for separate mountings shall be Type 1379 with 15mm (1/2 inch) NPT bottom connections. Each gage, except control air gages, shall be furnished with the equivalent of an Ashcroft Type 1106S pulsation dampening valve of the same material as the bourdon tube.

n. Thermometers:

Thermometers for local mounting shall be equivalent to Ashcroft 50A142E 127mm (5 inch dial) "Every Angle" bimetallic thermometers. Thermometers for panel mounting shall be equivalent to Ashcroft Dial 600A gas actuated with Type 1377 case and stainless steel armored capillary tubing of length required for the installation. Dial size shall be 114mm (4 1/2 inch) minimum. Readability shall be considered in final selection of dial size and larger dials shall be furnished if required. The dials shall be engraved with service legends, or separate nameplates of engraved laminated phenolic shall be furnished attached to the dial faces to identify the service. Legends shall be as directed by the Engineer. Thermowells shall be furnished for all thermometers.

o. Thermocouples:

(1) All thermocouples shall be of the dual element type unless otherwise specified. Thermocouples shall be ISA Type E chromel-constantan thermocouples with Type EX extension wire. Thermocouples and extension wire shall comply to the special limits of error contained in ANSI MC96.1.

(2) All thermocouples shall be of the stainless steel sheathed, compacted magnesium oxide insulated type.

(3) Thermocouple assemblies shall be complete with weatherproof connection heads and nipples. Extension nipples, insulating bushings, and compression fittings shall be furnished. Heads shall be designed for positive connection and for a terminal termperature differential of not more than 0.06°C (0.1°F). Thermocouples equipped with thermowells shall be spring loaded for positive contact with the wall. Thermowells shall be furnished. The lead wire for all related detectors shall be brought to common junction boxes.

(4) Thermocouple leads shall be ungrounded unless otherwise specified.

p. Resistance temperature detectors:

All resistance temperature detectors shall be 100 ohm, metal sheathed, ceramic packed; platinum resistance temperature detectors suitable for design temperature, pressure, and velocity conditions for the specific application. Each detector shall be furnished as a complete assembly, including nipple and connecting head. Detector elements equipped with thermowells shall be spring loaded for positive contact with the wall. Thermowells shall be furnished.

q. SO_2 measuring system:

(1) The measuring system shall use a multiple-point sampling, in situ measuring technique fully suitable for the dry gas and saturated gas services anticipated at the module inlets and outlets.

(2) The measuring system shall have automatic and manual zero and span calibration checks that are free from interference effects of the flue gas and do not require external calibration gases or light sources.

(3) The measurement output shall be automatically compensated for temperature variations if special absorption is used.

(4) The calibration gases shall be measured dynamically at the actual process temperature and pressure and using the normal optical measurement path.

(5) The measuring system shall include all accessories required for a complete, operating, installed system.

7.23 ELECTRICAL EQUIPMENT

7.23.1 The Vendor shall design, fabricate and install all of the electrical equipment necessary for the operation of the FGD system. The equipment shall include at least the following:

a. 6.9 switchgear.

b. 6.9 kV/4C0 volt transformers and distribution.

c. 400/220 volt transformers and distribution.

d. Motors.

e. Heaters.

f. Valves.

g. Lighting and electrical utilities.

h. Grounding.

i. Underground conduit and duct banks as required.

j. Necessary electrical enclosures.

Note: Distribution shall include all motor control centers, cables, terminal boxes, and wiring necessary to route the required power to the motors, heaters, valves, instruments, control panels, and any other electrical equipment.

7.23.2 Raceway

a. Unless specified otherwise, all raceway interconnections between devices, panels, boxes, and fittings shall conform to ANSI C80.1 and UL 6. All conduit connections shall be the the threaded type. Unless specified otherwise, all conduit shall be hot-dip galvanized rigid steel. All conduit entering outdoor enclosures shall enter through Efcor "Water-Tite" hubs or threaded openings, or equal.

b. Raceway systems where required for hazardous areas shall be in accordance with the National Electrical Code.

c. One exterior locknut, one interior locknut, and one bushing shall be provided at the termination of each conduit not terminated in a hub. Locknuts shall be designed to securely bond the conduit to the box or cabinet when tightened. Locknuts shall be constructed so that they will not be loosened by vibration.

d. Insulated bushings with insulating inserts in metal housings shall be provided on conduit 32mm (1 1/4 inches) and larger. Insulated bushings shall be grounding type. Standard bushings shall be galvanized.

e. Conduit fittings used on outdoor equipment shall be of heavy cast construction and shall be sealed and gasketed.

f. All conduit shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. A run of conduit shall not contain more than the equivalent of four quarter bends, including those immediately at outlets and fittings. Bends in conduit shall be made without reducing the internal diameter of the conduit.

g. All conduit runs shall be rigidly supported. Each conduit shall be supported within .3m (1 foot) of junction boxes and fittings. Support spacing along conduit runs shall be as follows:

	Conduit Size	Maximum Distance Between Supports
(1)	13mm (1/2 inch) through 32 mm (1 1/4 inch)	1.5 m (5 feet)
(2)	40 mm (1 1/2 inch) and larger	3 m (10 feet)

h. Conduit shall be supported by means of conduit clamps and clamp-backs.

i. Moisture pockets shall be eliminated from conduit installed on outdoor equipment. If water cannot drain to the natural opening in the conduit system, a hole shall be drilled in the bottom of a pull box or a "C-type" conduit fitting provided in the low point of the conduit run.

j. Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit shall project through the wall of the box to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to fasten the conduit securely to the box.

k. The raceway system provided for all interconnecting wiring shall be acceptable to the Engineer.

7.23.3 Electrical Enclosures

a. Unless indicated otherwise in this Specification, electrical enclosures, except junction boxes and pull boxes 4 inch trade size and smaller, shall be as follows:

Location	Enclosure Type
(1) Indoor (nonhazardous):	
(a) Dry areas	NEMA 12
(b) Areas where moisture conditions are more severe than those for which NEMA 12 enclosures are intended	NEMA 4
(2) Outdoor (nonhazardous)	NEMA 4

b. Electrical switchboards, panels, and cabinets, except those of cast metal, shall be constructed from steel plate reinforced as required to provide true surface and adequate support for devices mounted thereon. Thickness of the steel plate shall conform to the requirements of UL 50. Switchboards, panels, and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 90 Kg (200 pounds) on their tops after erection.

c. All electrical enclosures which have equipment mounted therein shall have a subpanel for mounting such equipment.

d. Enclosures containing control equipment shall have an insulated copper bus for the termination of signal cable shield wires. Enclosures containing control equipment that also have power or motor feeders shall have a separate grounding pad with a 10mm (3/8 inch) threaded hole for termination of the main grounding conductor.

e. Freestanding switchboards, panels, and cabinets shall be 2.3m (90 inches) high. Switchboard depth shall be not more than .9m (36 inches). Switchboard length shall be as required but not more than 6.1m (20 feet). The minimum width between barriers, with equipment mounted, shall be .61m (24 inches) of free working space. Ease of access to all equipment in the enclosure is of prime importance.

f. All junction boxes or pull boxes 100mm (4 inch) trade size or smaller in any dimension shall be galvanized malleable iron or Engineer approved equal cast ferrous metal.

g. Junction boxes and pull boxes shall be in accordance with the requirements of NEC, Article 370, Paragraphs 18, 19, 20, and 21 and shall be without knockouts.

h. Except where indicated otherwise in this Specification or on the Drawings, all junction boxes and pull boxes larger than 100mm (4 inch) trade size in all dimensions for use in indoor locations shall be sheet steel, hot-dip galvanized after fabrication and those for use in outdoor or damp locations shall be galvanized malleable iron or Engineer approved equal cast ferrous metal, sheet steel hot-dip galvanized after fabrication, or sheet steel, epoxy coated inside and outside after fabrication. The epoxy coating shall consist of a .05-.076mm (2 to 3 mil) base coat equivalent to Z.R.C. as manufactured by ZRC Chemical Products Company, followed by two finish coats of epoxy. Each finish coat shall be at least .05mm (2 mils) thick.

7.23.4 <u>Wiring</u>

a. In general, all devices furnished under this Specification requiring electrical connections shall be designed for wiring into junction boxes or enclosures with terminal blocks. Terminal blocks shall be provided for conductors requiring connection to circuits external to the specified equipment, for internal circuits crossing shipping splits, and where equipment parts replacement and maintenance will be facilitated.

b. Pigtails shall be included on one side of terminal blocks for shipping splits. Wiring splits shall be indicated on wiring diagrams with pigtails identified.

c. Terminal blocks for external circuit wiring shall be mounted in enclosures suitable for the equipment location and shall be arranged for convenient connection of external circuit conductors.

d. Control wiring or instrument leads shall not be spliced.

e. All spare contacts on lockout relays, limit switches, or similar devices shall be wired to accessible terminal blocks for the Owner's future connections. All wiring leaving a junction box or enclosure shall leave from terminal blocks and not from other devices in the enclosure.

f. Auxiliary equipment such as terminal blocks, auxiliary relays, or contactors shall be readily accessible. Auxiliary equipment shall be located in compartments, enclosures, or junction boxes in such arrangement that a serviceman will have direct access to the equipment without removing barriers, cover plates, or wiring. Grouped terminal blocks for all external connections shall be provided. Provisions shall be made to tie down all external cables connected to the terminal blocks.

g. Terminal blocks shall be grouped in the instrument and control compartment for easy accessibility, unrestricted by interference from structural members and instruments. Sufficient space shall be provided on each side of each terminal block to allow an orderly arrangement of all leads to be terminated on the block. Not more than two wires shall be terminated on each side of a terminal. All internal wiring shall terminate on the interior side of terminal blocks.

h. Arrangement of circuits on terminal blocks shall be such that all connections for one circuit plus any spare conductors shall be on adjacent terminals.

i. Terminal blocks shall not be mounted in compartments containing cables or buses operating at voltages above 600 volts.

j. A shorting type terminal block shall be installed at an accessible location for each set of current transformers supplied with the equipment furnished under this Specification. The shorting terminal block shall be the one nearest the current transformers. Every device requiring testing or removal which does not have internal shorting capability shall be provided with shorting type terminal blocks near the device as well as at the current transformers.

k. All electrical cables shall be conservatively selected for the electrical and environmental conditions of the installations and shall be of the best construction for the service where unusual service conditions are encountered. Oil resistant and proper temperature application cable shall be used throughout. Except where required to be otherwise to perform satisfactorily in the service, all electrical conductor shall be Class B, stranded copper, 14 gage (AWG) or larger. MI cable and PVC insulated cable are not acceptable.

l. Signal cable shall be shielded type.

m. Control panel and cabinet wiring shall be stranded copper conductor with Type SIS cross-linked polyethylene insulation rated at 600 volts, shall be designed for a maximum conductor temperature of 90°C, shall meet the insulation requirements of ICEA S-66-524, Part 3, shall meet the vertical flame test requirements if ICEA S-19-81, Paragraph 6.19.6, and shall be equivalent to Rockbestos Firewall Type SIS or General Electric Vulkene Supreme Type SIS VW-1.

n. Wiring across hinges shall be extra flexible, stranded as follows:

(1) 14 gage (AWG), 41 strands.

(2) 12 gage (AWG), 65 strands.

(3) 10 gage (AWG), 105 strands.

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o. General service power and control cables, integral to the equipment furnished but not internal wiring of control cabinets or panels, shall be rated for the maximum service voltage but not less than 600 volts. Power conductors and single conductor control cables shall have ethylene propylene rubber insulation with a neoprene conductor jacket and multiconductor control cables shall have flame resistant cross-linked polyethylene conductor insulation and an overall neoprene jacket or Engineer approved equal insulation systems, except NEC Type SF-2 silicone rubber insulated cable with braided glass jacket shall be used where ambient conditions cause conductor operating temperatures to exceed the temperature ratings of the general service cable insulation furnished.

p. All thermocouple wire shall be solid with insulation color coded in accordance with the requirements of ANSI C96.1. This requirement also applies to thermocouple extension wire which is furnished internal to Vendor furnished equipment.

q. Control conductor terminal connectors shall be compression type connectors properly sized for the conductor and the terminal. The connectors shall be constructed of fine grade high conductivity copper in accordance with QQ-C-576, and shall be tin plated in accordance with MIL-T-10727. The interior surface of the connector wire barrel shall be serrated, and the exterior surface of the connector wire barrel shall be provided with crimp guides. The tool used to install the connectors shall use a posi-crimp locking mechanism to assure proper installation.

r. Noninsulated terminal connectors shall be provided on conductors terminated on devices equipped with individual fitted covers, such as General Electric Type SB-1 control switches and General Electric Type HEA lockout relays. Preinsulated ring type terminal connectors shall be used on all current and potential transformer circuits. All other terminal connectors for conductors smaller than 8 gage (AWG) shall be preinsulated ring type.

s. Preinsulated terminal connectors shall include a vinyl sleeve, color coded to indicate conductor size.

t. Ring connectors shall be equivalent to AMP or 3M. Spade connectors shall not be used.

u. Each terminal block, terminal, relay, breaker, fuse block, and other auxiliary device, shall be permanently labeled to coincide with the identification indicated on the schematic wiring diagrams. All terminals provided for termination of external circuits shall be identified by inscribing circuit designations acceptable to the Engineer on white terminal block marking strips with black paint.

v. The arrangement of connections on terminal blocks shall be acceptable to the Engineer.

w. All connections requiring disconnect plug and receptacle type devices shall be provided with factory terminated conductors on each plug and receptacle. Plugs and receptacles shall be factory wired into junction boxes containing terminal blocks for the Owner's external connections. All conductors on the disconnect portion of plug-receptacle assemblies shall be in a common jacket.

x. All temporary wiring installed in the factory for equipment testing shall be removed prior to shipment of the equipment.

7.23.5 Pin and Socket Connectors

Pin and socket connectors shall have threaded couplings and crimp type contacts and shall meet Military Specification MIL-C-5015, except for pin and socket plating. Pin and socket plating shall be a minimum of .00013mm (0.000050 inch) of gold over .00013mm (0.000050 inch) of nickel. Connectors shall be equivalent to Amphenol, Cannon, or Pyle-National. If the Vendor is unable to furnish connectors as specified, he shall submit a sample of the connector he proposes to furnish accompanied by complete manufacturer's specification data with the request for Owner acceptance.

7.23.6 Cable Termination Provisions

a. Electrical conductors supplying the equipment provided under this Specification shall be sized for installation in covered electrical cable tray to a 150mm (6 inch) loading depth and with 40 percent random fill. Sizing will be in accordance with the requirements of NEMA WC 51, ICEA P-54-440 and ICEA P-32-382.

b. Capacity of conduit entrances, terminal enclosures, and conductor terminals shall be as required to accommodate eight copper or aluminum connectors.

7.23.7 Terminal Blocks

a. Terminal blocks shall be provided with white marking strips and, where permitted by the safety codes and standards, shall be without covers. At least 25 percent spare unused terminals shall be provided on each terminal block for circuit modifications and for termination of all conductors in a multiconductor control cable.

b. Fuses shall not be mounted on terminal blocks. Neither step type terminal blocks nor angle mounting of terminal blocks will be acceptable.

c. All terminal blocks, except internal terminal blocks in factory prewired electronic systems cabinets, shall be rated 600 volts minimum and shall have strap screw terminals. Terminal blocks for 10 gage (AWG) and smaller 600 volt insulated conductors shall be equivalent to Marathon 1500 Series or General Electric EB Series. Terminal blocks shall be appropriately sized for larger wire size or higher voltage insulated incoming conductors as necessary.

7.23.8 Fuse Blocks

Where fuse blocks rated 30 amperes, 250 volts are required by this Specification or the manufacturer's design, they shall be modular type with bakelite frame and reinforced retaining clips. Blocks shall be equivalent to Class H, 2 pole, Model 11530-2SR screw terminal fuse blocks as manufactured by Underwriters Safety Device Co., 7300 West Wilson Avenue, Chicago, Illinois 60656. Blocks for other current and voltage ratings shall be similar in construction and by the same manufacturer.

7.23.9 Fuses:

Where slow blow fuses are required for protection of equipment they shall be equivalent to Bussmann Type MDL, with ampere ratings of 1/4, 1/2, 1, or 2. Where fast acting fuses are required for protection of equipment they shall be equivalent to Bussmann Type NON, with ampere ratings of 1, 3, 6, 10, 15, 20, or 30.

7.23.10 Electrical Accessory Devices

Electrical accessory devices shall be furnished in accordance with the following requirements unless otherwise specified in this Specification:

a. Electrical instruments:

All electrical indicating instruments shall be of the switchboard type with 1 percent accuracy classification, shall be designed for flush mounting and unless otherwise specified, shall be approximately 25.8cm^2 (4 in^2). All instrument scales shall consist of black markings on a white background. Any instrument which is checked in the field and found to be inaccurate in excess of 2 percent shall be returned to the Vendor for calibration or replacement without cost to the Owner. All ac instruments shall be designed for operation through 5 ampere current transformer secondaries and 220 volt potential transforner secondaries. Instruments shall be equivalent to General Electric Type AB-40 or Westinghouse Type 241.

b. Control relays:

(1) General service auxiliary relays shall be equivalent to Gould Incorporated (I-T-E Imperial) Type J10A, J11A, or J13P. Where current carrying requirements exceed the capacity of the J10A, auxiliary relays shall be equivalent to General Electric Type HFA or HGA, or Westinghouse Type MG-6.

(2) Timing relays where the delay period is 3 minutes or less shall be equivalent to Gould Incorporated (I-T-E Imperial) Type J12A. Timing relays where the delay period may exceed 3 minutes shall be equivalent to Agastat Series 7000.

c. Control switches:

Control switches shall be 600 volt, 20 ampere, multistage, rotary type with a minimum of ten contacts. Switches shall have black, fixed, modern, pistol grip type handles and engraved black plastic escutcheon plates with targets. Switches shall be equivalent to Westinghouse Type W, General Electric Type SB-1, or General Electric Type SB-10.

d. Pushbuttons and selector switches:

Pushbuttons and selector switches shall be equivalent to Square D, Class 9001, Type K oiltight, or Honeywell Micro Switch Type PT. Toggle switches shall be equivalent to Honeywell Micro Switch Type TL.

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e. Indicating lights:

(1) Status indicating lights shall be equivalent to Honeywell Micro Switch Type PTW, push to test, with 387 lamps, plastic lenses, and appropriately sized resistors.

(2) Engraved indicating lights shall be equivalent to Master Specialties 2100 or 100 series with 387 lamps.

(3) Alternate indicating lights shall be Engineer approved.

f. Alarm contacts:

Alarm contacts for remote annunciation shall be suitable for operation at 125 volts dc. Alarm contacts shall be normally open contacts which close on alarm condition.

7.23.11 Molded Case Circuit Breakers

Molded case circuit breakers used in equipment covered under this Specification shall have not less than 5,000 amperes interrupting capacity at 125/250 volts dc, 10,000 amperes symmetrical interrupting capacity at 240 volts ac, and 25,000 amperes symmetrical capacity at 380 volts ac.

7.23.12 Weatherproofing

All outdoor electrical equipment and all appurtenances shall be designed for satisfactory operation during 129 km/hr (80 mile per hour) wind and driving rain. All exposed unpainted parts shall be fabricated of corrosion resisting metal. All ventilating openings on outdoor electrical equipment shall be louvered to prevent entrance of rain under weather conditions described above. All ventilating openings on outdoor electrical equipment shall be equipped with fine mesh filters and stainless steel bug screens.

7.23.13 Factory Prewired Electronic Systems Cabinets

Internal wiring in factory prewired electronic systems cabinets shall be installed according to the Vendor's standard for wire size, insulation, and method of termination on internal equipment, except that insulation for all wiring (including circuit board wiring, back plane wiring, power supply wiring, and interconnecting cables between devices) shall pass the vertical flame test in accordance with ICEA S-19-81. Identification of conductors may be done by insulation color coding identified on drawings or by printed wiring lists. Terminal blocks for connection of external circuits into factory prewired electronic systems cabinets shall meet all the requirements of the Paragraph 7.22.7

7.23.14 AC Motor Control

a. The switchgear breaker operating coils shall be momentarily energized to close the breaker and momentarily energized to trip the breaker.

b. The Vendor shall assure that the control devices and the control wiring, including terminal designations, are compatible with the appropriate starter and breaker control voltages and wiring as indicated.

c. Motor starters for 400 volt ac service shall include 400 volt, 3-phase, 50 hertz contactors with three manual reset thermal overload relays, 220 volt ac operating coils, and 400 to 230 volt dry type control transformers complete with one secondary lead fused and the other secondary lead grounded.

d. Large size starters which require line voltage to energize the operating coils shall be equipped with auxiliary contactors for use in the operating coil circuit. These contactors shall be operated from the 220 volt circuit of the control transformers.

e. Two speed starters and reversing starters, where required, shall be mechanically and electrically interlocked so that only one set of contacts can be closed at any one time.

f. Auxiliary contacts shall be mechanically operated by the starter contactor. The quantity of contacts shall be as required for the service.

g. Control transformers shall have 50 hertz ac ratings to permit operation at a primary voltage from 360 to 400 volts at a voltage ratio of 4/1. Assuming a 400 volt primary, each control transformer shall maintain a potential of not less than 192 volts at its secondary terminals during starter coil inrush while simultaneously serving a 100 VA load in addition to the coil load.

h. Starters for 220 volt or 208 volt ac service shall be similar to 400 volt starters except control transformers will not be required.

7.23.15 Lighting

a. All Work, unless the Engineer approves otherwise, shall be in accordance with the latest revisions of the National Electrical Code.

b. Miscellaneous loads such as unit heaters, fans, and fractional hp motors shall not be powered from lighting panels. Separate power panels shall be provided for that service.

c. Emergency lighting shall be provided in control rooms, at doors and stairs, and access routes to same.

d. The control room normal lighting shall be fluorescent and a minimum of 100 fc shall be provided. The emergency lighting shall be incandescent and normally off.

e. The ac lighting system shall be normally operating during all modes of plant operation. Upon loss of ac power, the emergency lighting system shall be energized automatically. After restoration of ac power, the emergency system shall be deenergized manually and the ac system used.

7.24 MODEL STUDY

7.24.1 The Vendor shall construct a model of the entire FGD system, including the fluegas ductwork and spray absorbers, and perform a set of three dimensional flow studies. The study shall be used to minimize solids buildup, minimize pressure drop, ensure proper flow distribution and velocities, determine the turndown capability of the absorber modules, and generally optimize the overall ductwork configuration. The studies shall also be used to determine the locations for accurate performance testing.

7.24.2 The entire FGD system from the outlet of the I.D. fan shall be included in the model study. The minimum acceptable scale for the model study shall be 1/10 of full size. The model shall be constructed of 6mm (1/4 inch) thick, clear Plexiglas to the greatest extent possible. All supports, stiffeners, flow control devices, and any other items located inside the ductwork shall be modeled into the ductwork. Duplicated or redundant items in the FGD system shall not be removed for the model study.

7.24.3 Airflow tests shall be run at 50, 75, and 100 percent of full load capacity and with different combinations of absorber modules to determine potential problems of gas distribution and ash fallout and the placement of duct hoppers.

7.24.4 All instrumentation used in the model shall be calibrated against a validated laboratory standard device. The Vendor shall use an airflow meter approved by the Engineer either upstream or downstream of the model. The airflow meter shall be capable of measuring flow from the maximum flow down to 25% of the maximum with an accuracy of ± 2% of the measured variable.

7.24.5 The data taken from the model shall include at least the following items for all flows:

a. Inlet flow distribution to the absorber manifold.

b. Inlet flow distribution to each absorber module.

c. Outlet flow distribution of each absorber module.

d. Pressure drop from the FGD system inlet to the absorber manifold.

e. Pressure drop from the absorber manifold to each absorber inlet.

f. Pressure drop across each absorber module.

g. Pressure drop from each absorber outlet to the outlet manifold.

h. A scale drawing of the model showing actual dimensions.

i. 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.

j. Isovelocity diagrams and histograms, indicating the coefficient of variation velocity deviation and mean velocity, at strategic points which shall include at least the following:

(1) Absorber inlets.

(2) Absorber outlets.

(3) Chimney inlets.

(4) One half duct diameter after each chimney inlet.

(5) Two duct diameters after the upper chimney inlet.

k. A complete description of the test procedures including flow rates, pressures, sample calculations, and assumptions. Any deviations in dynamic or geometric similtude by the model from the full size installation shall be listed and justified.

l. Conclusions that show type and location of devices required for proper gas distribution and any modifications necessary to the proposed ductwork. Conclusions shall state best economic solutions to the distribution problem.

m. Recommendations for location of test ports.

n. Recommendations for location and type of flow distribution devices in the chimney at wet and dry gas interfaces.

o. Recommendations for location of gas flow instrumentation points. The recommendations and conclusions from the model will be used in the final design of the system.

7.24.6 The Owner or the Engineer shall have the option of observing the scale model tests. The Vendor shall notify the Engineer at least 10 days prior to the scheduled testing.

7.24.7 After award of Contract, all changes in the Vendor's guarantees and the requirements of this Specification shall be made at no additional cost to the Owner. The Vendor shall make no changes to the FGD system design after the model study has been accepted unless approved by the Engineer. After acceptance of the FGD system, the model shall become the property of the Owner.

7.24.8 The model study shall in no way relieve the Vendor from providing a full-scale FGD system which meets the Vendor's guarantees and provides a uniform gas distribution. If corrections are necessary after the FGD system is built, the Vendor shall make such corrections at his own expense.

7.25 ACOUSTIC REQUIREMENTS

7.25.1 The Vendor shall submit as part of his Proposal a tabulation of octave band sound power levels in accordance with 7.24.2 below for the equipment being quoted without acoustic treatment or guarantee. The Proposal will be considered incomplete without this information.

7.25.2 The Vendor shall submit as part of his Proposal an additional price for a guaranteed maximum sound level of 90 dBA (90 decibels, A network weighted) when measured with a Type I precision sound level meter at slow response and at a distance of 1 meter

(3 feet) in any direction from the nearest surface of the equipment. The Vendor shall also submit with his Proposal a tabulation of octave band sound levels in accordance with 7.25.3 below for the equipment in the sound attenuated condition.

7.25.3 The Vendor shall complete and submit as part of his Proposal the attached Acoustic Data Summary Sheet. It is preferred that the octave band levels be sound power levels in decibels with a reference power of 10 (exponent -12) watt. However, sound pressure levels in decibels with a reference pressure of 0.0002 microbars will be acceptable providing the weighting network and distance to the sound source are indicated. In the event acoustic data for similar equipment will be acceptable. However, the equipment differences should be indicated and the Vendor's estimate of the acoustical effect of these differences should be indicated.

7.25.4 The maximum sound power or sound pressure levels will be verified by measurements at the installation site at the Purchaser's discretion. The Purchaser's Engineer will perform these requested tests in accordance with standard test procedures as applicable to the particular installation or type of equipment.

7.25.5 Where no specific testing procedure is applicable, verification tests shall be conducted in accordance with the following:

7.25.5.1 Institute of Electrical and Electronics Engineers (IEEE) Standard 85, "IEEE Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery."

7.25.5.2 American National Standards Institute (ANSI) S1.2, "Method for the Physical Measurement of Sound."

8.0 PERFORMANCE REQUIREMENTS AND GUARANTEES

8.1 The Vendor shall guarantee that the FGD system will operate at the specified performance ratings for the flue gas conditions stated in this Specification. The maximum continuous rating (MCR) condition represents the maximum boiler load operating condition and the maximum sulfur dioxide emission rate. The Vendor shall make performance guarantees at the MCR load point. Reduced load points of 25, 50, and 75 percent of MCR shall be predicted by the Vendor.

8.2 Spare equipment, such as absorber modules and pumps, shall not be used in order to meet the performance guarantees.

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8.3 Performance guarantees shall be submitted for the following operating parameters of the FGD system:

8.3.1 The FGD system shall continuously remove 75 percent of the sulfur dioxide produced by the boiler under all specified load conditions with the highest sulfur content coal listed in this specification.

8.3.2 There shall be no net increase in particulate emissions in kilograms (pounds) per hour due to the FGD system.

8.3.3 Flue gas pressure drop through the FGD system kPa (in H_2O).

8.3.4 Reagent consumption tonnes (tons) per hour.

8.3.5 Operating and connected horsepower for all motors and equipment.

8.3.6 Makeup water consumption liters per second (gallons per minute).

8.3.7 Gland seal water consumption liters per second (gallons per minute).

8.3.8 Compressed air consumption Nm ^{3}/sec (scfm) at rated pressure.

8.3.9 Isolation and control dampers shall have zero leakage of flue gas to the atmosphere. Isolation dampers shall have zero leakage of flue gas across the damper blades.

8.3.10 Minimum percent solids of waste slurry leaving the FGD system (percent solids).

8.4 All guillotine and double louver dampers shall be guaranteed to have zero leakage of flue gas to the atmosphere. Guillotine dampers shall be guaranteed to have zero leakage of flue gas across the damper blades.

9.0 MATERIAL REQUIREMENTS

9.1 Whenever a particular material is specified in this Specification, it shall be understood that designation is intended in a generic sense as being suitable for the severity of service anticipated; the designation is not intended to limit the Vendor's suggestion of other similar materials deemed more suitable for his equipment. The Vendor shall select materials that are commensurate with the abrasive and corrosive operating conditions anticipated, based upon the specified analysis of fuel, reagent, and makeup water.

9.2 When selecting materials, the Vendor shall pay attention to the fact that the FGD system will operate in an open water loop mode system. It is anticipated that FGD system slurry blowdown will be ponded without thickening or mechanical dewatering. Water losses due to solar evaporation are approximated to be 940 mm (37") per year based on water evaporation data.

9.3 ABSORBER MODULE

a. The absorber module shall be constructed of suitable erosion/corrosion resistant alloy materials.

b. Internal structures of the absorber module shall be of similar material and gage to the absorber shell. All spray pipes, mist eliminators, and other module internals shall be constructed of corrosion, erosion, and shock resistant materials.

9.4 TANKS

Tank material shall be as follows:

a.	Shell and cover	ASTM A283 Grade C steel
b.	Structural shapes	ASTM A36
c.	Nozzles	Carbon steel
d.	Flanges	Carbon steel

9.5 DUCTWORK

All materials shall be new and undamaged and shall conform to applicable AISC and ASTM standards and the following requirements:

	Upstream of Absorber Modules	Bypass Ductwork	Downstream of Modules
a. Ductwork plates and shapes exposed to flue gas	ASTM A588	ASTM A588	Alloy
b. External stiffeners not exposed to flue gas	ASTM A588	ASTM A588	ASTM A588

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	Upstream of Absorber Modules	Bypass Ductwork	Downstream of Modules
c. Steel pipe for interior stiffeners	ASTM A588	ASTM A588	Alloy
d. Bolts	ASTM A325 Type 3	ASTM A325 Type 3	ASTM A325 Type 3

9.6 EXPANSION JOINTS

a. For temperatures up to 204°C (400°F), expansion joints shall have two plies of fiberglass or Arimid fiber fabric, impregnated with Viton in multiple layers, or an Engineer approved equal as required to meet the design requirements. The expansion joints inner and outer seal shall be resistant to hot corrosive flue gas and weathering.

b. For temperatures greater than 204°C (400°F) up to 371°C (700°F), the Vendor shall furnish a composite joint made of multiple plies of fabrics and elastomers in accordance with recognized standards to meet the design requirements of this Specification. Expansion joint materials and details within this temperature range shall be subject to written approval of the Engineer.

c. The expansion joints shall conform to the following minimum requirements:

1. Frames ____________________
2. External stiffeners Carbon steel
3. Fasteners ____________________
4. Baffles ____________________

d. In all cases, the materials for a specific expansion joint shall have a corrosion resistance at least equivalent to that of the ductwork materials specified.

e. Asbestos and asbestos compound materials shall not be used.

f. Backup bars shall be at least 10mm x 50 mm (3/8" x 2") wide and manufactured of suitable materials.

9.7 DUCTWORK AND EXPANSION JOINT SUPPORTS AND HANGERS

a. Hanger rods shall be ASTM A36 steel.

b. Turnbuckles and clevises shall be of forged steel.

9.8 DAMPERS

9.8.1 <u>Guillotine Damper Materials</u>

a. Module inlet dampers shall be constructed of the following materials as a minimum:

(1)	Frame	Carbon steel
(2)	External stiffening	Carbon steel
(3)	Blade	Carbon steel
(4)	Seals	Inconel 625

b. Module outlet dampers shall be constructed of the following materials as a minimum:

(1)	Frame	Inconel 625
(2)	External stiffening	Carbon steel
(3)	Blade	Inconel 625
(4)	Seals	Inconel 625

9.9 SLURRY PUMPS

Slurry pumps shall be constructed of the following materials:

a. Casing: Cast iron (ASTM A48) or steel (ASTM A27) with replaceable liners.

b. Impeller: Soft natural rubber on steel skeleton.

c. Shaft: Heat-treated stainless steel, ASTM A276, Type 410.

d. Shaft sleeve: Hardened 420 stainless steel.

e. Baseplate: Steel, ASTM A36.

f. Wetted parts: 316L stainless steel.

9.10 OXIDIZING AIR COMPRESSORS

9.10.1 All materials shall be suitable for the service intended, and, as a minimum, shall be as follows:

a.	Casing	Cast iron
b.	Rotors	Cast iron or forged steel
c.	Shaft	Alloy steel

9.10.2 Coolers shall be constructed of the following materials:

a. Shells, channels, tube sheets, and covers shall be steel.

b. Tubes shall be inhibited admiralty metal.

9.11 PIPING

9.11.1 All piping materials shall be new and in accordance with the minimum requirements shown below. The specification of materials shall not relieve the Vendor of the responsibility of final selection of materials which will ensure the proper operation and performance of the FGD system.

a. Recycle spray piping - Abrasion-resistant fiberglass reinforced plastic, ABCO A-150 as manufactured by Atlantic Bridge Company Ltd. or Engineer approved equal.

b. Reagent feed piping - Schedule 80 carbon steel, Class 150.

c. Reaction tank bleed and sump piping - Abrasion-resistant fiberglass reinforced plastic, ABCO A-150 or Engineer approved equal.

d. Make up water piping - Schedule 40 carbon steel, Class 150.

9.11.2 Carbon Steel Class 150 Pipe Requirements:

a. Pipe:

(1)	50mm (2") and and smaller	Seamless carbon steel, Schedule 80 or as required, ASTM A106, Grade B.
(2)	65mm to 250mm (2 1/2" to 10")	Seamless carbon steel, Schedule 40 or as required, ASTM A106, Grade B.

(3)	300mm to 650mm 12" to 26"	Seamless carbon steel, 10mm (0.375") wall, ASTM A106, Grade B.

b. Fittings:

(1)	65mm to 650mm (2-1/2" to 26")	Seamless carbon steel, butt weld fittings, ASTM A234, WPB, wall thickness to match pipe. Fittings shall be in accordance with ANSI B16.9.
(2)	50mm (2") and smaller	3000 lb forged carbon steel socket weld fittings, ASTM A105. Fittings shall be in accordance with ANSI B16.11.

c. Flanges:

(1)	65mm to 650 mm (2 1/2" to 26")	150 lb raised face forged carbon steel, welded neck flanges, faced and drilled, same bore as matching pipe. ASTM A105. Flanges shall be in accordance with ANSI B16.5, (use flat face to mate butterfly valves and pump flanges).
(2)	50mm (2") and smaller	Use unions.

d.	Unions 50mm (2") and smaller	3000 lb forged carbon steel socket weld unions, ASTM A105, Bonney Forge Fig. 602B, or Engineer approved equal.

e. Bolts:

(1)	Studs	ASTM A193, Grade B-7 continuous thread.
(2)	Nuts	ASTM A194, Grade 2H semi-finished heavy hex nuts.

f.	Gaskets, all sizes	304 SS Flexitallic with graphite filler, 150 lb spiral wound, Style CG.

g.	Welding	Shielded manual metal arc with commercial split backing ring with knock off spacer pins.
h.	Instrument connections:	
	(1) Pressure	20mm (3/4") 300 lb forged steel sockolet or nippolet.
	(2) Temperature	32mm (1 1/4") 3000 lb, ASTM A105, full size sockolet.
i.	Valves:	
	(1) 50mm (2") and smaller	Globe valve, socket weld ends, 600 lb F.S. A105 Grade 2, OS&Y Hancock 5525 or Engineer-approved equal.
	(2) 80mm (3") and larger	AWWA Class 150B, butterfly flanged ends, 125B cast iron body, Pratt Model 2 F11 or Engineer approved equal.

9.11.3 Fiberglass Reinforced Plastic Pipe Requirements

a.	Pipe, 50mm - 900mm (2"-36")	Fiberglass/epoxy pipe, (ASTM D2310) as manufactured by Atlantic Bridge Company Ltd., P-150 standard ABCO pipe or Engineer approved equal.
b.	Fittings, 50mm - 900mm (2"-36")	Polyester resin reinforced with chopped strand mat and wound roving capable of withstanding short term hydrostatic burst pressure of 10,342 kPa (1,500 psi)
c.	Flanges	Polyester resin with chopped strand glass and reinforced with sufficient chopped strand mat, woven and continuous winding. Flanges shall be drilled in accordance with ANSI B16.5.

d.	Mechanical joints	Subject to Engineer approval.
e.	Bolts	Regular square head carbon steel bolts, ASTM A307 Grade B, with unfinished heavy hex nuts or carbon steel, ASTM A307. Steel washers shall be used under bolt heads and nuts on all flanges.
f.	Branch connections	Use tee, lateral 45° same rating as pipe.
g.	Gaskets	Full face 60-70 shore hardness, 3mm (1/8") thickness, EPR (ethylene, propylene rubber).
h.	Adhesives	Piping fittings and flanges shall be cemented together with an adhesive recommended by the pipe manufacturer. The procedure used shall be in accordance with the manufacturer's instructions.

9.11.4 Abrasion Resistant FRP Pipe Requirements:

a.	Pipe, 50mm - 900mm (2"-36")	Fiberglass/epoxy pipe (ASTM D2310) as manufactured by Atlantic Bridge Co., Ltd., A-150, abrasion-resistant or Engineer approved equal.
b.	Fittings, 50mm - 900mm (2"-36")	Polyester resin, abrasion-resistant mix, with sufficient layers of chopped strand mat, filament roving, and woven material to withstand short term hydrostatic burst pressure of 10,342 kPa (1500 psi).
c.	Flanges, 50mm - 900mm (2"-36")	Polyester resin, abrasion-resistant mix, with sufficient chopped strand mat, woven and continuous winding to provide resistance to bolting torques up to 135.6 Joules (100 ft-lbs). Flanges shall be drilled in accordance with ANSI B16.5, 150 lb drilling pattern.

d.	Mechanical joints	Subject to Engineer approval.
e.	Bolts	Regular square head carbon steel bolts ASTM A307 Grade B, with unfinished heavy hex nuts of carbon steel, ASTM A307. Steel washers shall be used under bolt heads and nuts on all flanges.
f.	Branch connections	Use tee, lateral 45° same rating as pipe.
g.	Gaskets	Full face 60-70 shore hardness, 3mm (1/8") thickness, EPR (ethylene, propylene rubber).
h.	Adhesives	Pipe fittings and flanges shall be cemented together with an adhesive recommended by the pipe manufacturer. The procedure used shall be in accordance with the manufacturer's instructions.

9.12 VALVES

9.12.1 For general service valves, valve body and trim materials shall be as follows:

a.	Bronze	ASTM B62 for Class 125 and 150 valves. ASTM B61 for Class 200 and 300 valves.
b.	Carbon steel	Forged - ASTM A105 Cast - ASTM A216 Grade WCB.
c.	Stainless steel:	
	(1) Body	AISI Type 316.
	(2) Stems, discs, and seat facings	AISI Type 410, 420, or ASTM A182 Grade F-6, except that trim for stainless steel body valves may be the same material as the body.

d. Nickel alloy (for seat facings) — Monel metal or other alloy having not less than 60 percent nickel content.

9.12.2 Steel body gate, globe, and check valves:

a. Steel body valves 50mm (2 inches) and smaller shall have forged carbon steel or forged stainless steel bodies as required for the service. Trim materials shall be as follows:

(1) Stem	11-14 percent chromium stainless steel.
(2) Disc	Equivalent to or better than body material.
(3) Seating surfaces	Stellite faced.

b. Steel body valves 65 mm (2 1/2 inches) and larger shall have carbon steel or stainless steel bodies as required for the service. Trim materials shall be as follows:

(1) Stem	11-14 percent chromium stainless steel.
(2) Disc	Equivalent to body material.
(3) Seating surfaces	Stainless steel on nickel alloy, or hardened stainless steel on stainless steel.

9.12.3. Bronze gate, globe, and check valve trim materials shall be as follows:

a. Discs	Stainless steel, except nickel alloy may be used for gate valves.
b. Stem	Brass.
c. Seats	Stainless steel, except nickel alloy may be used for gate valves.

9.12.4 Butterfly Valves:

Valve materials shall be equivalent to or shall exceed the strength and corrosion-erosion resistance of the following listed materials:

a.	Valve body	Cast iron - ASTM A48 Class 40 or ASTM A126 Class B Cast steel - ASTM A216, Grade WBC. Stainless steel - ASTM A296, Grade CF-8M.
b.	Disc	Austenitic cast iron -ASTM A436, Type 1. Stainless steel - ASTM A296, Grade CF-8M.
c.	Shaft	Stainless steel - ASTM A276, Type 304. Stainless steel - ASTM A276, Type 316.
d.	Soft seat	Synthetic rubber which does not contain polyisoprene.
e.	Hard seat	Stainless steel - ASTM A276, Type 304.
f.	Valve sleeve bearings	Self-lubricated bronze or other acceptable nonlubricated material.

9.13 INSULATION MATERIALS

a. Insulation shall be fiberglass with a minimum temperature rating of 250°C (475°F).

b. Lagging shall be aluminum with a minimum thickness of 1mm (.04 inches).

c. Flashing shall be same material as lagging with a minimum thickness of 1mm (.04 inches).

d. Wire mesh shall be galvanized steel.

9.14 Materials used for construction of the control system shall not contain carcinogens (cancer-producing substances).

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10.0 FABRICATION AND ASSEMBLY REQUIREMENTS

10.1 The means employed for doing the various classes of Work shall be at the option of the Vendor subject to approval of the Engineer as may be necessary to safeguard the quality and results of all the features of the Work and specific erection and testing procedure as specified herein.

10.2 The Vendor shall perform all Work of assembling items of equipment requiring field assembly as follows:

10.2.1 Setting in place on foundations to accurate line and grade.

10.2.2 Properly shimming up with steel shims, including drilling holes in equipment bases for insertion of grout where required.

10.2.3 Aligning to manufacturers' standards as set forth in their erection manuals

10.2.4 Doweling of bed plates and separate coupling bases including drilling where required, of equipment bases, and shims, reaming of holes in embedded metal frames, and installation of coupling guards.

10.3 The Vendor shall maintain the portions of the jobsite affected by the Work in a condition acceptable to Owner as regards to housekeeping.

10.4 There shall be no cutting, burning, heating, welding, or tacking of any kind to fabricated, installed equipment, or both, for temporary support, attachment purposes, or other reasons without the specific approval of the Owner.

10.5 ROTATING EQUIPMENT

10.5.1 Rotating equipment shall be field checked by the Vendor for alignment, as specified in the instruction book for the equipment.

10.5.2 Approval shall be obtained from the Owner before the final coupling of the equipment is undertaken. The Vendor shall be responsible for the final coupling to manufacturer's tolerances. If the motor is coupled to the equipment, the coupling shall be disconnected to establish the direction of motor rotation.

10.5.3 The Vendor shall open, or make accessible for inspection any parts of equipment, such as speed increaser gear, as the Owner may direct prior to equipment being placed in operation. The Vendor shall check all bolts to the specified torque values.

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The bolts shall be locked in place by a method approved by the Engineer. The couplings on preassembled equipment shall be disconnected by the Vendor and alignment verified. Field assembled couplings shall be aligned as stated for other rotating equipment.

10.5.4 Internals shall be carefully handled and installed in the manner and sequence recommended by the manufacturer.

10.5.5 After the equipment has been installed and tested and the installation has been approved by the Owner or his agent, the Vendor shall dowel the equipment.

11.0 INSTALLATION AND ERECTION REQUIREMENTS

11.1 GENERAL ERECTION REQUIREMENTS

11.1.1 Details of erection Work not covered herein shall conform to accepted good engineering and construction practice, the requirements of AISC, the Engineer's Drawings, the erection drawings, applicable nationally recognized codes, and all applicable state and local codes.

11.1.2 All equipment shall be installed in accordance with the manufacturer's instructions, especially valves which require special body cooling procedures or removal of internals during welding.

11.1.3 Equipment Protection:

a. Equipment shall be protected from weld spatter during construction.

b. Equipment having glass components such as gages or equipment having other easily broken components shall be protected during the construction period with plywood enclosures or other suitable means.

11.1.4 Location Tolerances

a. All equipment shall be located with 3mm (1/8 inch) of the locations dimensioned on the Drawings.

b. Any miscellaneous steel shall be erected to AISC tolerances. All parts shall be assembled accurately. Light drifting will be permitted to draw the parts together, but drifting to match unfair holes will not be permitted.

11.1.5 <u>Shaft Alignment and Balance</u>

a. Alignment of rotating machinery shafts shall be as nearly perfect as practicable. Offset between coupling halves shall not exceed .001 mm per mm (0.001 inch per inch) of shaft diameter with proper allowance for expansion of the driver or driven unit when operating. Faces of coupling halves, with couplings square on their shafts, shall be parallel within .025mm (0.001 inch). Measurements shall be made with a dial indicator.

b. Motors:

(1) Motors and equipment shall be aligned using stainless steel shim stock. Stainless steel shims cut to the same size as the motor foot shall be installed beneath each motor wherever practicable when aligning shafts so that future realignment may be performed without grinding the motor baseplate. Motors 224 kW (300 horsepower) and larger shall receive a hot alignment check and shall be doweled.

(2) All motors shall be checked for proper rotation before connection to the driven equipment. A record shall be kept of all motor rotation checks.

(3) Motors shall be electrically connected in accordance with the attached Motor Specification.

c. Machinery shall operate without excessive vibration, bearing overheating, or other conditions which would tend to shorten the life of the machinery. Before the equipment is operated, all bearings, shafts and other moving parts shall be checked for proper alignment, and cleaned and lubricated in accordance with the equipment manufacturer's recommendations and instructions.

d. Final alignment and vibration readings will be witnessed by the Owner or the Field Project Manager. Copies of records indicating all final alignment measurements shall be furnished to the Owner.

11.1.6 Doweling:

All mechanical equipment including motor drives shall be doweled using tapered dowels after shafts have been aligned as directed by the Owner.

11.1.7 Miscellaneous Equipment:

Items of miscellaneous equipment such as locally mounted pressure and flow transmitters, pilot controls for control valves, etc., shall be installed in easily accessible locations, subject to the acceptance of the Owner. All such items shall be rigidly supported from the building structure by means of suitable brackets.

11.1.8 Equipment Piping Connections:

All equipment having piping connections shall be leveled, lined, and wedged in place but shall not be grouted or bolted prior to the initial fitting and alignment of connecting piping. All equipment shall, however, be grouted or bolted to its foundation prior to final bolting or welding of the connecting piping.

11.1.9 Pump Suction Strainers:

All pump suction strainers shall be installed before starting the associated equipment. Temporary strainers for all general service pumps shall be furnished and installed.

11.1.19 Electrical Equipment:

All electrical equipment, wiring, conduit, conductors, and raceways furnished with the FGD system equipment shall be installed except as specified herein.

11.2 SHOP STRUCTURAL WELDING

Unless otherwise specified, all welding of shop-fabricated components shall be performed in accordance with the following requirements:

11.2.1 All welds, welding, and related operations for equipment, ductwork, and devices shop fabricated from steel plate and structural shapes shall conform with the Structural Welding Code by the American Welding Society, AWS D1.1.

11.2.2 All welding procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS D1.1. All procedure qualifications shall be in written form and shall be submitted to the Engineer for review prior to beginning the Work. Accurate records of welder and welding operator qualifications shall also be maintained by the Vendor and shall be made available to the Owner and the Engineer upon request.

11.2.3 All welds shall be properly identified on detailed shop drawings and are subject to review by the Engineer.

11.2.4 Except as otherwise accepted, welding shall be performed using only those joint details which have prequalified status when performed in accordance with AWS D1.1.

11.2.5 The provisions of Table 4.1.4 of the AWS D1.1 concerning filler metal requirements for ASTM A588 steel shall apply and shall also be used for Type A441 steel. The corrosion characteristics of the weld metal shall be similar to the corrosion characteristics of the base metal. The welding processes, filler metals, and fluxes specified for these types of steel in AWS D1.1 shall be used.

11.2.6 Welding of materials or combinations of materials not provided for in AWS D1.1 shall be subject to welding procedure qualification testing in accordance with Section 5 of AWS D1.1. These procedures and the qualification data shall be submitted to the Engineer for review.

11.2.7 Components to be welded shall be accurately positioned and shall be rigidly secured during welding.

11.2.8 All welded joints exposed in exterior locations or subject to submergence in any location shall be provided with continuous weld along the contact edges.

11.2.9 Seal welds shall have full contour weld beads, or in the case of corner welds, a full throat and legs.

11.2.10 All butt welded joints shall be full penetration welds, except as agreed in writing by the Vendor and the Engineer.

11.2.11 All interior seams and joints of the ductwork exposed to flue gases shall be seal welded.

11.2.12 Groove welds shall be terminated at the ends of the joint by use of extension bars or runoff plates. Extension bars and runoff plates shall be removed upon completion and cooling of the weld, and the ends of the weld shall be made smooth and flush with the edges of the abutting parts.

11.2.13 All welds shall be chipped and sandblasted or wire brushed to remove all flux, scale, and spatter.

11.2.14 Welding Methods:

a. Only the following welding processes will be permitted subject to proper code qualification and/or the concurrence of the Engineer:

(1) Shielded metal arc.

(2) Gas metal arc.

(3) Flux cored arc.

(4) Submerged arc.

b. The short circuiting transfer mode of the gas metal arc welding process shall not be used with materials or connections that involve a member more than 5mm (3/16 inch) thick. The use of the self-shielded electrodes in the flux cored arc welding processes will be permitted only in certain cases with the specific acceptance of the Engineer. Supplemental shielding of self-shielding electrodes, in the flux cored arc welding process, will be acceptable.

c. Filler metal shall be in accordance with Table 4.1.4 of AWS D1.1 for welding of ASTM A588 materials.

d. Welding between carbon and stainless steels, if required, shall use AWS Class 309 filter metal.

e. The Vendor shall provide for the care and maintenance of filler metals to prevent damage from the atmosphere or the misapplication of filler metals.

f. Low hydrogen electrodes shall be stored and handled during use in a manner that will maintain their low hydrogen characteristics. The methods used for storage and handling shall be fully described in the welding procedures submitted or in a separate electrode storage and handling procedure submitted to the Engineer for review prior to beginning the Work.

11.3 FIELD STRUCTURAL WELDING

Unless otherwise specified, all welding of field-erected components shall be performed in accordance with the following requirements:

11.3.1 All welds, welding, and related operations for equipment, ductwork, and devices constructed from steel plate and structural shapes shall conform with the Structural Welding Code by the American Welding Society, AWS D1.1.

11.3.2 Field welding of components of field erected tanks shall be in accordance with the requirements of Paragraph 11.5.3.

11.3.3 Field welding of piping components shall be in accordance with the requirements of Paragraph 11.7.16.

11.3.4 Shop welding requirements are specified in Paragraph 11.2 of this Specification.

11.3.5 All welding procedures and operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of the AWS D1.1. All procedure qualifications shall be in written form and shall be submitted to the Engineer for review prior to beginning the Work. No welding shall be done until the Engineer's review is completed. Accurate records of welder and welding operator qualifications shall be maintained by the Vendor and shall be made available to the Owner and the Engineer upon request.

11.3.6 All welds shall be properly identified on detailed drawings and are subject to review by the Engineer.

11.3.7 Except as otherwise accepted, welding shall be performed using only those joint details which have prequalified status when performed in accordance with AWS D1.1.

11.3.8 The provisions of Table 4.1.4 of AWS D1.1 concerning filler metal requirements for ASTM A588 steel shall apply and shall also be used for Type A441 steel. The corrosion characteristics of the weld metal shall be similar to the corrosion characteristics of the base metal. The welding processes, filler metals, and fluxes specified for these types of steel in AWS D1.1 shall be used.

11.3.9 Welding of materials or combinations of materials not provided for in AWS D1.1 shall be subject to welding procedure qualification testing in accordance with Section 5 of AWS D1.1. These procedures and the qualification data shall be submitted to the Engineer for review.

11.3.10 Components to be welded shall be accurately positioned and shall be rigidly secured during welding.

11.3.11 All welded joints exposed in exterior locations or subject to submergence in any location shall be provided with continuous weld along the contact edges.

11.3.12 All butt welded joints shall be full penetration welds, except as agreed in writing by the Vendor and the Engineer.

11.3.13 Seal welds shall have full contour weld beads, or in the case of corner welds, a full throat and legs.

11.3.14 All interior seams and joints of the ductwork exposed to flue gases shall be seal welded.

11.3.15 All welds shall be chipped and wire brushed to remove all flux, scale, and spatter.

11.3.16 Welds that are not dimensioned on the equipment drawings shall be sized to develop the full strength of the weakest component involved in the connection.

11.3.17 Each welding operator shall be qualified for all welding procedures and positions required in a joint that he welds. The entire weld of any structural joint shall be made by one operator.

11.3.18 Each welding operator shall be assigned an identification mark or symbol and, upon completion of a structural weld, the operator shall apply his assigned mark in the parent metal adjacent to the weld.

11.3.19 In addition to operator and procedure qualifications, the Vendor shall maintain accurate records of each welding operator's identification mark, and of the welded joints each operator makes. All such records shall be available to the Owner and the Engineer upon request.

11.3.20 <u>Welding Methods</u>

a. Only the following processes will be permitted subject to proper code qualification and/or the concurrence of the Engineer:

(1) Shield metal arc.

(2) Gas metal arc.

(3) Flux cored arc.

(4) Submerged arc.

b. The short circuiting transfer mode of the gas metal arc welding process shall not be used. The use of the self-shielded electrodes in the flux cored arc welding processes will be permitted only in certain cases with the specific acceptance of the Engineer. Supplemental shielding of self-shielding electrodes, in the flux cored arc welding process, will be acceptable.

c. Filler metal shall be in accordance with Table 4.1.4 of AWS D1.1 for welding of ASTM A588 materials.

d. Welding between carbon steel and stainless steel shall use AWS Class 309 filler metal.

e. The Vendor shall provide for the care and maintenance of filler metals to prevent damage from the atmosphere or the misapplication of filler metals.

f. Low hydrogen electrodes shall be stored and handled during use in a manner that will maintain their low hydrogen characteristics. The methods used for storage and handling shall be fully described in the welding procedures submitted or in a separate electrode storage and handling procedure submitted to the Engineer for review prior to beginning the Work.

11.4 STRUCTURAL AND MISCELLANEOUS STEEL ERECTION

11.4.1 Structural Steel Erection

a. All steel shall be erected in accordance with AISC specifications, codes, and standards.

b. The bases of columns and the tops of column baseplates shall be shop milled, except rolled steel bearing plates less than 100mm (4 inches) thick may be straightened by pressing. Shop milling shall be performed on butted ends for bolted column splices, but is not required for welded column splices with full penetration welds. Ends of columns that butt against a plate shall be shop milled.

c. Welding:

(1) All welding shall be shielded metal arc, submerged arc, or flux-cored arc.

(2) E70 series electrodes shall be used for shielded metal arc welding; F7 series shall be used for submerged arc welding; and E70T series electrodes shall be used for flux-cored arc welding.

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(3) Welding shall conform with AWS D1.1, Part 4 of AISC Manual of Steel Construction, and the AISC Quality Criteria and Inspection Standards.

(4) Welds shall be inspected in accordance with AWS D1.1 to determine their acceptability. Defective welds shall be corrected in accordance with AWS D1.1.

(5) All welds shall be stamped with a mark identifying the welder.

(6) Welders shall be removed from work after two defective welds.

d. Shop connections shall be welded, riveted, or made with high-strength bolts.

e. Field connections shall be as follows:

(1) Unless clearance is insufficient, connections shall be bolted friction type using ASTM A325 or A490 bolts and conform to the AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

(2) All bolted connections shall be made with 19mm (3/4 inch) bolts, nuts, and washers unless otherwise indicated or specified.

(3) The Vendor shall use at least the minimum number of rows of bolts for a given beam size as required in Tables 1 and 2 of Part 4 of the AISC Manual of Steel Construction.

(4) High-strength bolts shall be tightened to the correct bolt tension in accordance with Part 5 of the AISC Manual of Steel Construction.

(5) Load indicators shall be used for all A325 bolts for friction type connections to determine the specified minimum bolt tension. Coronet load indicators as manufactured by Cooper and Turner, Inc., East Hartford, Connecticut, or Engineer-approved equal shall be used. They shall be installed in accordance with the manufacturer's written instructions.

f. Girt and miscellaneous steel connections shall use either ASTM A307 or ASTM A325 bolts.

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g. Bolts:

(1) All bolts required for structural attachments shall conform to ASTM A490 or A325. ASTM A325 Type 3 bolts shall be used with ASTM A588 steel.

(2) The installation of high-strength bolts shall conform to all applicable requirements of the AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts," except as otherwise modified and supplemented herein.

(3) Tightening shall be done using either the calibrated wrench method, the "turn-of-nut" method, or the load indicator washer method. A washer shall be used under the element turned for whichever method is used. Load indicator washers shall not be used with Type 3 bolts.

(4) Load indicator washers shall be "Coronet Load Indicators" or "Bethlehem Load Indicator Washers." When using load indicator washers, tightening shall be done in accordance with the manufacturer's written instructions.

h. The locations and elevations of anchor bolts and footings shall be checked before erecting structural steel. Any discrepancies shall be reported to the Engineer immediately.

i. Steel shall be protected from entrapped water that can cause damage by freezing or corrosion.

j. Erection bracing:

(1) All necessary temporary struts, ties, cables, temporary flooring, planking, and scaffolding needed for the erection of the structural steel or the support of erection machinery shall be provided.

(2) Erection bracing shall be placed as required to maintain proper position against loads from erection equipment, construction material, and wind.

(3) Bracing shall remain in place until sufficient steel connections, concrete slabs, exterior walls, and roof decks are in place to insure stability of the structure.

11.4.2 Column and Equipment Baseplate Grouting

The Vendor shall grout and prepare foundation surfaces for structural steel and equipment in accordance with the following:

a. Grout shall be placed under baseplates using the "dry-pack" method or a flowable nonshrink grout. Special care shall be taken not to disturb baseplate grade and alignment. The "dry-pack" method shall not be used under baseplates having dimensions 460mm (18 inches) or greater. Flowable nonshrink grout shall be used in conjunction with sleeved anchor bolts and/or shear bare.

b. Grout placed by the dry-pack method shall consist of 2 parts sand to one part portland cement with a minimum of water.

c. Flowable nonshrink grout shall be one of the following:

   (1) Masterflow 713 grout, Master Builders Company of Cleveland, Ohio.

   (2) Saurereisen F100, Saurereisen Cement Company of Pittsburgh, Pennsylvania.

   (3) Five Star Grout, U.S Grout Corporation, Old Greenwich, Connecticut.

d. Exposed edges of the grout shall be cut off at 45 degree angles along the edges of the baseplate after the grout is initially set.

e. Minimum grout thickness shall be 38mm(1 1/2 inches).

f. Baseplates shall be grouted only during favorable weather conditions. Dry-pack grout shall be cured with curing compound or wet burlap. Flowable, nonshrink grout shall be cured according to the manufacturer's instructions.

g. Base bearing and leveling plates shall be supported by steel wedges of shims until the supported members have been plumbed and grouted.

h. Nuts threaded on anchor bolts are not acceptable as supports prior to grouting.

i. Projecting portions of shims or wedges which would be exposed after grouting shall be removed prior to grouting.

j. Grouting for equipment shall be in accordance with the requirements of the equipment manufacturer.

11.4.3 Concrete Equipment Bases and Anchor Bolts

a. The Owner will furnish all concrete equipment bases. Concrete bases will have a 27,580 kPa (4,000 psi) minimum ultimate compressive strength.

b. Bolts (including washers and nuts) shall be furnished and installed by the Vendor for column and equipment anchorage on concrete bases. Bolts shall be ASTM A307, low-carbon steel, externally and internally threaded standard fasteners.

c. Pipe sleeves, other anchorage members, and concrete bases shall be protected from deleterious materials at all times and from water which may cause ice damage during freezing weather.

d. Anchor bolt projections shall be protected at all times from all damage that may result from construction activities within the scope of this Contract. The Engineer shall be notified of damaged anchor bolts and repair shall be made with the Engineer's approval.

e. All sleeves of anchor bolts used for column anchorage shall be grouted by completely filling the sleeves with flowable, nonshrink grout prior to grouting the baseplates.

f. Anchor bolts shall not be overstressed during tightening. They shall be tightened to snug tight as defined by AISC unless otherwise required.

11.4.4 Miscellaneous Steel Erection

a. Handrails:

(1) Posts shall be spaced no more than 1.8mm (6 feet) apart, center to center.

(2) All handrails shall be formed and welded. All welds shall be ground smooth and even with the surface of the pipe, including all field welds required for erection.

(3) All handrails shall be formed carefully at all corners where a change of direction or elevation occurs.

(4) All rails and posts shall be installed plumb, level, straight and true, and in alignment.

(5) Handrails shall clear columns or other vertical or horizontal projections by at least 76mm (3 inches).

(6) All plates, bolts, and additional items shall be furnished and installed as required for fastening to supporting members.

(7) Pipe sleeves shall be furnished for posts of handrail sections that must be removable for maintenance or service.

b. Kickplates:

Kickplates shall extend 100mm (4 inches) above the top of grating and shall be installed at the edge of uncovered openings, walkways, and platforms.

c. Grating:

(1) Main bars shall be vertical within a tolerance of .10mm per mm (0.10 inch per inch) of depth.

(2) Longitudinal bow before fastening to supports shall be less than 1/200 of the length.

(3) Transverse bow before fastening to supports shall be less than 10mm (3/8 inch) in 900mm (3 feet).

(4) Crossbars shall not deviate from a straight line perpendicular to the main bars by more than 5mm (3/16 inch) in 900mm (3 feet).

(5) Crossbars shall match crossbars of adjacent sections to form a continous pattern of straight lines.

(6) Panel width and length tolerances shall be ±6mm (±1/4 inch).

(7) All openings in grating required for installation of all piping, wiring, and equipment installed under this Contract shall be provided.

(8) All openings 100mm (4 inches) and larger shall be bonded with a metal bar the same size as the main bearing bar. Metal bars shall be welded to each bearing bar with a 5mm (3/16 inch) fillet weld 19mm (3/4 inch) long, and tack welded to all cross bars.

(9) The following locations shall be trim-banded:

(a) The open end of grating at the head of a ladder.

(b) Manway opening.

(c) Hinged sections.

(d) Grating panels with four crossbars or less.

(10) Fasteners shall be spaced as required to overcome irregularities and maintain grating contact with supports. Each panel shall be anchored with at least two fasteners at each end and one fastener at each intermediate support.

(11) All grating shall be fastened with galvanized clips similar to Type "C" as manufactured by I.K.G. Industries. Clips shall be fastened to welded studs similar to Type CPL as manufactured by Nelson Stud Welding Company. Studs shall be installed in accordance with the manufacturer's printed instructions. Galvanized washers and nuts shall be used with this system.

(12) All grating shall be removable.

d. Stairs:

(1) Stringers of channel sections shall be adequate to carry the specified design loads without excessive deflection.

(2) Stringers shall be cross braced to provide lateral stability where the horizontal run exceeds 3.7m (12 feet).

(3) Struts and hangers shall be provided where required to suit the specified live load.

(4) Treads shall be bolted to stringers with at least two 10mm (3/8 inch) bolts.

e. Checkerplate:

(1) Checkerplate shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

(2) Checkerplate shall be fastened in place with a countersunk stainless steel screw in each corner of each piece and at 460mm (18 inch) spacings around the plate perimeter. Checkerplate shall be plug welded where permanent fastening is required.

(3) Screws shall be 6mm (1/4 inch) countersunk stainless steel.

11.5 TANK ERECTION

11.5.1 Tanks shall be erected on foundations furnished by the Owner. The foundations will be constructed in accordance with standard construction practices. Any shimming required for leveling the tank bottoms shall be the Vendor's responsibility.

11.5.2 The tanks shall be erected using procedures meeting the requirements and recommendations of API 650 and in accordance with the requirements specified herein.

11.5.3 <u>Welding</u>

a. All welds, welding, and related operations for steel shall conform to the requirements of API 650, Appendix D.

b. All inside butt welded joints shall be ground smooth and flush. Bottom fillet welds shall be ground smooth.

c. All field joints shall be properly identified on the erection drawings and shall be subject to the acceptance of the Owner.

d. Components to be welded shall be accurately positioned and shall be rigidly secured during welding.

e. Each welding operator shall be qualified for all welding procedures and positions required in a joint that he welds. The entire weld of any structural joint shall be made by one operator.

f. Each welding operator shall be assigned an identification mark or symbol, and upon completion of a weld, the operator shall apply his assigned mark in the parent metal adjacent to the weld.

g. In addition to operator and procedure qualifications, the Vendor shall maintain accurate records of each welding operator's identification mark, and of the welded joints each operator makes. All such records shall be available to the Owner upon request.

11.6 DUCTWORK ERECTION

11.6.1 Ductwork, expansion joints, and dampers shall be erected as follows:

a. All materials erected under this paragraph shall be erected in accordance with AISC standards, the equipment detail and erection Drawings, and this Specification.

b. Details of the erection work not covered herein shall conform to accepted good engineering practice, the requirements of AISC, applicable nationally recognized codes, and all applicable state and local codes.

c. Unless otherwise specified, erection tolerances shall be as specified in the AISC Manual of Steel Construction.

d. Particular care shall be exercised to provide maximum stability of the ductwork sections and expansion joints during erection.

e. All defects in erection shall be corrected to the satisfaction of the Owner and the Engineer.

11.6.2 DUCTWORK

a. The ductwork shall be erected to the lines and elevations indicated on the erection Drawings. Edges and corners shall match adjoining sections in all dimensions within a tolerance of 3mm (1/8 inch). The Owner shall be notified immediately of sections which do not match within the specified tolerances. Ductwork sections shall be reworked or replaced, as acceptable to the Owner.

b. All parts shall be assembled accurately as indicated on the Drawings and matchmarks shall be carefully followed. Light drifting to draw the parts together will be acceptable, but drifting to match unfair holes will not be acceptable. Any enlargements of holes necessary to make connections in the field shall be done by reaming with twist drills, care being taken not to weaken the adjoining metal. Holes shall not be enlarged by burning.

c. All field joints shall be assembled and abutting surfaces drawn tightly together. Assembled sections shall be checked for alignment, plumb, and level in accordance with the specified tolerances before welding.

d. Unless otherwise specified or indicated on the Drawings, field joints shall be bolted with high-strength bolts and seal welded.

e. All welds inside the ductwork shall be seal welds and shall provide a gastight structure upon completion.

f. Ductwork sections shall be furnished in whole units to the maximum extent practicable. Temporary stiffeners, braces, or lifting lugs installed for shipping and erection purposes shall be removed after final assembly of the ductwork. All weld metal remaining after removal of temporary pieces shall be ground flush with the ductwork surfaces.

g. Where required, bolt holes shall be field drilled, using Vendor furnished templates.

11.6.3 Alloy Ductwork

a. All welding shall be done in accordance with the metal manufacturer's recommendations.

b. Alloy shall be welded in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

c. Prior to welding, all welded surfaces shall be solvent cleaned using a method recommended by the metal manufacturer.

d. All welding variables such as heat input and interpass temperature shall be as recommended by the metal manufacturer.

e. All fabrication procedures shall be as recommended by the metal manufacturer.

f. Alloy breeching shall be shop fabricated as much as possible to minimize field welding.

g. Welding electrodes shall be as follows unless otherwise approved by the Engineer:

(1) Coated electrodes shall conform to AWS A5.11.

(2) Bare electrodes shall conform to AWS A5.14.

11.6.4 Expansion Joints:

a. Expansion joints shall be erected at the locations indicated on the erection Drawings. The expansion joints shall provide a gastight structure. The Vendor shall use care in installation of the expansion joints throughout the system to prevent damaging the joint material. The joint shall be protected from weld spatter during erection and after installation until such time as the completed installation is accepted by the Owner. Where joints are provided with a backup bar and flange angle, the expansion joint angle shall be seal welded to the ductwork flange angle.

b. After the expansion joints are completely installed, the Vendor shall remove all shipping bars, if provided, and shall grind all excess weld flush with parent metal.

11.6.5 Dampers

a. Dampers shall be installed at the locations indicated on the erection Drawings. Edges and corners of the dampers shall match those of the ductwork within a tolerance of 3mm (1/8 inch). Drifting to match erection holes which are not squared will not be permitted.

b. After the dampers are bolted into position and checked for damage, warpage, excessive deflection, or improper alignment due to erection, the damper frame shall be seal welded to the ductwork flanges.

c. After the dampers are completely installed, the Vendor shall remove all shipping bars, if provided, and shall grind all excess weld flush with the parent metal.

11.6.6 Bolts

a. All bolts shall be 22mm (7/8 inch) diameter unless otherwise indicated on the equipment Drawings.

b. The installation of high-strength bolts and bolting tools and equipment shall conform to all requirements of Paragraph 11.4.1g.

c. High-strength bolted connections shall be friction type connections, except where other type connections are required by the Drawings or this Specification. Contact surfaces of friction type connections shall not be painted and shall be free of loose scale, dirt, burrs, oil, paint, lacquer, galvanizing, and other foreign materials that would prevent solid seating of the parts.

11.6.7 Welding

Welding shall be in accordance with the requirements of Paragraph 11.3.

11.7 PIPING ERECTION

Piping and associated equipment shall be erected as follows:

11.7.1 All piping, valves, fittings, and piping specialties shall be erected in accordance with the requirements of this paragraph. Any piping installation not specified herein shall be done in accordance with good engineering practice.

11.7.2 All temporary scaffolding and rigging required for installation of the piping system shall be supplied, erected, and dismantled in accordance with National Safety Standards.

11.7.3 All piping and support assemblies shall be erected in accordance with the base lines and elevations as shown on the Drawings.

11.7.4 The Drawings for small 50mm (2 inch and under) piping and tubing are only diagramatic; the exact location of these lines shall be determined in the field by the Vendor. The actual arrangement of the small piping, when erected, shall follow the general location shown on the Drawings insofar as practicable, shall be convenient to operator, and shall provide for proper expansion and drainage.

11.7.5 Prior to installation, piping shall be checked inside and outside to see that it is clean. Loose material including rust, mill scale, and foreign matter shall be removed.

11.7.6 During installation, all openings for pipe connections, all access openings, and all open-ended pipes shall be covered with temporary covers made of plywood or sheet metal.

11.7.7 The Vendor shall exercise particular care in assembling the piping to prevent loose material from getting into the piping system or equipment or causing damage to equipment during erection of the piping. Every precaution shall be taken to keep the inside of the piping clean and free from dirt and debris.

11.7.8 The Vendor shall endeavor to erect prefabricated piping and pipe lines at the jobsite before the erection of field-fabricated piping and main electrical ducts.

11.7.9 Piping herein specified shall be erected in place and supported using both temporary supports and the final pipe line supports. End points shall be temporarily held in place if connecting nozzles are not ready for welding. All field welds shall be made as herein specified with the greatest care, so as to erect the piping plumb and true.

11.7.10 Authorization by the Engineer shall be obtained prior to welding or attaching temporary pipe supports, scaffolding, lugs, or structural shapes to the building steel or equipment. These items shall be removed when installation is complete. Temporary welds shall be removed by cutting. Breaking of welds is prohibited. Weld metal remaining on the steel surfaces shall be removed by grinding to produce a surface equal to the original surface in the immediate area. Undercutting of structural steel shall be repaired by welding and grinding smooth. No temporary welds are permitted on the surface of previously erected adjacent piping, pipe supports, or vessels. The surface of adjacent piping shall be protected from arc strikes and weld spatter.

11.7.11 Pliers or pipe wrenches shall not be used for tightening nuts or tubing connectors. Proper cutting, forming, and assembling tools shall be used in the erection of all tubing. No tubing shall be cut with a hacksaw.

11.7.12 Fiberglass reinforced plastic pipe shall be installed in accordance with the recommendations of the manufacturer.

11.7.13 Miscellaneous Piping

a. All miscellaneous piping shall by installed in a neat, rectangular form. Special attention shall be given to securing a neat appearance. All piping shall be installed perpendicular or parallel to the major equipment, building structure, and floor levels, except in special cases approved by the Owner.

b. All piping, including tubing shall be installed in accordance with the following requirements:

(1) Piping shall not be installed above, or within a horizontal distance of 900mm (3 feet) from, electrical equipment such as switchgear, switchboards, control panels, motor controls, contactors, communication equipment, batteries, battery chargers, and motor generators unless written consent of the Engineer is obtained. Improperly located piping shall be removed and relocated.

(2) All branch piping shall be provided with shutoff valves at the main headers.

(3) Valves shall be installed in such a manner that they can be operated from the main operating floors or platforms without the use of ladders or special operating devices.

(4) Piping shall be installed with a minimum of 2.3m (7'6") headroom over passageways and walkways.

(5) Pipe runs which require drainage shall be installed so that they pitch toward the point of drainage.

(6) Routing:

(a) Piping subject to freezing shall not be routed in the vicinity of large doors which could be open for moving of mobile equipment or maintenance.

(b) Routings shall be selected to avoid interference with planned and dimensioned locations for lighting fixtures, electrical trays, raceways, or conduit. The Vendor shall review the Engineer's Drawings for electrical construction to avoid such interferences before routing the piping. The electrical drawings will be available at the site.

(c) Sketches of the proposed routing of all piping not located on the drawings shall be submitted to the Owner. The Owner's acceptance of all routings shall be obtained before the piping is erected.

11.7.14 Temporary Piping and Equipment

All temporary piping, valves, fittings, and equipment required for construction cleaning, testing, and startup shall be provided. All equipment, piping, and valves of a temporary nature shall be installed in a safe and workmanlike manner. This shall include such lines as hydrostatic test lines, blanking fixtures required to seal off piping terminals for hydrostatic tests, and all other temporary lines required to successfully complete the Work. When the temporary piping is no longer required, the Vendor furnished temporary piping shall be dismantled and removed from the site.

11.7.15 Thermal Expansion

a. All piping shall be installed so that excessive or destructive expansion forces will not exist either in the cold condition or under conditions of maximum temperature. All bends, expansion joints, and special fittings necessary to provide proper expansion shall be provided.

b. Where expansion joints are used, anchors shall be installed as required to prevent damage from the forces generated by the fluid pressure of the line. Care must be taken in installing expansion joint anchors to make certain that full play is allowed at all times from maximum to minimum temperatures.

c. Expansion loops shall be provided in all small hot lines if required.

11.7.16 Welding

In addition to the welding requirements specified in Paragraph 11.3, the following requirements shall apply to field welded joints:

a. Prior to start of Work, all welding procedures shall be submitted to the Engineer for review.

b. All welding procedures, welders, and welding operators shall be qualified in accordance with applicable code requirements before the Work is started.

c. Records shall be maintained of the welding procedures and welder performance qualifications tests for Work done under this Specification. Certified copies of any of the records shall be furnished to the Owner upon request.

d. The quality of welding shall be tested by removal of a section of material containing a weld if requested by the Owner.

e. Backing rings shall not be used for butt welded joints. Machining or automatic flame cutting shall be used wherever possible. Hand flame cutting will be permitted only where machine cutting is impractical. All slag shall be removed from cuts and hand cut ends shall be ground smooth.

f. Pipe ends for socket welding or screwed connections shall be reamed to the full inside diameter to remove all burrs and obstructions.

11.7.17 Pipe Supports

a. Insofar as possible, pipe supports shall be installed so as to be vertical in the hot position of the piping. This shall be accomplished by offsetting the structural attachment from the pipe attachment when the piping is in the cold position.

b. The support assemblies shall not be used for the attachment of rigging to hoist the pipe into place. The piping shall be securely held in place by other means until the pipe support is completely assembled and attached to the pipe and building structures and the spring support set to take care of pipe sway. All rigging shall be removed so as not to impose a sudden load on the pipe support.

c. Spring supports shall not be used during hydrostatic testing of piping systems unless they are pinned or blocked to act as rigid supports. All piping having spring supports which are not pinned or blocked shall be held securely in place by other temporary means throughout the testing. After successfully passing the hydrostatic test, the pin or blocking device shall be removed.

d. After the piping has been completely installed, insulated, and filled with its normal operating medium, the springs shall be adjusted to the "C" or cold position. If necessary, the spring support shall be readjusted to the "H" or hot position after the line has been placed in service at its normal maximum operating temperature condition.

e. Welding of pipe supports to structural steel forming a part of the building supporting structure shall be accomplished by means of the electric metal arc method only, and the quality of welding shall be at least equivalent to that provided by the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings. The structural beams shall not be heated more than necessary to attach the support. All welds shall run parallel to the axis of the span and all welding shall be staggered with cooling allowed between subsequent deposits. No welding across beam flanges will be permitted. Loaded beams shall be unloaded or properly shored prior to field welding if 10 percent or more of the flange or web cross-sectional area would be heated to over 260°C (500°F) at any one time.

11.7.18 Cutting and Drilling Structures

a. All necessary drilling, cutting, and patching of structures required for proper installation of piping or bolts shall be done, but only with the consent of the Owner.

b. Holes shall not be cut in structural steel. Wherever possible, clamps shall be used for attaching erection rigging. Lugs may be welded to structural steel only with the consent of the Owner. Upon completion of the Work, the lugs shall be removed and the surfaces ground smooth.

c. All holes cut in grating or floor plate shall be banded and reinforced in accordance with the details which will be provided by the Engineer. Holes in floor plate shall be machine cut. Aluminum shall be used for banding aluminum plate and steel for steel grating or floor plate. After bands and reinforcements have been installed, all welds shall be ground smooth and weld area, bands, and reinforcements shall be painted to match adjacent surfaces. Two coats of zinc-rich galvanizing repair compound shall be applied to damaged areas of galvanized metals.

d. If normal grating support is removed by the cutting of holes, the Vendor shall add miscellaneous angles or other steel as required to properly support the grating.

e. Holes in concrete floors shall be provided with machine cut steel pipe sleeves in accordance with the details which will be provided by the Engineer.

f. All openings in concrete shall be made by core drilling, saws, or similar clean cutting equipment.

g. Where boxouts are left in concrete walls for the passage of pipes, the Vendor shall provide seal rings on the pipes and concrete fill the wall openings.

h. Holes cut in walls and roofs shall be complete with sleeves, collars, panel edge closures, reinforcing, flashing, and other accessories in accordance with the details which will be provided by the Engineer.

11.7.19 Equipment Connections

a. All piping, valves, and fittings furnished with the equipment shall be installed in accordance with this Specification.

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b. When attaching piping to equipment connections, the Vendor shall take special care that excessive stresses are not transmitted to and imposed upon such connections.

c. In the case of flanged connections, the piping shall be installed and supported so that accurate matching of bolt holes and uniform contact over the entire flange area are obtained prior to the installation of any flange bolts. Bolts shall be uniformly and carefully tightened to uniformly compress the gaskets and minimize flange stress.

d. Special precaution shall be taken in allowing for shrinkage during welding of nozzle connections so as not to impose excessive stresses on the equipment.

e. Fit-up of the flanges to equipment connections may be checked by the Owner after the bolts have been installed. Bolts shall be removed and replaced and new gaskets installed if requested by the Owner.

f. All equipment drains shall be piped to bell-ups or floor drains. Connections to bell-ups shall be calked unless otherwise directed by the Owner. Equipment oil drain points shall be provided with a bronze plug cock of the same size as the connection and a screwed cap or plug.

g. When welding to coated tanks, the Vendor shall wrap all tank connections and the immediate tank area. The wrappings shall be kept wet. The Vendor shall be responsible for protecting the tank coating during the welding operation.

h. After startup, if the connecting piping is exerting excessive strains on the equipment, the piping shall be altered by adjusting the piping supports, cutting and rewelding joints, and removing sections of piping, as necessary to eliminate the excessive strains. Piping which vibrates excessively shall be anchored or snubbed as necessary.

i. All flanged joints shall be checked and retightened after approximately 10 days of operation at normal operating temperatures.

11.7.20 Valve Installation

All valves shall be installed in accordance with the following:

a. Excessive piping strains and bending moments on valves, especially Class 150 large steel gate valves and butterfly valves, shall be avoided. Excessive strains and moments will result in distorted valve seats.

b. All steel globe valves shall be installed, wherever possible, so that closing the valve will relieve the pressure from the packing and permit repacking of the valve with the plant in normal operation. This shall be accomplished by installing the valves on all branch lines from a pressure source, with the pressure under the seat of the valve. In the case of a bypass line, or a line containing two or more globe valves connecting two pressure sources that cannot be taken out of service after the plant is in normal operation, the valve at each end of the line shall be installed in such a manner that the connecting line between the valves may be taken out of service for repacking of both valves when they are closed. Exceptions to the above requirements are those valves for which the manufacturer indicates the required direction of flow through the valve.

c. Valve discs and plugs shall be off the valve seats when welding valves into the lines.

d. Check valves shall not be installed in vertical runs of piping unless they are specifically designed for vertical operation.

11.7.21 Installation of Joint Unions

Unions shall be installed in all piping as required at equipment connections, as directed by the Owner, and in piping that contains instruments and special items such as meters, level controllers, float switches, and gage glasses, so that these items may be easily removed from the line. Every precaution shall be taken in installing unions so that the adjoining seating surfaces fit up squarely without forcing.

11.7.22 Flanged Connections

a. The faces of all flanges and gaskets shall be wiped clean when making flanged joints. The contact faces of all flanges shall meet squarely, and particular care shall be exercised in pulling up flanged joints to prevent overstressing of flanges or flange bolts.

b. The threads of all bolts shall be painted with a suitable thread lubricant before the joint is made. The lubricant shall be suitable for the operating temperatures involved.

11.7.23 Miscellaneous Small Connections

a. All openings for vents, drains, instruments, and other similar connections made after erection of the piping systems shall be drilled. No burning of such openings will be permitted. Any burrs remaining on the inside wall of the pipe after drilling shall be removed.

b. The low points of all water piping systems and other systems to be hydrostatically tested shall be provided with 19mm (3/4 inch) minimum screwed plugged openings as required to permit drainage of the systems.

c. The lubricating oil drains on all machinery shall be provided with a brass plug cock of the same size as the equipment connection and a screwed pipe plug before the installation of the oil.

11.7.24 Damage to Machined Surfaces

a. Special measures shall be taken to avoid damage to machined surfaces such as flange facings or pipe ends which have been prepared for welding. Any damage to welding ends shall be repaired prior to butting up for welding. If a flange facing is marred, scratched, or damaged to such an extent that, in the opinion of the Owner, the flange will be a cause for leakage, that flange shall be repaired or replaced.

b. When assembled equipment is being welded, separate ground leads shall be attached to the equipment, pipes, or components to prevent stray welding currents from arcing the internals of the equipment. Wherever possible, the ground lead shall be 2/0 cable or larger, directly and mechanically connected adjacent to the welding area, and returned directly to the welding power source.

11.7.25 Instrument and Control Piping

a. All instrument and control installation, tubing, and piping shall be done by workmen experienced in this type of work and in accordance with the recommendations of the equipment manufacturer.

b. Instruments shall be mounted and piped so that they function under the conditions of the FGD process.

c. Water and air purging of instrument connection piping shall be provided as required.

11.7.26 Pressure Connection Piping

a. Unless otherwise specified, pressure connections between instrument enclosure bulkhead fittings and primary shutoff valve(s) on the process piping or equipment shall be made with the materials specified in Paragraph 9.11.1, subject to the following:

(1) All stainless steel tubing shall be continuously supported.

(2) 13mm (1/2 inch) outside diameter stainless steel tubing shall be fully protected as well as continuously supported in trays where it is subject to mechanical damage.

(3) Capillary tubing shall be fully protected as well as fully supported for the full length of its run.

b. Pressure connecting piping shall preferably slope continuously from the process connection to the instrument, and all horizontal runs shall have a minimum slope of 42mm per meter (1/2 inch per foot). The preferred direction of slope is downward from process to instrument for liquid piping, and upward for flue gas and compressed air piping. The direction of slope may be reversed by use of appropriate vents or drain connections.

11.7.27 Flowmeter Piping

Flowmeter connecting piping or tubing shall slope continuously from the pressure taps or reservoirs to the meter or flow transmitter, and all horizontal runs shall have a minimum slope of 42mm per meter (1/2 inch per foot). Connecting piping shall be adequately supported so that no pockets are formed in either the hot or cold positions. If piping runs are subject to freezing, the high and low pressure runs shall be installed so that both runs can be insulated and freeze protected as a single unit. The preferred direction of slope is downward from process to instrument for liquid piping, and upward for flue gas and compressed air piping. The direction of slope of liquid piping may be reversed by use of a vent valve and riser in each line at the system high point, if the static pressure at the high point is positive under all conditions of operation. The direction of slope of flue gas and compressed air piping may be reversed by use of drain pots and drain valves at the system low point.

11.7.28 Tubing Installation

All instrument and control pneumatic tubing, supply air piping, and capillary tubing shall be installed in accordance with the following:

a. Special tools shall be used for all bending and forming operations. Tubing shall be carefully handled to avoid flat spots, kinks, and short bends. Any tubing so damaged shall be replaced. All piping and tubing shall be air blown after erection and before attachment to equipment at either end.

b. Care shall be exercised in the installation of tubing to assure a neat job and ease of maintenance and trouble-shooting. Tubing runs shall be absolutely straight. Both horizontal and vertical runs of light drawn temper copper tubing and stainless steel tubing shall be continuously supported in solid aluminum tubing supports. Lashing or taping to the building structure will not be permitted. Parallel runs of individual tubes shall be run in one plane and uniformly spaced.

c. Tubing runs 20mm (3/4 inch) outside diameter and smaller shall be continuous from panel to panel or junction box. All connections in tubing 20mm (3/4 inch) outside diameter and smaller shall be made only by use of bite type tubing fittings. Annealed soft temper and light drawn tubing runs longer than 15.2m (50 feet) may use bite type couplings to splice the tubing at intermediate points; however, such tubing runs shall contain not more than one section less than 15.2m (50 feet) long. Splice couplings shall be located to facilitate checking and correction of leaks. Solder or braze joints will not be permitted under any circumstances.

d. Type K drawn type tubing 25mm (1 inch) outside diameter and larger shall be connected by means of braze joint fittings. Brazing shall be accomplished in accordance with the requirements specified in ANSI B31.1. Brazing shall be performed in accordance with written procedures and by brazers who have been previously qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. Brazing filler metals shall be either silver or copper-phosphorous alloys.

e. Tubing supports shall be complete with fittings as manufactured by James C. White Company, Greenville, South Carolina, or Engineer approved equal. The tubes shall be attached to the supports using stainless steel yoke clamps and bolts or plastic sleeved J-bolts. The supports shall be rigidly attached to the building structure using screws, bolts, clips, or hangers.

11.7.29 Tubing Cable Installation

a. Tubing cable runs shall be continuous from termination to termination.

b. Tubing cable shall be installed with both horizontal and vertical runs continuously supported. Except as otherwise specified, tubing cable supports shall be aluminum with long radius fittings, all as manufactured by James C. White Company, Greenville, South Carolina, or Engineer approved equal.

c. Tubing cable shall be laid or pulled into supports so that neither the supports nor the cables are damaged. Tubing cable shall lie parallel and shall be secured to the larger trays by tying with heavy waxed cord. Tubing cable shall be attached to the other supports by stainless steel yoke clamps and bolts or plastic sleeved J-bolts. Provisions shall be made for temperature changes in accordance with the tubing cable manufacturer's recommendations.

d. Equipment and procedures used in pulling tubing cable shall be similar to those used for pulling electrical cable. Care shall be exercised to prevent excessive strain on the cable and damage to the cable jacket. The cable manufacturer's recommended minimum bending radius of the cable shall not be exceeded. Cable grips shall have a swivel connector to prevent twisting under strain and upon completion of pulling, the grip area plus an additional 150mm (6 inches) of cable shall be discarded. The cable shall be examined after installation and any damage to the sheath of the cable will be cause for rejection.

11.7.30 Air Supplies

a. All air supply headers, branch air supply headers, and miscellaneous connecting tubing for air supplies to transmitters, controllers, control loop accessories, control valves, control drives, electric-to-pneumatic converters, instrument enclosures, and panel-mounted pneumatic devices shall be furnished and installed. This shall include tapping the main air supply headers, installing a shutoff valve for each branch header and each individual instrument air supply, installing the branch air supply lines, and installing a Fisher 67 FR pressure regulator for each device requiring air that is not located in an instrument enclosure.

b. Each air supply header shall be run from a shutoff valve on a Owner furnished air receiver located in the absorber area.

11.7.31 Signal Tubing

All pneumatic signal tubing shall be furnished and installed. Junction boxes and tubing cable may be furnished and installed in lieu of individual runs where it is advantageous to do so.

11.7.32 Flexible Hoses

a. Flexible hoses shall be furnished and installed on all air supply and signal lines for control valves and all pneumatic control and instrumentation devices which are not mounted on the building structure, including controllers installed on tanks or pressure vessel instrumentation columns, and controllers installed on valve yokes. The flexible hose shall be Parker Type 221, 6mm (1/4 inch) rubber hose with Buna N liner, steel wire braid reinforcement, and a rubber outer covering, complete with Parker Series 22 brass fittings. One end shall have 6mm (1/4 inch) male pipe threads. The opposite end shall have a JIC 37 degree swivel fitting and a brass JIC 37 degree flare to 6mm (1/4 inch) male pipe connector. Each hose shall be 900mm (3 feet) long.

b. End connections of flexible hoses shall be supported and affixed so that any relative movement between the pneumatic device and the building structure is absorbed by the flexible hose itself, and not by the tubing to which it is connected.

11.7.33 Tubing Trays

Trays for support of tubing cable runs shall be furnished and installed as follows:

a. Trays and all tray fittings required for the FGD system shall be manufactured by one manufacturer. The trays are indicated on the Drawings. The trays shall be trough type, manufactured by one of the following:

(1) Husky/Burndy

(2) Globe Cable Strut

(3) P-W Industries, Inc.

(4) T. J. Cope

(5) Chalfant

(6) The Binkley Company

b. All trays shall be steel galvanized after fabrication. Hanger clamps, fastening hardware, and pins shall be of corrosion resistant metals. Steel accessories shall be hot-dip galvanized after fabrication. The trays shall have bottom slots not more than 100mm (4 inches) wide.

c. Continuous rigid trays shall be formed of one piece or shall have bottom members formed of one piece and welded or upset swaged to channel type side rails. The trays shall have the depths indicated on the Drawings.

d. The entire tray system shall be designed and constructed so that no part of the completed tray installation will exceed the following deflection limits:

(1) DEFLECTION OF TRANSVERSE STRUT

Tray Width	Maximum Deflection Based on 150 Pounds/Linear Foot, Uniformly Distributed	
mm (inches)	mm	(inch)
(a) 150 (6)	.15	(0.006)
(b) 300 (12)	.05	(0.020)
(c) 450 (18)	1.8m	(0.070)
(d) 600 (24)	4.1mm	(0.160)

(2) DEFLECTION OF LONGITUDINAL MEMBER

Unsupported Span	Weight of Conductor/Foot of Tray		Maximum Deflection*
m (feet)	kg/m (pounds/linear foot)		mm(inch)
1.5 (5)	223	(150)	8.9 (0.35)

*Tested as free or simple beam.

e. Covers:

(1) All vertical trays shall be furnished with ventilated covers. The top tray of horizontal runs located under grating floor or insulated pipe shall be furnished with solid covers.

(2) All covers shall be of the same metal as the tray with which they are used. They shall be of the formed type with the edges turned to provide rigidity. Cover straps shall be furnished as required.

f. Hanger clamps:

Hanger clamps, fabricated especially for the trays with which they are associated, shall be furnished as part of the tray system. The clamps shall be designed for use with 13mm (1/2 inch) hanger rods and fasteners. Clamps shall be of a design that does not use cross members under the supports and shall be constructed so that hanger rods do not extend below the tray bottom.

g. Tray installation:

Tubing cable trays shall be installed in accordance with the tray manufacturer's instructions and the following:

(1) The Vendor shall cut the trays to the length required. The trays shall be cut with saws and all surfaces over which the conductors and cables will be laid shall be ground or filed to remove any sharp edges which could cause damage to the tubing cable jacket either during installation or in normal service.

(2) Where layers of trays are staggered, or are of different widths, and where they cannot be supported on wall brackets, they shall be supported with hanger rods and cross members assembled from Unistrut or Kindorf materials.

(3) Cable tray covers shall be notched to provide clearance around clamps and supports as required for proper fit. Notches shall be cut by sawing and the edges ground or filed smooth.

(4) Cable trays shall be bracket supported from walls or columns and hangers supported from overhead structural members at intervals not exceeding 2.4m (8 feet), measured along tray centerlines between supports.

(5) Supports on concrete or masonry shall be secured with concrete anchors. Clamps shall be used to secure support to structural steel. Hanger rod support shall include two rods, one on either side of the tray. Nuts shall be fully threaded on the rods and not more than five rod threads shall be allowed to project below the lower nut.

h. Rainhoods and flashing:

(1) Pipes passing through sleeves in the roof or through building walls shall be provided with rainhoods and weatherproof flashing.

(2) Details of rainhoods and flashing design shall be submitted to the Engineer for acceptance.

11.7.33 Final Adjustment:

After the initial operation of the system, all flange bolts shall be checked for tightness, and all hangers readjusted.

12.0 PERSONNEL REQUIREMENTS

12.1 START-UP SUPERVISION

12.1.1 The Vendor shall provide the services of a start-up engineer who shall be present at the jobsite before the equipment is placed in service. The start-up engineer and the erection superintendent may be one and the same person.

12.1.2 The start-up engineer shall be responsible for the overall start-up of the FGD system and system components. The start-up engineer shall also be responsible for reporting the status of the start-up to the Engineer.

12.1.3 In addition, the start-up engineer shall perform as a minimum the following duties:

a. Supervise start-up of the FGD system.

b. Supervise the calibration of all feeders and control instrumentation, and check and record time intervals in the preparation of the reagent slurry, slurry storage, and the response time of the FGD system to changes in flue gas conditions.

c. Instruct the Owner's personnel in the start-up and operation of the equipment. The start-up engineer shall be part of the Vendor's training staff and shall remain on site for the duration of the one year warranty period.

12.2 WELDERS

12.2.1 All welders shall be qualified in accordance with the Performance Qualification Specification prescribed by Section IX of the ASME Boiler and Pressure Vessel Code.

12.2.2 Welders shall be previously qualified by passing the tests prescribed in the AWS Standard Qualification Procedure, or by passing other qualification tests as the Engineer may approve. Welders shall have been tested within the past 6 months and their qualification shall be considered as remaining effective indefinitely unless the welder is not engaged in a given process of welding for which he is qualified for a period exceeding 6 months.

13.0 INSPECTIONS AND TESTS

13.1 Materials and equipment tests shall be made by the Vendor in accordance with code requirements, local and state regulations, and the following:

13.1.1 The Vendor shall be fully responsible for setting up and conducting shop tests of equipment to establish compliance with this Specification and all applicable codes and standards.

13.1.2 Prior to the start of fabrication, the Owner shall be given a shop fabrication and field-erection schedule with dates of all proposed inspections and tests to be conducted by the Vendor. The Owner shall be notified at least 1 week in advance of those inspections and tests that he requests to observe.

13.1.3 The test facilities shall be subject to prior inspection by the Owner.

13.1.4 All materials, equipment, tools, instruments, blocking, bracing, bulkheads, blanking plates, and all labor required to complete the tests shall be furnished.

13.1.5 Personnel performing the tests shall be qualified and experienced. Tests shall be performed as many times as necessary to assure proper quality of materials and workmanship. If any tests reveal unsatisfactory materials or workmanship, such materials or installation shall be repaired or replaced to the satisfaction of the Owner.

13.1.6 The Vendor shall be responsible for proper protection of equipment to prevent damage during testing and shall bear all repair or replacement cost of any item damaged as a direct or indirect result of the tests.

13.2 The following inspections and tests shall be performed:

13.2.1 Gas Envelope Leak Tests

a. After erection of the equipment, leak tests shall be performed to prove the gastightness of the absorber modules and ductwork.

b. Testing shall be by one or more of the following methods:

(1) Smoke bomb test.

(2) Vacuum box test.

(3) Air pressure sound test.

(4) Liquid penetrant through wall test.

13.2.2 Checkout and Trial Operation

a. After erection, all equipment shall be checked out and trial operated.

b. The Owner shall be notified in advance of all equipment checkouts, trial operation activities, and tests so that a designated representative may be present to witness the operations.

c. All equipment shall be cleaned. Rotating machinery shall be lubricated, checked for freedom of movement by hand if possible, and all prerequisite operating conditions established before the application of motive power. All bearings shall be inspected by the Vendor prior to final alignment and again prior to initial rotation checks of the equipment to ensure bearings contain no foreign material and to ensure that no abnormal conditions exist. A copy of the bearing check report shall be given to the Owner. Equipment subject to pressure shall be checked for leakage.

13.2.3 Testing of Dampers

a. The Owner and Engineer shall be notified in writing at least 2 weeks in advance so that they may have a representative present. The Vendor shall not ship the dampers until the test has been successfully completed and witnessed or until formal waiver of such test has been received by the damper manufacturer from the Engineer.

b. The Vendor shall perform a complete leakage, deflection, and pressure load test to be witnessed by the Engineer. This test shall be performed on each of the isolation dampers and the bypass dampers and shall illustrate the amount of leakage through the closed damper under job conditions of pressure and temperature, as well as the amount of the blade deflection.

c. Shop performance test:

(1) Each damper shall be subjected to the maximum system differential static pressure while the temperature of the air blowing toward the damper is raised from ambient to 149°C (300°F) at a rate of increase of 14°C (25°F) per minute. At no time during the test shall leakage exceed specified limits. The damper shall remain closed until the temperature has reached the maximum test temperature of 260°C (500°F) and then shall be operated at a minimum of ten complete open/shut cycles. This operational test shall be performed with the operators and blowers furnished with each damper as part of this Specification. Failure of the damper to operate freely and easily, or leakage in excess of specified limits during this temperature and pressure test, will result in rejection of the damper.

(2) Each damper shall be inspected during and after the pressure test to determine the following:

(a) The extent to which blades, frames, and seals have been distorted or deflected. Deflections shall be measured and recorded.

(b) Whether the physical change or distortion that occurs has any effect on the operation of the damper under full load pressure.

d. Test chamber shall be airtight and shall not leak to ambient under test conditions.

13.2.4 Testing of Pumps

a. Slurry and water pumps shall be shop tested.

b. The pump casing shall be hydrostatically tested at 150 percent of the pump shutoff head.

13.2.5 Testing of Tanks

a. Tanks shall be tested in accordance with AWWA D100.

b. Welded joints shall be tested in accordance with the requirements stated in API Standard 650, Appendix D, and as specified herein. The Owner's inspector will use API Standard 650, Appendix D, as a guide. He will be the sole judge of acceptability of welds and welding repairs.

c. Radiographic examinations:

The welded joints in the shells of the tanks shall be radiographically inspected. The location of the required spot radiographs shall be as determined by the Owner's inspector and shall be, insofar as practicable, uniformly distributed. The number of spot radiographic tests required shall be in accordance with API Standard 650. Results of radiographic tests shall be submitted to the Owner's inspector for acceptance and defective welds shall be repaired as directed by the inspector.

d. Tank bottom testing:

After completion of all welding of the bottom of the tank, a vacuum shall be applied to the joints and the joints shall be tested for leaks using soapsuds, linseed oil, or other material acceptable to the Owner's inspector.

e. Tank shell testing:

After completion of the tank and before any external piping has been connected, the tank shall be filled with water and all submerged joints inspected. Any leaking joints shall be rewelded after dropping the water level to at least .3m (1 foot) below the point being repaired. The test shall be repeated until all joints are tight.

f. The Vendor shall furnish all piping, valves, hoses, and other equipment required to fill tanks for the tank shell tests and to dispose of water following the tests. The Owner's approval shall be obtained prior to filling tanks. The Owner's approval shall also be obtained for the time and method of discharging water from the tanks following the tests.

13.2.6 Testing of Valves and Valve Actuators

a. Steel valves shall be hydrostatically tested and given a seat leakage test in accordance with MSS-SP-61, "Pressure Testing of Steel Valves," as applicable. When testing across-the-seat, the closure force shall not exceed 350 Newtons (80 pounds) force applied at the rim of the hand-wheel, and test hold times shall be a minimum of 5 minutes. A back seat leakage test shall be performed in accordance with MSS-SP-61 with packing removed. No leakage is allowed with a minimum test hold time of 5 minutes. The shell test shall be performed with the backseat removed from contact and the packing installed so the entire stuffing box will be subject to the hydrostatic pressure. Power actuated valves shall be tested across-the-seat as required for manual valves except the operating force shall be the normal force of the actuator after the torque and limit switch settings have been made.

b. Cast iron valves shall be hydrostically tested in accordance with applicable provisions of MSS SP-70.

c. Pneumatic valve actuators:

An air leakage test shall be performed on the diaphragm-to-case assembly at a pressure equal to 1 1/4 times the maximum air operating pressure. No visible leakage shall be permitted over a 3 minute interval as determined by using a soap lather, soap bubble, or water submergence test.

13.2.7 Testing of Piping

a. Piping materials and systems covered by the Specification shall conform to the testing requirements of the applicable codes and specific inspection requirements as defined in Paragraph 9.11.1.

b. The Vendor shall be responsible for nondestructive examination, inspection, and testing of the welds, piping, and piping component materials covered under this Specification. Radiographic films, certificates, records, reports, and so forth, for the Work performed in accordance with ANSI B31.1 shall be kept on file by the Vendor for the duration of the Contract. The Engineer shall have access to these files for inspection. Upon completion of the Contract, these records shall be submitted to the Engineer.

c. Upon completion of installation, the following tests shall be performed:

(1) Hydrostatic tests:

(a) Nondestructive examinations shall be performed in accordance with ANSI B31.1, including hydrostatic testing at 1.5 design pressure on the applicable flow diagrams unless stated otherwise in Paragraph 9.11.1. The Vendor shall furnish all temporary pipe, fittings, and pumps required to perform hydrostatic tests.

(b) Pipe hangers, snubbers, and restraints shall be blocked, disconnected, or pinned as required prior to hydrostatic testing, or cleaning, and shall be restored to operating condition following the test.

(c) Components shall be isolated and openings shall be plugged as required to accomplish the required hydrostatic tests and to prevent overpressurizing connecting piping.

(d) Fabricated assemblies are <u>not</u> required to be hydrostatically tested in the factory.

(e) All buried piping shall be hydrostatically tested prior to backfilling of the trench.

(2) Ultrasonic test:

Each length of ASTM A 335 alloy pipe required for the piping specified herein, sized 150mm (6 inches) and over shall be 100 percent ultrasonic inspected for defects. Any piece of pipe having a defect determined by this method shall be further tested to determine the extent of the defect. Pipe material found to be defective shall be repaired where possible, or rejected. No piece containing such a defect and repaired by the producer shall be accepted by the Vendor without the Engineer's approval.

(3) Radiograph test:

(a) All cast steel fittings shall be 100 percent radiographed and the weld ends of such fittings shall satisfactorily pass dye penetrant inspection. The Engineer shall be given all documentation confirming that the above has been successfully completed.

(b) All shop and field welds of ASTM A335 and ASTM A106 Grade C shall be 100 percent radiographed.

(4) Pressure testing:

All piping shall be pressure tested in accordance with the following:

(a) The valves shall be tested along with the piping. Any blind flanges or removable plugs required for piping and for openings not closed by the valves shall be furnished.

(b) The pressurization equipment, including water piping from the supply, shall be furnished by the Vendor.

(c) The water remaining in the piping after testing shall be kept from freezing until commercial operation of the unit.

(d) Except as otherwise specified herein for "air test", all pressure testing shall be done hydrostatically with cold water. The test pressure shall be 1 1/2 times the design pressure rating of the piping and shall be applied for at least 1 hour. Leaks shall be repaired and the system retested until accepted by the Owner as satisfactory.

(e) All lubricating oil piping and air piping shall be given an air test.

(f) The test pressure shall not be applied until the components being hydrostatically tested and the pressurizing medium are approximately at the same temperature. All expansion joint control rods and attachments shall be properly adjusted before application of test pressure.

(g) Before the test pressure is applied, all air shall be expelled from the piping being hydrostatically tested. The Vendor, at the direction of the Owner, shall make the required taps at the high points of the piping systems and shall plug the taps upon completion of the testing.

(h) Lines to be air tested shall be given an application of a leak detection fluid which shall reveal the presence of leaks by easily visible means, such as bubble formation.

(i) All end closures shall be left in place to prevent foreign materials from entering the piping during other Work.

(5) Operating tests:

All completed Work shall be tested by an operating test under normal service conditions. Upon completion of each operating test, the Vendor shall correct loose or otherwise faulty hangers and shall apply such devices as may be required to eliminate sway or vibration of piping and/or supports.

d. Inspection:

All ferritic alloy and austenitic stainless steel material, welded plate material, and special wall seamless carbon steel material purchased by the Vendor shall be subject to visual inspection and approval at the pipe mill by the Owner. All pipe fabricated or welded under this Specification shall be subject to visual inspection and approval by the Owner. Any inspection by the Owner shall not be considered as a waiver of any warranty or other rights. The Owner shall have free access to the pipe mills and to the Vendor's shop and field facilities for inspection of all fabrication and welding and for observing all inspections and tests performed by the Vendor. All tests required for certification shall be made at the expense of the Vendor.

13.2.8 <u>Testing of Welds</u>

a. Testing of shop welds shall be as follows:

(1) The Owner or the Owner's representative will make regular vists to the Vendor's facilities for the purpose of inspecting welding and welding records.

(2) The Vendor shall visually inspect all welds and shall correct all defective welds in accordance with AWS D1.1. Personnel performing visual inspection of welds shall be qualified and certified in accordance with AWS QC1, "Standard for Qualification and Certification of Welding Inspectors".

(3) Nondestructive tests shall be conducted by the Vendor as specified herein on the welded portions of equipment, ductwork, and devices fabricated from plate and structural shapes.

(4) The Owner or his representative may require additional welding tests in addition to those specified herein. The additional tests will be paid for by the Owner, if no weld defects are found. The additional tests shall be at the Vendor's expense if weld defects are found. If the testing is by radiography, the acceptance shall be in accordance with AWS D1.1 requirements.

(5) The Vendor shall perform a leak test upon equipment after installation in the field. Shop welds which leak shall be repaired by the Vendor.

(6) Butt welded joints:

Shop butt welded joints, without regard to the number of welders or welding operators working thereon, shall be examined by radiographic inspection. One spot, selected at random by the Owner or his representative from a 3 meters (10 foot) section, shall be examined. If no defects are found, one additional spot per 61 meters (200 feet) of weld shall be examined. If defects are found in the tests, the tests shall be conducted at the rate of one spot per 3 meters (10 feet) until no defects are found. Thereafter, tests shall be conducted at the rate of one spot per 61 meters (200 feet) of weld. The testing shall meet the inspection and qualification requirements of AWS D.1.1. All unacceptable defects found by radiography shall be removed, rewelded, and reinspected by radiography.

(7) Sealing, corner, and lap joints:

All sealing, corner, and lap joints shall be randomly inspected by .3m (1 foot) samples of magnetic particle inspection. The total length of the random inspection shall be at least one percent of the total length of welding, and at least one inspection per subassembly shall be performed. Defects shall be repaired and adjustments made to welding procedures and methods in order to prevent further defects. Magnetic particle inspections shall conform to the inspection and qualification requirements of the AWS D1.1.

(8) Structural fillet welds:

Fifteen shear-loaded end shop connections will be selected at random by the Owner or his representative for testing. Connections selected shall receive 100 percent magnetic particle inspection. The testing shall meet the qualifications and inspection requirements of AWS D1.1. If none of the 15 connections inspected require welding repairs, inspection shall be continued randomly at the rate of one inspection per 50 connections produced. If welding repairs are required due to defects disclosed, then testing shall be continued for every connection until 15 consecutive connections are found to be nondefective. Thereafter, testing shall be at the rate of one test per 50 connections.

b. Testing of field welds shall be as follows:

(1) The Owner or the Owner's representative will make regular inspections of welding and welding records.

(2) The Vendor shall visually inspect all welds and shall correct all defective welds in accordance with AWS D1.1. Personnel performing visual inspection of welds shall be qualified and certified in accordance with AWS QC1, "Standard for Qualification and Certification of Welding Inspectors".

(3) Nondestructive tests shall be conducted by the Vendor as specified herein on the welded portions of equipment, ductwork, and devices fabricated from plate and structural shapes.

(4) The Owner or his representative may require additional welding tests in addition to those specified herein. The additional tests will be paid for by the Owner if no weld defects are found. The additional tests shall be at the Vendor's expense if welded defects are found. If the testing is by radiography, the acceptance shall be in accordance with AWS D1.1 requirements.

(5) Structural fillet welds:

Fifteen sheer-loaded end field connections will be selected at random by the Owner or his representative for testing. Connections selected shall receive 100 percent magnetic particle inspection. The test-

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ing shall meet the qualifications and inspection requirements of AWS D1.1. If none of the 15 connections inspected require welding repairs, inspection shall be continued randomly at the rate of one inspection per 50 connections produced. If welding repairs are required due to defects disclosed, then testing shall be continued for every connection until 15 consecutive connections are found to be nondefective. Thereafter, testing shall be at the rate of one test per 50 connections.

(6) Butt welded joints:

Field butt welded joints, without regard to the number of welders or welding operators working thereon, shall be examined by radiographic inspection. One spot, selected at random by the Owner or his representative from a 3 meters (10 foot) section shall be examined. If no defects are found, one additional spot per 61 meters (200 feet) of weld shall be examined. If defects are found in the tests, the tests shall be conducted at the rate of one spot per 3 meters (10 feet) until no defects are found. Thereafter, tests shall be conducted at the rate of one spot per 61 meters (200 feet) of weld. The testing shall meet the inspection and qualification requirements of AWS D1.1. All unacceptable defects found by radiography shall be removed, rewelded, and reinspected by radiography.

(7) Sealing, corner, and lap joints:

All field-welded sealing, corner, and lap joints shall be randomly inspected by .3 meters (1 foot) samples of magnetic particle inspection. The total length of the random inspection shall be at least one percent of the total length of welding. Defects shall be repaired and adjustments made to welding procedures and methods in order to prevent further defects. The magnetic particle inspections shall conform to the inspection and qualification requirements of AWS D1.1.

13.2.9 Testing of the Control System

The Vendor shall factory test the control system.

13.2.10 Testing of the Electrical System

The following electrical tests and checks shall be performed by the Vendor and may be witnessed by the Owner:

a. All circuits and equipment, except instrumentation and control panels which could be damaged by this test, shall be meggered and the reading recorded.

b. When received, all motors, including those shipped with driven equipment, shall be meggered and the reading recorded.

c. All systems shall be checked out and tested to make certain that operation of these systems conforms to the design drawings.

d. Phase rotation and voltage of power interconnections shall be checked.

e. All fuse and circuit breaker ratings are as specified herein or as shown on the Drawings.

f. All metering circuits are wired correctly.

g. Control switch boards are installed, connected, clean, and ready for operation.

h. All relay shipping blocks are removed.

i. Protective relays are properly set and adjusted.

j. All motors shall be checked for rotation, properly lubricated, tested, clean, and ready for operation, with driven equipment connected or safely disconnected as required.

k. Valve operators and other limit switches are correctly connected and adjusted.

l. Operation of building service equipment, including unit heaters, shall be checked.

m. Insulated bearings shall be checked.

13.2.11 Testing of Structural Steel and Other Building Materials

a. Mill tests for structural steel materials shall be in accordance with the AISC Code of Standard Practice (latest edition).

b. Testing of all other building materials shall be in accordance with applicable ASTM requirements.

13.2.12 Performance Testing

a. Performance Test I:

(1) After the 90 days of operation, a performance test shall be conducted to establish that the FGD system meets the guarantees of performance as specified in Paragraph 8.0.

(2) The test equipment and procedures for meeting emission guarantees shall be in accordance with EPA Methods 5 and 6 as stated in the Federal Register, Vol. 36, No. 247, "Standard of Performance for New Stationary Sources" and as in effect at the time of the bid. The testing shall be conducted by a third party selected by Owner and Engineer and agreed to by the Vendor.

(3) All costs of the performance tests, exclusive of power, water and reactant shall be borne by the Vendor. If the FGD system fails, the Vendor shall modify, redesign, and retest the FGD system to meet the performance guarantees at the earliest possible time at his own expense.

b. Performance Test II:

(1) Within 60 days after the successful completion of Performance Test I and the Reliability Test, another performance test shall be conducted to establish the guarantees of performance as specified in Paragraph 8.0.

(2) All costs of Performance Test II will be borne by the Owner. The Vendor shall modify, redesign, and retest the FGD system to meet the performance guarantees if the FGD system fails to meet all the specified guarantees.

(3) The test procedures and methods for establishing system performance and guarantees shall be as set forth under Performance Test I.

14.0 CLEANING, CORROSION PROTECTION, AND COATING

14.1 All equipment shall be cleaned of all sand, dirt, and other foreign materials immediately after removal from storage and before the equipment is brought to the installation site. All piping and tubes shall be air blown.

14.2 Machine finished surfaces, polished surfaces, or other bare metal surfaces which are not to be painted, such as machinery shafts and couplings shall be provided temporary protection during storage and construction periods by a coating of suitable nondrying, oily, rust preventive compound.

14.3 REPAIR OF DAMAGED PAINT

14.3.1 After erection of the equipment, all exposed shop prime and finish painted surfaces which have been damaged, and all previously unprimed surfaces, shall be repaired by repainting. Previously unprimed exposed surfaces shall be prime painted.

14.3.2 Before application of paint, all surfaces to be painted shall be thoroughly cleaned of all dirt, rust, scale, grease, oil, and other foreign materials by wire brushing, scraping, or sandblasting.

14.3.3 Prime painting shall consist of one brush-applied coat of primer of a type which matches the shop primer paint used.

14.3.4 Damaged finish painted surfaces shall be repaired with paint equivalent to the shop paint.

14.3.5 All surfaces of aluminum jackets which will be in contact with steel or cast iron shall be thoroughly prime painted with an alkyd resin zinc chromate primer.

14.3.6 Areas, tanks, or equipment that will be inaccessible after complete erection of the equipment shall be finish painted. The paint manufacturer and color will be determined by the Owner.

14.4 DAMPERS

All damper operators, seal air valve operators, motors, seal air fans, and limit switches shall be primed and painted in accordance with the equipment manufacturer's standard. All exposed machined surfaces shall be protected with a suitable rust preventive compound.

14.5 TANKS

Tanks shall be painted in accordance with API 650 and the following:

14.5.1 All testing and repair work shall be accepted by the Owner before blasting or painting is started.

14.5.2 Surface Preparation and Cleaning

a. All rough or irregular welds and plate edges shall be ground as required to eliminate sharp edges. All weld spatter shall be removed. Lubricants shall be removed from all surfaces with a suitable solvent.

b. The underside of the tank bottom plates shall be cleaned in accordance with Steel Structures Painting Council Specification SSPC-SP 6 "Commercial Blast Cleaning". All interior surfaces shall be blast cleaned in accordance with SSPC-SP 5 "Blast Cleaning to White Metal" using silica sand of 16 to 30 mesh size. Blasted surfaces shall be thoroughly cleaned and coated the same day they are blasted.

14.5.3 Tank Bottom Coating

After the tank bottom and first shell course have been completed and tested, the underside of the bottom plates of each tank shall be prepared as specified above. One coat of Koppers Bitumastic Mill Undercoat followed by two coats of Koppers Bitumastic No. 50 shall then be applied in accordance with the coating manufacturer's recommendations.

14.5.4 Tank Interior Surfaces

If the contents of the tank have a pH of 7.0 or less, the tank shall be painted or lined with a suitable corrosion or erosion resistant material.

14.5.5 Tank Exterior Surfaces

All tank exterior surfaces, except for the underside of the bottom plates, will be painted by others. The underside of the bottom plates shall be coated as specified herein.

14.5.6 All tanks installed by the Vendor shall be flushed and internally cleaned by the Vendor prior to being put into operation.

14.6 PUMPS

Pumps shall be shop cleaned and painted with the manufacturer's standard finish.

14.7 OXIDIZING AIR COMPRESSORS

Exposed surfaces shall be prime and finish painted with the manufacturer's standard paint as appropriate for the application.

14.8 PIPING

14.8.1 <u>Cleaning</u>

a. The inside and outside surfaces of all pipe, tubing, valves, and fittings shall be cleaned of all dirt, sand, loose mill scale, and other foreign materials immediately after removal from storage and before erection. All lines shall be thoroughly flushed or blown before being placed in service. All compressed air lines shall be air blown.

b. Care shall be taken during fabrication operations as well as shipping, loading and unloading, handling, storage, and erection of the pipes, to keep internal portions of the pipe clean. Following hot forming fabrication and heat treatment or bending, the inside of each piece of pipe shall be cleaned internally by shot or grit blasting to leave the pipe free of all sand, scale, or other foreign matter. After other fabrication operations, the pieces shall be cleaned of all sand, scale, or other foreign matter by using an air driven turbine cleaner. Care shall be taken to keep weld areas free of contaminants during welding operations.

14.8.2 Painting

a. External nonmachined, carbon steel surfaces of piping shall be painted with one coat of a lead base red primer. The dry film thickness shall be .1mm (4 mils) minimum. External nonmachined surfaces of chrome-moly piping shall be weather protected with mill pipe oil.

b. The shop paint shall be mixed and applied in accordance with the Steel Structures Painting Council Paint Specification SSPC PA 1, "Shop, Field and Maintenance Painting".

c. Paint shall be omitted at all areas of field welding. All contact surfaces of field bolted connections shall be painted.

d. All threads shall be protected with a heavy coating of grease (No-Oxide A, or equal).

e. Stainless steel and other corrosion-resisting surfaces shall not be painted.

f. Field paint will be by others.

14.8.3 Coating

The external surfaces of all buried steel pipe shall be shop coated with hot coal tar enamel and asbestos felt wrap in accordance with AWWA Specification C203. Field welded joints shall be coated and wrapped with comparable materials after hydrostatic testing and prior to backfilling.

14.9 AGITATORS

Exposed surfaces which are not rubber covered shall be prime and finish painted with the manufacturer's standard paint as appropriate for the application.

14.10 ELEVATOR

All exposed metal work shall be given two coats of good quality preservative paint.

14.11 STRUCTURAL AND MISCELLANEOUS STEEL

14.11.1 Surface Preparation

Steel surfaces shall be dry and clean in accordance with the following requirements:

a. All grease, oil, and contaminants shall be removed in accordance with SSPC-SP 1.

b. All weld spatter shall be removed and all burrs on cut edges and rough welds shall be ground to comply with the requirements of AWS.

c. All surfaces shall be blasted clean to near white metal in accordance with SSPC-SP 6. Profile depth shall be .038 to .064mm (1.5 to 2.5 mils.)

14.11.2 Shop Prime Coat

a. Blast-cleaned surfaces shall be primed before any rust bloom forms.

b. One coat, dry film thickness of 3 mils, of any of the following inorganic, zinc-rich primers shall be applied:

(1) Carboline Company's "Carbo-Zinc 11".

(2) Cook Paint & Varnish Company's "Galva-Pac 101".

(3) Mobil Chemical Company's "Mobilzinc 7, 13-F-12".

(4) Tnemec Company, Inc., "90-92E Tnemezinc".

c. Primer shall be applied in strict accordance with the manufacturer's recommendations.

d. Primer shall be applied to all steel surfaces except the areas within 50mm (2 inches) of field welds and surfaces specified to be hot-dip galvanized.

14.11.3 Field Spot Painting

a. Paint shall cover all blemished surfaces, bolts, welds, and the unpainted surfaces at field-welded connections.

b. An epoxy, organic zinc-rich primer by the same manufacturer and of the same dry film thickness at the shop prime coat shall be used.

c. Touchup paint shall be applied immediately after power sanding the surface in accordance with SSPC-SP 3 to remove weld slag, splatter burrs, and other foreign materials.

d. The shop prime coat shall be maintained or replaced on all steel surfaces where required for the duration of the Contract, unless the steel is turned over to the Owner's painting contractor prior to that time.

e. Galvanized material furnished under this contract shall have all welds, burrs and other blemishes repaired by touching-up with an organic zinc-rich coating. Carboline CZ676, Cook 920-A-171, or Tnemec 90-93, .076mm (3 mils) dry film thickness, shall be applied. The manufacturer's written instructions for surface preparation and application shall be followed.

14.11.4 All unfinished miscellaneous steel furnished under this Contract for support of piping shall be thoroughly cleaned of dirt, rust, or mill scale in accordance with Steel Structures Painting Council Specification SSPC-SP 7, "Brush-off Blast Cleaning" and shall receive one .076mm (3 mil) dry film thick shop coat of standard red oxide primer.

14.11.5 Interior grating treads and landings shall be painted with Blaw-Knox epoxy coating process "Ponbake" or Engineer approved equal. Damaged coating areas shall be touched up in the field as recommended by the manufacturer. Exterior stair treads and landings shall be hot-dip galvanized after fabrication.

15.0 MARKING AND IDENTIFICATION

15.1 Each package, skid, box and crate shall be marked on the outside with the following information so that it is readily visible:

a. (OWNER'S name)
(Project identification)
(Address)
(City, state, zip code)

b. Purchase Order number:

c. Weight:

d. Equipment Nos. as applicable:

15.2 Each unit shall be identified with a tag number. The number shall be permanently imprinted with at least 5mm (3/16") high letters on a 22-gage stainless steel tag. The tag shall be attached to the enclosure with pins of a similar material.

15.3 Each unit shall have a permanently secured data plate made from at least 22-gage stainless steel, permanently imprinted with 5mm (3/16") high letters, and containing the following information:

a. Manufacturer's name and address:

b. Model Number:

c. Serial Number:

d. Date of Manufacture:

e. Duty:

f. Weight:

15.4 The data plate shall be located where it is readily visible and shall be securely attached with pins of a material similar to the plate.

15.5 Equipment item numbers shall be utilized by the Vendor in designating equipment. Numbers so assigned by the Vendor may be reassigned at the option of the Engineer.

15.6 Items furnished under these specifications, but not identified herein, shall have tags inscribed as directed by the Engineer.

16.0 PACKAGING, SHIPPING, AND STORAGE

16.1 The Vendor shall be responsible for receiving, unloading, hauling, uncrating, checking, storing, handling, setting in proper place, assembling, aligning work on drives, shimming, doweling, and rigging in accordance with the Drawings and Specifications, as required, to place into commercial operation all items of equipment, complete with appurtenances thereto.

16.2 The Vendor shall be responsible for the protection and safe handling of all equipment and materials until the Work is completed and accepted by the Owner. The responsibility of the Vendor for equipment and materials, furnished by the Owner, shall begin on delivery of same at the jobsite.

16.3 Storage and protection of equipment and materials will be subject to approval by the Engineer.

16.4 Proper and adequate handling equipment and rigging shall be used at all times. Equipment and rigging shall be examined and checked at frequent intervals and at any time when so requested by the Engineer.

17.0 ACCEPTANCE CRITERIA

17.1 The Vendor shall guarantee that the FGD system, and all parts thereof, are entirely suitable for utility service, and the workmanship is top quality in every respect.

17.2 Any and all equipment found to be defective or not in accordance with the requirements of this Specification shall be warranted for a period of 12 months after the successful completion of the Owner's acceptance test.

17.3 The material and labor costs due to removal of defective equipment, repairs made to or replacement of defective equipment, and reinstallation of the equipment into the FGD system shall be borne by the Vendor. Further, the warranty on those components which are repaired or replaced shall be extended for 1 year to begin after the completion of repairs or replacement.

17.4 If the FGD system fails to meet any or all of the guarantees specified in paragraph 8.0, the Vendor without delay and at his own expense shall make recommendations to the Owner concerning modifications required to rectify the situation. Upon the Owner's approval of the recommendations, the Vendor shall perform, at his own expense all alterations required for the FGD system to meet all guarantees.

17.5 If the corrective measures are not successful and the FGD system does not meet all guarantees specified, the Vendor shall compensate the Owner for acceptance of deficient equipment in an amount not to exceed (later) percent of the total Contract price.

SECTION IV

LIST OF DRAWINGS

LIST OF DRAWINGS

The following Drawings set forth the location and extent of the Work specified herein:

Dwg No.	Rev.	Date	Title

CRITERIA FOR EVALUATION OF PROPOSALS

All proposal and data submitted with the proposal, will be evaluated by the Engineer using the following criteria:

1. Compliance with the Engineer's Specification and other bid documents.

2. Compliance with the Project Schedule.

3. Bid price for the complete wet FGD system.

4. Escalation Factors:

   Escalations, in the full amount if quoted, will be added to the bid price for the purpose of evaluation. In the event of escalation without a limit, an estimated escalation will be used in evaluations.

5. Building and Foundation Factors:

   Building and foundation major items will be evaluated at unit costs of $(later) per cubic meter (per cubic foot) of building. Volume; $(later) per cubic meter (per cubic yard) of foundation volume; $(later) per ton of structural steel; and $(later) per square foot of building siding.

6. Reagent Usage Efficiency:

   A present worth cost of $(later) per tonne (ton) per year will be assessed for the differential reagent usage rate at design conditions. The differential usage rate is that rate, in tons per year, required by the bidder's system over the rate required by the system consuming the least reagent.

7. Power Demand and Energy:

   A demand charge of $(later) per kw (hp) will be assessed for the differential actual electrical power requirement at maximum continuous rating. An energy charge of $(later) per kw (hp) will be charged for the differential total connected electrical power requirement. The differential power is that power, in hp, required by the bidder's system over the electrical power required by the system consuming the least power. The power requirements involved in this evaluation wll be the power consumed by all motor drives over 15 kw (20 hp) rating.

8. Pressure Drop:

A present worth cost of $(later) per kPa (inch H_2O) will be assessed for the differential flue gas pressure drop attributable to the bidder's FGD system. The pressure drop attributable to the FGD system will be considered as that from the discharege of the ID fans to the inlet to the stack.

9. Process Water Consumption:

A present worth cost of $(later) per liter/sec (gallon per minute) will be assessed for the differential quantity of process water consumption. Process water includes all fresh makeup water and gland seal water introduced into the FGD system.

10. Compressed Air Consumption:

A present worth cost of $(later) per Nm^3/s (scfm) will be assessed for the differential quantity of compressed air consumed by the FGD system.

PROJECT SCHEDULE

Completion time of the Work is of the essence. Delivery of the equipment and materials, and completion of erection shall be timely. The various activities shall be completed in accordance with the milestone dates listed below:

The Schedule of Activities below stipulates the milestone dates for the Work included in this Specification. The Vendor shall perform the activities shown on or before the dates indicated to avoid delay of the entire project. All submittals indicated shall be made to the Engineer.

Schedule of Activities

Activity	Months after Notification of Contract Award
1. Operation	
a. Vendor to complete erection of equipment.	(Later)
b. Date of initial operation of the unit.	(Later)
c. Date of commercial operation of the unit.	(Later)
2. Planning, Engineering, and Documentation:	
a. Engineering Schedule	1
b. Initial detailed Procurement/ Production/Shipping Schedule	2
c. Design Data and Performance Curves:	
1. Performance curves and mass balance diagrams	2
2. Electrical design data	3
3. Mechanical design data	3
4. Structural design data	4
5. Control design data	9

Activity	Days after Notification of Contract Award
d. Motor Design Data	(Later)
e. Preliminary Erection Schedule	(Later)
f. Model Test Final Reports	(Later)
g. Critical Path Network Schedule for Erection	(Later)
h. Instruction Manuals	(Later)
3. Drawing Schedule:	
a. Layout and Platform Arrangement	3
b. Location of Auxiliary Equipment	3
c. Miscellaneous Piping and Wiring	3
d. Detailed Ductwork and Expansion Joints	8
e. Arrangement of Piping and Accessories	8
f. Electrical Control Wiring	11
g. Details of Construction	12

The date indicated for completion of erection is the latest acceptable date for completion of all erection work including testing, with the equipment ready to be placed in service.

The Vendor shall submit a detailed Procurement/Production/Shipping Schedule for the equipment and materials no later than the date indicated; thereafter the production schedule shall be updated as directed by the Owner, but at least every 30 days.

The Vendor shall submit a preliminary erection schedule no later than the date listed in the Schedule of Activities. The preliminary schedule will be used for coordination with delivery and construction schedules of other Vendors.

ATTACHMENT 1
EQUIPMENT DATA

1. Bidder's Name ______________

2. Manufactuer's Name ______________

3. Quotation Number ______________

4. FGD System Performance:

		Units	% Maximum Continous Rating 50	75	100
a.	Flue gas flow	m^3/S (acfm)			
b.	Flue gas temperature to absorber modules	^oC (^oF)	150(300)	150(300)	150(300)
c.	Sulfur dioxide content of total flue gas stream at inlet to absorber	tonnes/hr (lb/hr)			
d.	Number of modules operating				
e.	Sulfur dioxide removal efficiency	%			
f.	Liquid to gas ratio in scrubber	liters/sec per Nm^3/sec (gal/min per 1000 acfm)			
g.	Reagent consumption	tonnes/hr (lb/hr)			
h.	Water consumption	tonnes/hr (lb/hr)			
i.	Sulfur dioxide content in flue gas stream after absorption	tonnes/hr (lb/hr)			
j.	Particulate in absorber gas effluent during operation with particulate inlet content of .0129 kg/per million kJoules (0.03 lb per million Btu).	tonnes/hr (lb/hr)			

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			% Maximum Continous Rating		
			50	75	100
k.	Water droplet carry-over in absorber gas effluent:				
	(1) Before mist eliminator	tonnes/hr (lb/hr)	____	____	____
	(2) After primary mist eliminator	tonnes/hr (lb/hr)	____	____	____
	(3) After secondary mist eliminator	tonnes/hr (lb/hr)	____	____	____
l.	Absorber gas effluent temperature	^oC (^oF)	____	____	____
m.	Gas pressure drop:				
	(1) Across ductwork and dampers between induced draft fan outlet isolation dampers and absorber modules	kPa (inH_2O)	____	____	____
	(2) Across absorbing stage	kPa (inH_2O)	____	____	____
	(3) Across mist eliminator	kPa (inH_2O)	____	____	____
	(4) Across ductwork and dampers between module outlet elbows and chimney breeching	kPa (inH_2O)	____	____	____
	(5) Total across all flue gas absorber system elements	kPa (inH_2O)	____	____	____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			% Maximum Continous Rating 50	75	100
n.	Recirculation flow:				
	(1) Total head	m (ft)	____	____	____
	(2) Rate	l/s (gal/min)	____	____	____
	(3) Bhp required		____	____	____
	(4) pH		____	____	____
	(5) Percent solids by weight		____	____	____
	(6) Specific gravity		____	____	____
o.	Absorber bleed flow:				
	(1) Total head	m (ft)	____	____	____
	(2) Rate	l/s (gal/min)	____	____	____
	(3) Bhp required		____	____	____
	(4) Percent solids by weight		____	____	____
	(5) pH		____	____	____
	(6) Specific gravity		____	____	____
	(7) Solids constituents:				
	(a) $CaSO_3$-1/2 H_2O	%	____	____	____
	(b) $CaSO_4$-2 H_2O	%	____	____	____
	(c) $CaCO_3$	%	____	____	____
	(d) Inerts	%	____	____	____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

		% Maximum Continous Rating 50	75	100
p. Final slurry:				
(1) Dry solids production	tonnes (lb) solids/hr	____	____	____
(2) Percent solids by weight		____	____	____
(3) Density	kg/m^3 (lb/ft^3)	____	____	____
(4) Solids constituents:				
(a) $CaSO_3$-1/2 H_2O	%	____	____	____
(b) $CaSO_4$-2 H_2O	%	____	____	____
(c) $CaCO_3$	%	____	____	____
(d) CaO	%	____	____	____
(e) Fly Ash	%	____	____	____
(f) Inerts	%	____	____	____
q. Compressed air requirements:				
(1) Service air	m^3/sec (acfm)	____	____	____
(2) Control air	m^3/sec (acfm)	____	____	____
5. Absorber Modules:				
a. Overall dimensions of each module	m (ft)	____	____	____
b. Materials:				
(1) Shell		____		
(2) Vanes		____		
(3) Spray pipes		____		

(4) Nozzles ____________

(5) Other internals ____________

(6) Coatings, manufacturers, types and locations used ____________

c. Number of spray levels ____________

d. Number of nozzles per level ____________

e. Nozzle flow and pressure drop ____________

f. Spray contact time sec ____________

g. Shell thickness, minimum mm (in) ____________

h. Access doors:

(1) Number ____________

(2) Type ____________

(3) Size ____________

(4) Seal ____________

i. Gas flow area:

(1) Inlet duct ____________

(2) Absorber section ____________

(3) Mist eliminator section ____________

(4) Outlet duct ____________

j. Recirculation headers:

(1) Manufacturer ____________

(2) Type and quantity ____________

(3) Model ____________

(4) Material ____________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(5)	Wall thickness	mm (in)	____________
(6)	Design header pressure psi	kPa (psi)	____________
(7)	Design flow per spray head	l/s (gal/min)	____________
(8)	Provisions for removal		____________
(9)	Estimated life of spray heads		____________

k. Weight of each module:

(1)	Dry	kg (lb)	____________
(2)	Operating	kg (lb)	____________
(3)	Flooded	kg (lb)	____________

l. Module support ____Top____Inter-mediate____Bottom

6. Mist Eliminators:

			Primary	Secondary
a.	Manufacturer		______	______
b.	Type		______	______
c.	Model		______	______
d.	Material		______	______
e.	Flammability rating		______	______
f.	Temperature limitations:			
(1)	Continuous operation	^oC (^oF)	______	______
(2)	Excursion	^oC (^oF) and time	___;___	___;___
g.	pH limitations		______	______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			Primary	Secondary
h.	Support material		______	______
i.	Spray water:			
	(1) Water quality requirements		______	______
	(2) Flow rate	l/s (gal/min)	______	______
	(3) Pressure	kPa (psi)	______	______
	(4) Cleaning flux	kg/m^2 (lb/ft^2)	______	______
j.	Wash headers:			
	(1) Manufacturer		______	______
	(2) Type		______	______
	(3) Material		______	______
	(4) Wall thickness	mm (in)	______	______
k.	Superficial gas velocity through horizontal mist eliminator at MCR		______	______

7. Module Purge Air System:

(1) Number of purge fans		____________
(2) Flow per fan	Nm^3/sec (scfm)	____________
(3) Fan discharge pressure	kPa (inH_2O)	____________
(4) Fan manufacturer		____________
(5) Model		____________
(6) Fan	kW (bhp)	____________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(7) System materials ______

(list components) ______

______

______

______

______

______

(8) Fan location ______

(9) Purge locations ______

______

(10) Time required for safe entry min ______

______

(11) System description ______

______

______

______

		Induced Draft Fans to Module Inlets	Module Outlets to Chimney Breeching Connection	Bypass Duct
8. Ductwork:				
a. Weight of ductwork	kg (lb)	______	______	______
b. Plate materials by ASTM no. and manufacturer's designation		______	______	______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			Induced Draft Fans to Module Inlets	Module Outlets to Chimney Breeching Connection	Bypass Duct
c.	Coating, manufacturer and type (limits if more than one type)		______	______	______
d.	Plate thickness	mm (in)	______	______	______
e.	Duct dimensions, LxW	m (ft)	______	______	______
f.	Gas velocity:				
	(1) At design flow		______	______	______
	(2) At 25% load		______	______	______
g.	Design pressure	kPA (inH_2O)	______	______	______
h.	Access doors:				
	(1) Number		______	______	______
	(2) Type		______	______	______
	(3) Size		______	______	______
	(4) Locations		______	______	______
i.	Test port locations		______	______	______
j.	Duct coatings:				
	(1) Manufacturer		______	______	______
	(2) Type		______	______	______
	(3) Temperature limitations:				
	(a) Continuous operating	^oC (^oF)	______	______	______

(ed)

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			Induced Draft Fans to Module Inlets	Module Outlets to Chimney Breeching Connection	Bypass Duct
(b) Excursion		°C (°F) and time			
(4)	pH limitations (range) at 21.1°C (70°F)				
(5)	Coating thickness				
(6)	Method of installation				
k.	Ductwork fabricator				
l.	Thickness of insulation				
m.	Describe method of ductwork support				
n.	Spring hangers				
(1)	Type				
(2)	Manufacturer				
o.	Instrument tap locations				
p.	Expansion joints:				
(1)	Location				
(2)	Manufacturer				
(3)	Size	m x m (ft x ft)			
(4)	Quantity				
(5)	Belt material				
(6)	Belt thickness				
(7)	Maximum movement				

1003

ATTACHMENT 1
EQUIPMENT DATA (Continued)

		Induced Draft Fans to Module Inlets	Module Outlets to Chimney Breeching Connection	Bypass Duct
(8) Belt temperature rating				
(9) Belt pressure rating				
(10) Frame material				
(11) Baffle material				
(12) Unit weight	kg (lb)			

9. Dampers:

		Module Inlet Dampers	Module Outlet Dampers	Flue Gas Bypass Damper
a. Type				
b. Manufacturer				
c. Model number				
d. Number of blades				
e. Damper inside dimensions:				
(1) Length	mm (in)			
(2) Width	mm (in)			
f. Damper face area	m^2 (ft^2)			
g. Maximum operating temperature	^oC (^oF)			
h. Maximum temperature differential across closed blades	^oC (^oF)			

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			Module Inlet Dampers	Module Outlet Dampers	Flue Gas Bypass Damper
i.	Maximum pressure differential across closed blader				
j.	Pressure drop across full open damper at design flow	kPa (inH_2O)			
k.	Flue gas leakage to atmosphere				
l.	Maximum leakage across closed blades:				
	(1) With seal air				
	(2) Without seal air				
m.	Damper weight	kg (lb)			
n.	Materials of construction:				
	(1) Frames				
	(2) Blades				
	(3) Shafts				
	(4) Seals				
	(5) Packing				
	(6) Bearings:				
	(a) Type				
	(b) Manufacturer				

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			Module Inlet Dampers	Module Outlet Dampers	Flue Gas Bypass Damper
o.	Damper operator:				
	(1) Rated speed	r/min	______	______	______
	(2) Rated torque	kg-m (J)	______	______	______
	(3) Operating torque	kg-m (J)	______	______	______
	(4) Time rating:				
	(a) Closed to full open		______	______	______
	(b) Open to full closed		______	______	______
	(5) Locked-rotor torque	kg-m (J)	______	______	______

10. Seal Air System Fans:

a.	Manufacturer		______
b.	Type		______
c.	Quantity per damper		______
d.	Capacity	Nm^3/sec (scfm)	______
e.	Discharge pressure	kPa (inH_2O)	______
f.	bhp		______
g.	Materials:		
	(1) Fan		______
	(2) Ductwork		______
	(3) Valves		______

ℓD

ATTACHMENT 1
EQUIPMENT DATA (Continued)

11. Slurry Pumps:

a.	Manufacturer		______
b.	Model number		______
c.	Type		______
d.	Quantity supplied		______
e.	Number of spares		______
f.	Design conditions:		
	(1) Total head	m (ft)	______
	(2) Capacity	l/s (gal/min)	______
	(3) Slurry solids	%	______
	(4) Specific gravity		______
g.	Power requirements for each pump	kw (bhp)	______
h.	Motor hp and service factor		______ ; ______
i.	Motor speed	r/min	______
j.	Pump materials (by common name and standard number):		
	(1) Casing		______
	(2) Impellers		______
	(3) Shaft		______
	(4) Shaft sleeves		______
	(5) Stuffing box		______
	(6) Other wetted parts		______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

k.	Seal, cooling, or injection water requirements for each pumr		
	(1 Flow	l/s (gal/min)	__________
	(2) Pressure	kPa (psi)	__________
l.	V-belts:		
	(1) Manufacturer		__________
	(2) Model number	kPa (psi)	__________
m.	Gear reducer:		
	(1) Manufacturer		__________
	(2) Model number		__________

12. Water Pumps:

a.	Manufacturer		__________
b.	Model number		__________
c.	Type		__________
d.	Quantity supplied		__________
e.	Number of spares		__________
f.	Design conditions:		
	(1) Total head	m (ft)	__________
	(2) Capacity	l/s (gal/min)	__________
g.	Power requirements for each pump	kW (bhp)	__________
h.	Motor hp and service factor		_____; _____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

i. Motor speed r/min ______

j. Pump materials (by common name and standard number):

(1) Casing ______

(2) Impellers ______

(3) Shaft ______

(4) Shaft sleeves ______

(5) Stuffing box ______

(6) Wear plates ______

(7) Other wetted parts ______

k. Seal, cooling, or injection water requirements for each pump:

(1) Flow l/s (gal/min) ______

(2) Pressure kPa (psi) ______

l. V-belts:

(1) Manufacturer ______

(2) Model number ______

(3) Rating ______

13. Oxidizing Air Compressors:

a. Number furnished ______

b. Manufacturer ______

c. Model number or type ______

d. Discharge capacity Nm^3/sec (scfm) ______

e. Discharge pressure kPa (psig) ______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

f. Power required:

(1) At 100% capacity kW (bhp) ____________

(2) At 50% capacity kW (bhp) ____________

g. Motor hp and service factor ______ ; ______

h. Motor speed r/min ____________

i. Blower speed r/min ____________

j. Rotor tip speed m/sec (ft/sec) ____________

k. Gear reducer (if used):

(1) Manufacturer ____________

(2) Model number ____________

(3) Type ____________

(4) Speed:

(a) Driver r/min ____________

(b) Blower r/min ____________

(5) Efficiency % ____________

l. Filter silencer:

(1) Manufacturer ____________

(2) Model number ____________

(3) Connections, size and type:

(a) Inlet ____________

(b) Outlet ____________

(4) Casing dimensions mm (in) ____________

(5) Material ____________

(6) Sound reduction dBA ____________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

m. Discharge silencer:

(1) Manufacturer ______________________

(2) Model number ______________________

(3) Connections, size and type:

(a) Inlet ______________________

(b) Outlet ______________________

(4) Casing dimensions mm (in) ______________________

(5) Material ______________________

(6) Sound reduction dBA ______________________

(7) Overall sound pressure level dBA ______________________

n. Cooling water requirements:

(1) Minimum required flow at 37.8°C (100°F) l/s (gal/min) ______________________

(2) Recommended flow l/s (gal/min) ______________________

(3) Pressure drop at recommended flow kPa (psi) ______________________

o. Field assembly:

(1) Will the blower, motor, and other parts be shipped completely assembled on the baseplate? ______________________

6/1

(2) Description and weights of components to be field assembled ______________

____

____

____

____

14. Reagent Preparation System:

a. Weigh feeders:

(1) Manufacturer ______________

(2) Model and type ______________

(3) Number ______________

(4) Distance from the centerline of the feed to the centerline of the discharge ______________

(5) Maximum capacity tonnes/hr (lb/hr) ______________

(6) Turndown ratio ______________

(7) Accuracy % ______________

b. Ball mill:

(1) Manufacturer ______________

(2) Model and type ______________

(3) Maximum capacity tonnes/hr (lb/hr) ______________

(4) Turndown ratio ______________

(5) Mill speed ______________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(6) Materials:

(a) Shell __________

(b) Lining __________

(7) Lining thickness __________

(8) Operating weight kg (lb) __________

(9) Bearing cooling:

(a) Cooling media __________

(b) Flow required l/s (gal/min) __________

(10) Ball:

(a) Material __________

(b) Total weight __________

(11) kW (bhp) at design capacity __________

(12) Motor kW (hp) and service factor __________

(13) Starting torque __________

(14) Crusher capacity tonnes/hr (lb/hr) __________

(15) Crusher kW (bhp) __________

(16) Speed reducer:

(a) Manufacturer __________

(b) Rated kW (hp) __________

(c) Oil cooling media __________

(d) Cooling flow l/s (gal/min) __________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(17) Overall sound power level ________________

c. Classifiers:

(1) Manufacturer ________________

(2) Type ________________

(3) Number operating ________________

(4) Number of spares ________________

(5) Maximum capacity ________________

(6) Turndown ratio ________________

(7) Pressure drop kPA (psi) ________________

(8) Required flow and pressure at inlet flange ________;________

(9) Materials:

(a) Classifier ________________

(b) Liner ________________

(10) Liner thickness ________________

d. Distributors:

(1) Quantity ________________

(2) Type ________________

(3) Material ________________

15. Tanks:

a. Absorber reaction tanks:

(1) Number of tanks ________________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(2)	Materials:		
	(a) Plates		______
	(b) Structural shapes		______
	(c) Bottom		______
(3)	Coatings, manufacturer and type		______
			______
			______
(4)	Total lining surface per tank	m^2 (ft^2)	______
(5)	Overall dimensions	m (ft)	______
(6)	Normal liquid level	m (ft)	______
(7)	Normal capacity	liters (gal)	______
(8)	Maximum capacity	liters (gal)	______
(9)	Liquid retention time	min	______
(10)	Solids retention time	hr	______
(11)	Weight of each tank:		
	(a) Dry	kg (lb)	______
	(b) Operating	kg (lb)	______
	(c) Flooded	kg (lb)	______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(12) Reactor tank agitators:

(a) Manufacturer ____________________

(b) Model number ____________________

(c) Physical orientation (top or side entry) ____________________

(d) Number per tank ____________________

(e) Location ____________________

(f) Impeller speed r/min ____________________

(g) Shaft diameter ____________________

(h) Shaft length ____________________

(i) Reducer:

1 Manufacturer ____________________

2 Model number ____________________

3 Max torque rating ____________________

(j) Materials:

1 Shaft ____________________

2 Impeller ____________________

(k) Bhp per agitator:

1 With oxidation air ____________________

2 Without oxidation air ____________________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(l) Motor hp and service factor ______ ; ______

(m) Output torque:

1 Operating:

a With oxidation air ______

b Without oxidation air ______

2 Maximum capability ______

(n) Number of sparger oxidation rings ______

(o) Air flow per sparger ______

(p) Seal water requirement l/s (gal/min;) kPa (psig) ______

b. Reagent storage tanks:

(1) Number of tanks ______

(2) Materials:

(a) Plates ______

(b) Structural shapes ______

(3) Coatings, manufacturer and type ______

______

______

(4) Overall dimensions m (ft) ______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(5)	Normal liquid level	m (ft)	______
(6)	Volume	l (gal)	______
(7)	Liquid retention time	min	______
(8)	Weight of each tank:		
	(a) Dry	kg (lb)	______
	(b) Operating	kg (lb)	______
	(c) Flooded	kg (lb)	______
(9)	Tank agitators:		
	(a) Manufacturer		______
	(b) Model number		______
	(c) Number per tank		______
	(d) Location		______
	(e) Impeller speed	r/min	______
	(f) Reducer:		
	1 Manufacturer		______
	2 Model number		______
	(g) Materials:		
	1 Shaft		______
	2 Impeller		______
	(h) Bhp per agitator		______

(i) Motor hp and service factor ________ , ________

c. Reaction tank bleed surge tank:

(1) Number of tanks ____________

(2) Materials:

(a) Plates ____________

(b) Structural shapes ____________

(3) Coatings, manufacturer and type ____________

____

____

(4) Overall dimensions m (ft) ____________

(5) Normal liquid level m (ft) ____________

(6) Volume l (gal) ____________

(7) Liquid retention time min ____________

(8) Weight of each tank:

(a) Dry kg (lb) ____________

(b) Operating kg (lb) ____________

(c) Flooded kg (lb) ____________

(9) Tank agitators:

(a) Manufacturer ____________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(b) Model number ______________________

(c) Number per tank ______________________

(d) Location ______________________

(e) Impeller speed r/min ______________________

(f) Reducer:

1 Manufacturer ______________________

2 Model number __________ __________

(g) Materials:

1 Shaft ______________________

2 Impeller ______________________

(h) Bhp per agitator ______________________

(i) Motor hp and service factor __________; __________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

16. Piping:

Service*	Size mm (Inch)	Wall Thick-ness, mm (Inch)	Max Operating Press kPA (psig)	Temp ^{o}C (^{o}F)	Velocity m/s (fps)	Lining Material	Pipe Material

a. Tubing materials and application ______

b. Piping supports:

(1) Manufacturer ______

(2) Type(s) and application ______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

17. Valves:

a. Clear liquid isolation valves:

Service	Valve Type	Quantity Size mm (inch)	Body Material	Packing Type	Operator Type	Max. Press. kPa (psig)	Operating Temp. °C (°F)
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					

ATTACHMENT 1
EQUIPMENT DATA (Continued)

b. Slurry isolation valves:

Service	Valve Type	Quantity Size mm (inch)	Body Material	Packing Type	Operator Type	Max. Press. kPa (psig)	Operating Temp. ^{o}C (^{o}F)
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					

ATTACHMENT 1
EQUIPMENT DATA (Continued)

c. Clear liquid control valves:

Service	Valve Type	Quantity Size mm (inch)	Body Material	Packing Type	Operator Type	Max. Press. kPa (psig)	Operating Temp. °C (°F)
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					

ATTACHMENT 1
EQUIPMENT DATA (Continued)

d. Slurry control valves (if applicable):

Service	Valve Type	Quantity Size mm (inch)	Body Material	Packing Type	Operator Type	Max. Press. kPa (psig)	Operating Temp. ^{o}C (^{o}F)
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					
		;					

ATTACHMENT 1
EQUIPMENT DATA (Continued)

18. Sump Pumps:

a.	Manufacturer		__________
b.	Model		__________
c.	Flow	l/s (gpm)	__________
d.	Head	m (ft)	__________
e.	Number		__________
f.	Slurry characteristics:		
	(1) Solids by weight (approx) %		__________
	(2) Flow rate	l/s (gal/min)	_____ _____
	(3) Specific gravity (approx)		__________

19. Miscellaneous Fans:

a.	Service		__________
b.	Quantity		__________
c.	Manufacturer		__________
d.	Capacity per fan	Nm^3/s (scfm)	__________
e.	Fan outlet pressure	kPa (in H_2O)	__________
f.	kW (bhp) per fan		__________
g.	Motor kW (hp) and service factor		__________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

h. Wheel:

(1) Type ______

(2) Diameter ______

(3) Speed r/min ______

i. Materials:

(1) Shaft ______

(2) Casing ______

j. Casing thickness ______

k. Bearing type ______

l. Lubrication type ______

m. Enclosure type ______

n. Weight ______

20. Instrumentation and Controls:

a. Local liquid level controllers:

(1) Manufacturer ______

(2) Model number ______

(3) Quantity ______

(4) Locations ______

______

______

______

______

ATTACHMENT 1
EQUIPMENT DATA (Continued)

b. Local pressure controllers:

(1) Manufacturer ______________________

(2) Model number ______________________

(3) Quantity ______________________

(4) Locations ______________________

____

____

____

____

c. Local temperature controllers:

(1) Manufacturer ______________________

(2) Model number ______________________

(3) Quantity ______________________

(4) Locations ______________________

____

____

____

____

d. Flow transmitters:

(1) Manufacturer ______________________

(2) Model number ____________________

(3) Quantity ____________________

(4) Locations ____________________

____

____

____

____

e. Magnetic flow transmitters:

(1) Manufacturer ____________________

(2) Model Number ____________________

(3) Quantity ____________________

(4) Locations ____________________

____

____

____

____

f. pH transmitters

(1) Manufacturer ____________________

(2) Model number ____________________

(3) Quantity ____________________

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(4) Locations ______________________

____

____

____

____

____

g. Description of other characteristics, such as electronic trip, voltage to current, current to voltage ______________________

____

____

____

____

____

____

____

____

____

____

____

____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

21. Utilities Required by FGD System:

		% of boiler MCR 50	75	100
a. Power:				
(1) Additive preparation equipment:				
(a) Reagent mills	kW	____	____	____
(b) Pumps	kW	____	____	____
(c) Agitators	kW	____	____	____
(2) Absorber equipment:				
(a) Recycle pumps	kW	____	____	____
(b) Oxidation compressors	kW	____	____	____
(c) Agitators	kW	____	____	____
(d) Miscellaneous pumps	kW	____	____	____
(3) Other equipment	kW	____	____	____
(4) Lighting, HVAC, and miscellaneous	kW	____	____	____
(5) Total connected kW		____	____	____
(6) Total connected kVA		____	____	____
(7) Normal operating kW		____	____	____
(8) Normal operating kVA		____	____	____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

			% of boiler MCR		
			50	75	100
b.	Makeup Water:				
	(1) Daily average	l/s (gal/min)	____	____	____
	(2) Maximum instantaneous	l/s (gal/min)	____	____	____
c.	Compressed air for instruments and controls, operating	N m^3/s (scfm)	____	____	____
d.	Reagent:				
	(1) Consumption	tonnes/hr (lb/hr)	____	____	____
	(2) Stochiometry, moles $CaCO_3$ per mole SO_2 removed		____	____	____
e.	Gland seal water:				
	(1) Equipment requiring gland seal water		____________		
			____________		
			____________		
			____________		
	(2) Flow rates required	l/s (gal/min)	____________		
			____________		
			____________		
			____________		

ATTACHMENT 1
EQUIPMENT DATA (Continued)

(2) Flow rates required — l/s (gal/min) ______________________

____

____

____

(3) Minimum inlet pressure — kPa (psi) ______________________

____

(4) Quality restrictions, if any ______________________

____

f. Cooling water:

(1) Equipment requiring cooling water ______________________

____

____

____

(2) Flow rates required — l/s (gal/min) ______________________

____

____

____

____

ATTACHMENT 1
EQUIPMENT DATA (Continued)

22. Structural Items:

		Estimated Quantities		
		Reagent Prep. Area	Absorber Area	Waste Treatment Area
a. Reinforced concrete	M^3 (yd^3)	______	______	______
b. Structural steel:				
(1) Structural and miscellaneous steel except for support of ductwork	kg (tons)	______	______	______
(2) Structural and miscellaneous steel for ductwork support	kg (tons)	______	______	______
(3) Platform grating		______	______	______
(4) Steel stairs	vertical m (ft)	______	______	______

ATTACHMENT 2

Refer to Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 3

Refer to Motor Data Sheets included in Electrical Motor Specifications E-1 and E-2.

ATTACHMENT 4

ACOUSTIC DATA
SUMMARY SHEET

Octave Band Geometric Mean Frequency (Hertz)	Equipment Without Acoustic Treatment or Guarantee	Equipment With Maximum Sound Level Guarnatee of 90 dBA at 1 meter (3 feet)
63	______	______
125	______	______
250	______	______
500	______	______
1000	______	______
2000	______	______
4000	______	______
8000	______	______

Kind of levels given, indicate which of the following:

Sound Power Levels re 10 (exp -12) watt	______	______
Sound Pressure Levels re 2x10 (exp -4) microbars	______	______

If sound pressure levels are given, indicate both of the following:

Weighting network use A, B, C, or Linear (None)	______	______
Distance to sound source Feet or Meters	______	______

Vendor Comments: ______________________________

____

____

____

ATTACHMENT 5.

SPECIFICATION EXCEPTIONS

GILBERT/COMMONWEALTH WET FGD SYSTEM

The bidder certifies that the bid is complete and in absolute agreement with the requirements of this Specification, except as specifically stated below. (Use additional sheets if required).

____
(BIDDER'S NAME)

____
(MANUFACTURER'S NAME)

____
(QUOTATION NUMBER)

Attest: ____________________________
(SIGNATURE)

____
(TITLE)