SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 1 – SITE DATA

CONTENTS

1. SITE DATA

This section contains information that shall form the basis for the guaranteed plant design and includes information on site data, properties of fuel and raw water, environmental design basis, in accordance with the Contract.

The following information is included in this section:

a) Site data, including location, topography, meteorological data, wind, precipitation and evaporation and site seismicity;
b) Fuel data, including coal and high speed diesel specifications;
c) Water analyses;
d) Environmental – air emission, wastewater discharge, noise emission, light pollution; and
e) Performance in accordance with the Contract.

The geotechnical reports relevant to the Site and which include initial soil data is provided in Attachment D of Section 5 - Employer’s Requirement. The foundation design for the Plant shall be based on the Contractor’s evaluation of these data and such supplementary and new data that the Contractor shall collect and evaluate. Soil resistivity data for the Site is not provided in this soil data report hence the Contractor is required to carry out a comprehensive Soil Resistivity test to be uses in his design for electrical fault analysis.

The soil profile to be used as the basis for seismic analysis and design shall be determined by the Contractor and reported to the Engineer for review.

Site survey drawings are provided in Attachment B4 of Section 5 - Employer’s Requirement.

1.1 LOCATION

The Site is adjacent to the Kazol River or upstream of Rabnabad Channel at Dhankhali Union, Kalapara Upazila, Patuakhali District of Bangladesh. The Site is located in the east of Kalapara and the west of Rabnabad Channel. The longitude and latitude of the Site is 21°59'40.1"N, 90°18'23.51"E. The distance between the Site and Patuakhali is 39km (linear distance, similarly hereinafter), and the distance between the Site and Barisal is 78km. The east of the Site is the Rabnabad Channel and the south is the Andharmanik River.

At present, rice paddies are planted mostly in the land and dotted with a few simple houses. The width of the Site is about 2km from east to west, and the north-south length of the Site is about 1.8km. The natural elevation of the Site is about -0.2 ~ 3.8m (MSL). The Site meets the requirement of constructing Payra Thermal Power Plant (2 x 660MW). Due to the low terrain, the elevation of the plant is expected to be backfilled to about 6m (MSL). Besides, since the Site quantity of earthwork is larger, we can consider taking out sand from the east side of Rabnabad Channel used for backfilling. The Site is distributed with scattered simple houses and graves. There is no airport, natural park, wildlife sanctuary and places of historic interest near the Site at present.

1.2 TOPOGRAPHY

The proposed site feature is estuary delta and adjacent to Rabnabad Channel and Andharmanik river, with altitude being 1.80m~2.30m. The proposed site is surrounded by water on three sides (east, south and west).

The dwellings of the site will be removed by the Employer. The demolition inside of the plant boundary is outside the scope of the Contractor.

The Site filling and ground improvement works for the power block area shall be up to +5.55m above MSL and shall be undertaken by the Employer and is not in the scope of this Contract. The consolidation of the improved ground shall be minimum 85%. Areas where other facilities are to be located outside the power block area shall be levelled and compacted by sand filling up to +5.55m above MSL by the Employer without any ground improvement.

The ash pond area will not be filled and improved. After checking the suitability of the site, the area shall be leveled and compacted by filling and cutting to a final level to be established upon a site survey.

1.3 METEOROLOGICAL DATA

Payra Thermal Power Plant (2 x 660MW) will be located in Khepupara, Patuahali, Barisal, Bangladesh, which has a tropical marine monsoon climate (wet and rainy).

In total, Bangladesh has 35 permanent meteorological observation stations. The Khepupara meteorological station is about 7.7km to the southwest of the proposed site and there is no high mountain between them. Given the similar geomorphic and climatic conditions, Khepupara meteorological station was selected as reference station for meteorological analysis.

Respective locations of the Site and Khepupara meteorological station are shown in Figure 1.3-1. The geographical coordinates of Khepupara meteorological station are 90°14′E and 21°59′N, and the sea-level altitude of meteorological platform is 1.83m.

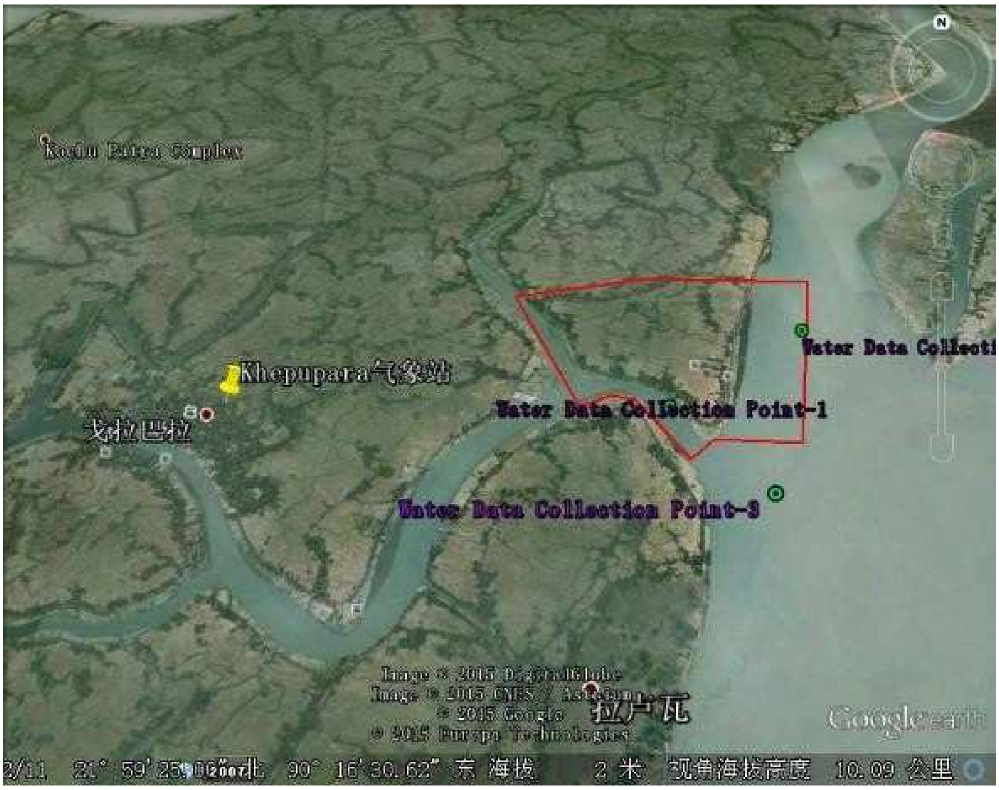


Figure 1.3-1: Respective locations of the plant site and Khepupara meteorological station

Based on the 31-year (1984-2014) data collected by Khepupara meteorological station, the monthly statistic values of relevant meteorological parameters (maximum air temperature, minimum air temperature, average atmospheric pressure, and mean relative humidity) over the past years are tabulated in this chapter.

1.3.1 AIR TEMPERATURE

General characteristic values:

Monthly average, maximum and minimum air temperature values over the past years are shown in Table 1.3-1.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean	19.0	21.8	26.6	28.8	295	29.2	28.5	28.5	28.4	27.5	24.2	20.2
Max.	29.2	32	35.3	35.8	35.5	34.9	33	33.5	34.2	34.3	32.2	29.7
Min.	10.1	12	16.5	20.2	21.2	23	23.8	24.1	23.3	20.8	16	11.6

Table 1.3-1: Monthly average, maximum and minimum air temperature values over the past years (Unit: °C)

Mean air temperature over the past years: 26.0 °C

Extreme maximum air temperature over the past years: 42.3 °C
Extreme minimum air temperature over the past years: 5.6 °C

30-year minimum air temperature

The minimum air temperature takes place between November and February, with January accounting for the largest proportion of 75% and December accounting for the lowest proportion of 10%.

Based on the minimum air temperature data collected by Khepupara meteorological station, the 30-year minimum air temperature is 6.0 °C.

Relative humidity

The monthly mean relative humidity values over the past years are shown in Table 1.3-2.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean	74	76	79	80	84	86	84	87	85	82	79	76

Table 1.3-2 Monthly mean relative humidity values over the past years (Unit: %)

Mean relative humidity over the past years: 81%
Minimum daily mean relative humidity over the past years: 29%

1.3.2 ATMOSPHERIC PRESSURE

The monthly mean atmospheric pressure values over the past years are shown in Table 1.3-3.

Mean atmospheric pressure over the past years: 1007.8kPa
Maximum daily mean atmospheric pressure over the past years: 1020.9kPa
Minimum daily mean atmospheric pressure over the past years: 987.1kPa

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Mean	1014.8	1012.8	1009.7	1006.9	1004.0	1000.6
Month	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Mean	1000.8	1002.0	1005.3	1009.4	1012.6	1014.8

Table 1.3-3: Monthly mean atmospheric pressure values over the past years (unit: kPa)

1.4 WIND

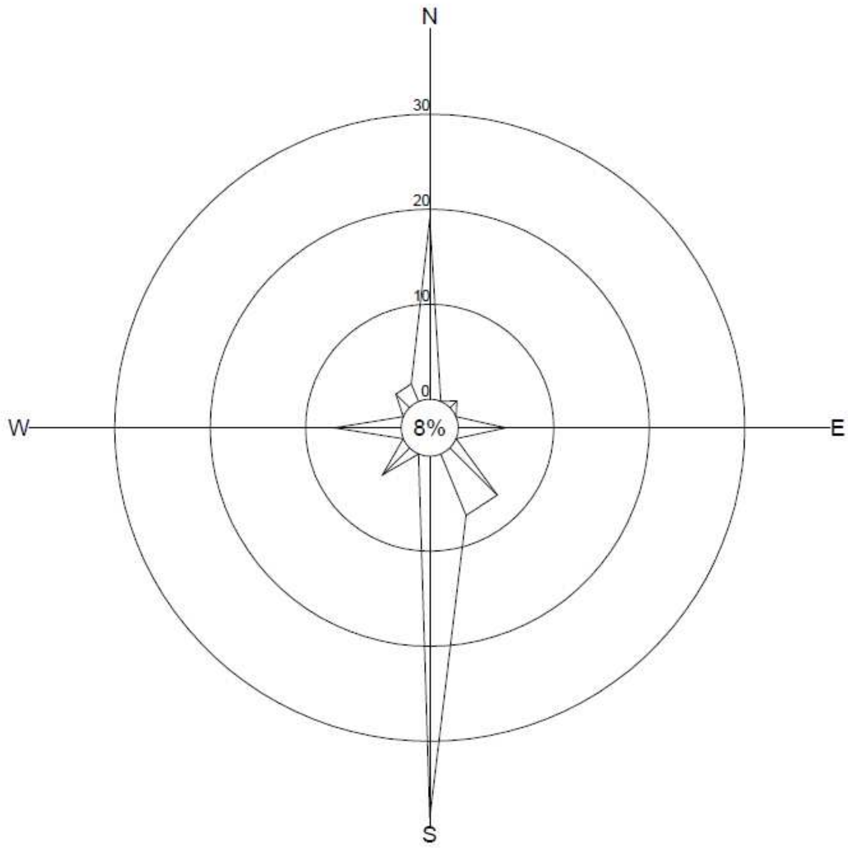
1.4.1 GENERAL WIND CONDITIONS

The monthly mean wind speed, most frequent wind direction, maximum wind speed and the corresponding wind direction are shown in Table 1.3-4

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean wind speed	1.6	1.9	2.4	2.9	3.0	2.9	2.8	2.6	2.1	1.4	1.2	2.2
Most frequent wind direction	N	NW	S	S	S	S	S	ES	ES	NW	NW	NW

Table 1.3-4: Monthly mean wind speed, most frequent wind direction, maximum wind speed and the corresponding wind direction (unit: m/s)

Mean wind speed over the past years: 2.19m/s
Most frequent wind direction all the year round: S
Year-round wind rose diagram below:



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1.4.2 DESIGN WIND SPEED

Maximum wind speed in mile

The location of the proposed site is shown in Figure 1.4-1 (from Bangladesh National Building Code), according to which that the plant site falls within the 260km/h equivalent zone and recurrence interval is 50 years.

According to the Bangladesh National Building Code (2006), the 50-year maximum wind speed at the height of 10m above the ground where the plant site is located reaches 260km/h (Patuakhali, to the northwest of the proposed site).

Based on the above analysis and relevant data from the isoline map and the maximum wind speed table, the 50-year maximum wind speed at the height of 10m above the ground shall be 260km/h.

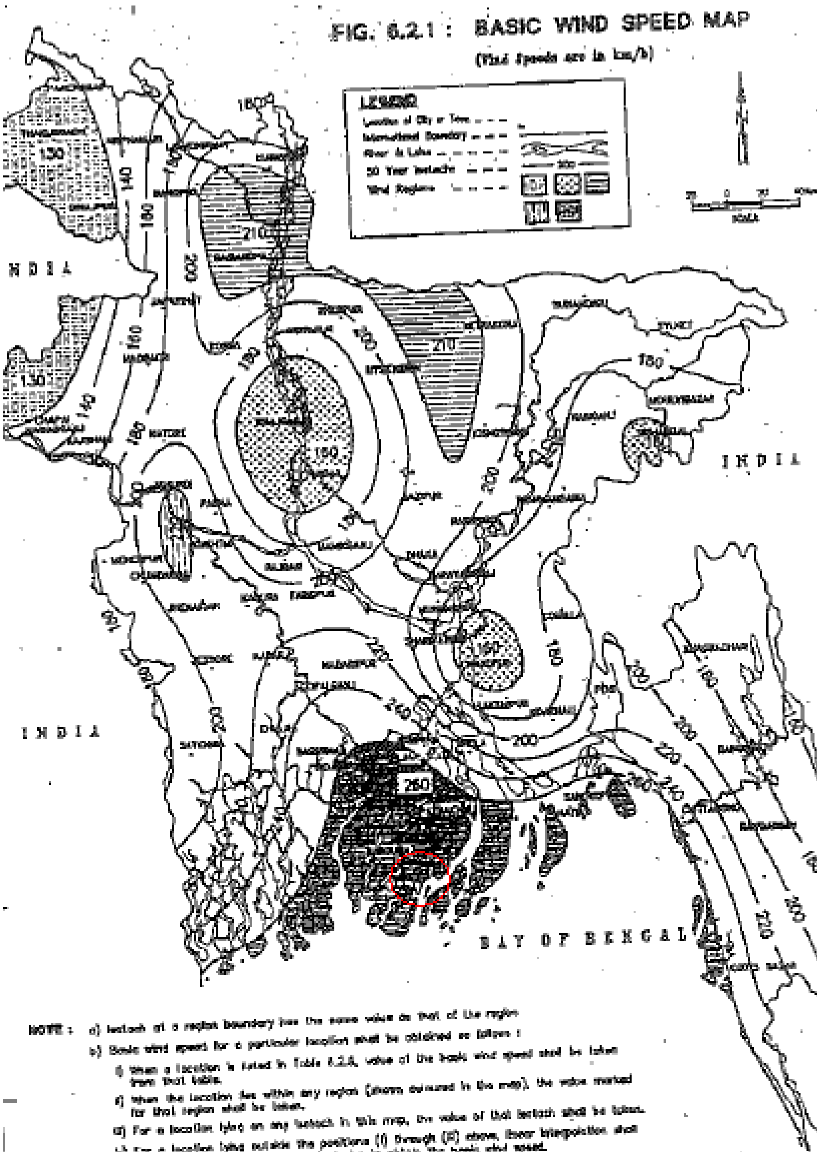

Figure 1.4-1 Relative location of the proposed site in the maximum wind speed isoline map

Design wind speed based on domestic standards

The 50-year 10min maximum wind speed at the height of 10m above the ground where the proposed site is located is 56.6m/s.

Design wind pressure

The 50-year basic wind pressure of the proposed site is 1.82kN/m3.

Wet-bulb temperature

The daily mean wet-bulb temperature is 28.2°C under the cumulative frequency of 10%, which took place on June 23, 2011, with the corresponding daily mean dry bulb temperature, relative humidity and atmospheric pressure is 30.7°C, 88% and 998.4kPa respectively.

Frost-thaw cycle times

The maximum frost-thaw cycle time is 0 during the last 10 years.

Precipitation

The monthly mean precipitation values over the past years are shown in Table 1.4-1

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	15	10	29	49	206	459	604	437	447	340	30	7

Table 1.4-1: Monthly mean precipitation values over the past years (unit: mm):

Mean precipitation over the past years: 2632mm
Maximum precipitation over the past years: 3348mm (2005)
Minimum precipitation over the past years: 1895mm (2012)
Maximum 1d precipitation over the past years: 373mm (Jul 2, 1995)
Maximum 2d precipitation over the past years: 514mm (October 2010)

Evaporation

The monthly mean evaporation values over the past years are shown in Table 1.4-2

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	80.7	111.9	156.3	163.1	160.4	119.5	113.5	116.9	106.7	106.6	106.6	77.7

Table 1.4-2: Mean evaporation over the past years: 1413.2mm

Thunderstorm days

The monthly mean thunderstorm days over the past years are shown in Table 1.4-3.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	0.5	1.6	5.4	11.3	14.7	10.8	7.4	8.6	10.4	5.5	0.6	0.3

Table 1.4-3: Monthly mean thunderstorm days over the past years (unit: d)

Mean thunderstorm days over the past year: 77.0d
Maximum thunderstorm days over the past years: 106d (1963)
Minimum thunderstorm days over the past years: 53d (1992)

1.5 SITE SEISMICITY

The seismic loads are required to be calculated according to the International Building Code ("IBC") or other international code approved by the Employer. The following parameters shall be followed:

a) 0.10g for buildings and structures.

b) 0.15g for chimney.

Seismic peak ground acceleration: 10 percent (10%) probability of increase in a 50-year period at the values stated above.

1.6 TIDE TABLE

The design high and low water levels of the Site under different recurrence intervals are shown below:

Table 1.6-1 Design high and low water levels of the plant site under different recurrence intervals

Recurrence interval (years)	High water level (m)	Low water level (m)
Average	3.21	-1.04
5	3.46	-1.08
10	3.74	-1.14
20	4.05	-1.28
50	4.51	-1.46
100	4.89	-1.58
200	5.32	

From surveyed data analysis, the highest flood level near the project area is 5.605 m.

Significant wave height

The significant wave height of 50-year return period is 1.799m in the project site.

Bangladesh National Building Code (2006) states that the design surge heights at the coastal region from Bhola to Barguna is 6.2m (50-year return period) and 7.7m (100-year return period).

1.7 WATER TEMPERATURE

Design and average water temperature

The value of average water temperature at frequency of 10% in the hottest period (3 months) for the recent five years is 31.55°C (±0.665°C). Monthly average water temperature of the Site is as below:

Table 1.7-1 Average water temperature in the Site

Item	month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Monthly Average		20.6	23.6	27.1	29.0	29.5	29.3	28.7	28.7	28.6	27.8	25.1	21.7
Monthly average Maximum		22.2	25.2	28.3	30.0	30.4	30.2	29.3	29.3	29.1	28.5	26.3	23.0
Monthly Average minimum		19.5	22.1	25.2	26.7	28.9	28.2	28.1	27.9	28.0	27.3	24.2	20.2

The average water temperature of the Site is 26.6°C.

Daily & weekly variation and vertical variation of water temperature

Due to effects of tide, solar, wind and other factors, the daily and weekly variation of water temperature is obvious.

Table 1.7-2 Water temperature variation range in different layers of water intake points

Layers	Day	1	2	3	4	5	6	7
0.2H		4.3	4.7	4.4	4.3	4.1	4	3.7
0.5H		3	4	3.5	3.6	2.7	3.8	2.2
0.8H		2.1	2.7	3.2	2.4	1.6	3	2.1
Depth (m)		6.92	7.59	6.68	6.83	6.74	6.64	5.99

From sheet above, the daily and weekly variation is biggest in spring tide which ranges up to 4.7°C, whereas, the smallest variation is in neap tide, and mid-tide is in between.

1.8 SALINITY

In the vicinity of the Site, salt water and fresh water gets mixed together and the quantity of salt water will vary with the strength of tide, runoff size, boundary condition of estuary, in the medium and long term, salinity change is expected to be seasonal and spatial.

As such, the Site shall be considered to belong to a high salinity area, and the salinity range is between 10.01 to 15ppt.

1.9 FUEL

1.9.1 COAL

The coal characteristics, ranges and design basis provided in Attachment B3 of Section 5 as “Design Coal” are the specification for the Contractor’s delivery of the Works. The coal values provided as “Design Coal” shall be used as the basis for determining the achievement of guarantees under Attachment A3 (i) Schedule of Performance Guarantees.

In addition to the “Design Coal” characteristics and specifications listed in Attachment B3 of Section 5, there is also a listing of analyses of “Worst Coal” that may be burned. This coal must be taken into consideration by the Contractor for the design of the Works. Operating efficiency will not be evaluated based on burning of Worst Coal. The Power Station must be capable of achieving base load operation at the Dependable Capacity without the use of support fuel when burning any of the coals specified in Attachment B3 of Section 5, while the Power Station emissions remain in compliance.

For mercury and hydrogen fluoride emissions guarantees the following limits apply:

a) Maximum acceptable level of mercury in any of the coals cannot exceed 0.250 ppm by weight dry (or 250 ppb) in the coal as fired.
b) Maximum acceptable level of hydrogen fluoride in any of the coals cannot exceed 100 ppm by weight dry in the coal as fired.

1.9.2 HIGH SPEED DIESEL (HSD)

HSD shall be used for boiler startup, diesel generator operation and diesel driven fire water pump operation. The required distillate fuel quality is listed in Table 1.9-1 below:

Table 1.9-1
Distillate Fuel Specifications

Property	Unit	Limit
VISCOSITY KINEMATIC AT 100 DEG F	CST	MAX 9
FLASH POINT	DEG F	MIN 95
POUR POINT	DEG C	MAX 6
ASH	% WT	MAX 0.01
SULFUR CONTENT	% WT	MAX 0.25

Please refer to the relevant documents in the System Definitions in Attachment C of Section 5 of the Employer’s Requirements for additional requirements relating to Fuel Oil Unloading, Storage.

1.10 WATER

The design basis water analysis is provided in Attachment E1 of Section 5. Water from the river will be used for service water, and construction water uses. The water qualities for river water in Attachment E1 of Section 5 are the existing water qualities for the Contractor’s reference. The Contractor shall take into account this information to design the Plant, based on the operational requirements of the Plant’s equipments.

1.11 ENVIRONMENTAL

1.11.1 GENERAL ENVIRONMENTAL REQUIREMENT

The summary of environmental requirements used for the specification is laid down in the paragraphs below.

The Continuous Emission Monitoring System (hereinafter called 'CEMS') shall be installed to monitor flue gas from the Plant. CEMS shall be required to monitor amount of the flue gas and its concentrations of NOx, SO_2, Particulates and CO.

The continuous monitoring system for amount of the effluent from the wastewater treatment system and pH value and turbidity shall be monitored. The monitoring shall be conducted at the treated water pit of the wastewater treatment system in the Plant.

1.11.2 ENVIRONMENTAL LIMITS

The following environmental limit values shall be taken into account for the design and implementation of the Coal Based Power Plant:

Gas Emission*

Item	Unit	Country's Standards	Contract Limit
SPM	mg/Nm^3	150	50
SO_2	mg/Nm^3	N/A	200
NO_2	mg/Nm^3	600	350

*Guarantee Values of exhaust gas emission is referred to "Schedule of Other Guaranteed Criteria" Attachment A3 (ii) of Section 5

Noise Emission*

Item	Unit	Country's Standards	Contract Limit
Noise Level	dBA	Day : 75 Night : 70	Day : 70 Night : 70

*Guarantee Values of noise emission is referred to "Schedule of Other Guaranteed Criteria" Attachment A3 (ii) of Section 5
**"Country's standard" is standard for sound in industrial area (The time from 6 a.m. to 9 p.m. is counted as daytime. The time from 9 p.m. to 6 a.m. is counted as night time.)

Water Quality Standards for Effluent

Item	Unit	Country's Standards	Contract Limit
Amount of effluent	m^3/s	N/A	N/A

Item	Unit	Country's Standards	Contract Limit
Water Temperature	^{o}C	40 (Summer)	40 (Summer)
		45 (Winter)	45 (Winter)
pH	-	6-9	6-9
DO	mg/l	4.5-8	4.5-8
SS	mg/l	150	150
Oil	mg/l	10	10
BOD	mg/l	50 (at 20 ^{o}C)	50
As (Arsenic)	mg/l	0.2	0.2
Pb (Lead)	mg/l	0.1	0.1
Fe (Iron)	mg/l	2.0	2.0

*"Country's standard" is standard for inland surface water usable by fisheries

1.11.3 RIVER WATER DISCHARGE

The maximum river water discharge temperature at the outfall shall not exceed 40 ºC, and shall be in compliance with the limits established in the final approval of the applicable requirements of the Project's EIA.

1.11.4 ENVIRONMENTAL MONITORING

A monitoring plan for the construction and operation of the Plant shall contain at least the following information:

- Subject of monitoring;
- Parameters to be monitored;
- Monitoring locations;
- Monitoring duration and frequency;
- Proposed monitoring equipment;
- Proposed sampling equipment;
- Sampling methods;
- Methods for analysis;
- Responsible party;
- Reporting requirements.

The monitoring plan should be finalized, accepted by the Employer and ready for implementation at least 1 month prior to the start of mobilization to the site and start of any construction activities.

1.11.5 ENVIRONMENTAL MANAGEMENT PLAN

An environmental management plan has to include monitoring and mitigation measures.

The overview outlines only major mitigation measures and are not in a comprehensive extent. A more detailed mitigation plan has to be developed. The mitigation plan should include at least the following information:

- Subject of mitigation;
- Detailed description of mitigation;
- Preparatory works;
- Supervision requirements;
- Legislative background;
- Description of equipment, if needed;
- Responsible party;
- Reporting requirements.

The management plan should be finalized, accepted by the Employer and ready for implementation at least 1 month prior to the start of mobilization to the site and start of any construction activities.

1.12 PERFORMANCE GUARANTEES

The requirements of Attachment A3 of Section 5 shall be in accordance with the test protocols in Chapter 38 of Section 5 - Employer's Requirements and shall be as follows:

1.12.1 GUARANTEED THERMAL PERFORMANCE

The following definitions shall be used:

a. Maximum Continuous Rating = (MCR) 100% (Guarantee Point)
b. Turbine Maximum Continuous Rating (TMCR) (103% MCR under Valve Wide Open (VWO) condition)
c. Boiler Maximum Continuous Rating (BMCR) (105% MCR)

Performance Guarantees shall be based on the following conditions and parameters as shown in Table 1.12.1-1:

Table 1.12.1-1 Performance Guarantees Conditions	
Parameters (Basic for Performance Guarantees)	**Value**
Ambient Dry-Bulb Temperature, ºC	30.7
Ambient Relative Humidity,%	88%

Ambient Pressure, kPa (a)	99.84
Guarantee Fuel	Performance Test Coal (Attachment B3, Section 5)
Power Factor at GSU High Side Terminals	0.85 lagging
Raw Water Temperature	32.2
Plant Operating Loads	100% MCR, 75% MCR and 50% MCR
Make-up for output guarantee	0 percent of steam flow (no correction allowed)
Make-up for heat rate guarantee	0 percent of steam flow (no correction allowed)
Metering Point	HV side Of GSU transformer

In the event that conditions are not as described above, mutually agreed corrections shall be applied to the test results in accordance with the applicable ASME PTC codes.

The test coal shall be as close as possible to the Performance Test coal value indicated into Attachment B3, Section 5 of the ER in composition and characteristics such that a reasonable comparison to guaranteed performance can be made. During the boiler efficiency determination, the heating value and constituents of the test coal (including volatile matter and fixed carbon) shall be within a +/- 5% (relative) band of the Performance test coal analysis for ASME Code test corrections to apply. If the Performance Test coal provided does not meet criteria, mutually agreed corrections shall be determined and will apply.

The following table shows the Design Parameters that are to be considered for the design of the Plant:

Table 1.12.1-2
Design Parameters

Parameters (Basis for Design)	Value
Ambient Dry-Bulb Temperature, ºC	5ºC to 43ºC
Ambient Relative Humidity,%	29% to 95%
Ambient Pressure, kPa (a)	99.84
Maximum Wind Velocity	240km/hr
Rainfall	180cm to 340cm
Wind Direction	Winter – North-West Summer – South

1.12.2 GUARANTEED IN-PLANT NOISE EMISSIONS

The A-weighted sound pressure level resulting from the normal operation of each individual equipment package included in the Contractor's scope of supply shall be specified to not exceed a spatial average of 85 dB(A) along the equipment envelope at a height of 1.5 m above the ground and personnel platforms. The equipment envelope is the perimeter line that completely encompasses the equipment package at a distance of one meter from the face. During detailed design, the Contractor shall evaluate near-field sound levels on an individual equipment basis to identify special noise control measures necessary to comply with the 85 dB(A) criterion. If certain noise control measures are not reasonable and feasible for reasons including, but not limited to performance, maintenance access, heat buildup, space limitations, safety (such as on pulverisers and desuperheater valve stations), the Contractor shall implement administrative controls. Administrative controls include posting warning signs, prescribing hearing protection, and limiting personnel access.

During intermittent operations such as, but not limited to, startup and shutdown as well as upset and emergency conditions, the sound levels within the Plant may potentially exceed the sound levels experienced during normal operations. However, the in-plant noise emissions due to the Project during these intermittent operations shall not exceed an A-weighted sound pressure level of 115 dB(A) in any area that is normally accessible by facility personnel and is not posted to require hearing protection.

The Contractor shall conduct an in-plant noise survey to identify the in-plant areas associated with the Project that are exposed to A-weighted sound pressure levels exceeding 85 dB(A) during normal operation. These areas shall be identified with warning signs prescribing hearing protection in order to support compliance with DOSH permissible noise exposure levels. The in-plant noise survey shall be conducted in accordance with a test procedure developed by the Contractor and approved by the Employer. The in-plant noise emissions test procedure shall include the requirements detailed in Chapter 38.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 2 – SCOPE OF WORKS

CONTENTS

2 SCOPE OF WORKS

2.1 GENERAL DESCRIPTION AND REQUIREMENTS

The Power Station will be an ultra-supercritical pulverized coal fired electric power generating plant. The Plant shall be designed to burn coal as given in Attachment B3 of Section 5 delivered via the new jetty. The coal is transferred from transfer towers through the conveyor system to coal stock yard and coal silos/bunkers located in the boiler house. Air quality control shall meet IFC-World Bank standards and limits prescribed by the Laws, in particular the emission limits of the DOE requirements. The Power Station shall include flue gas cleaning equipment to reduce the particulate air pollutants and SO_x created during combustion. Flue gas desulfurization and particulate removal shall be included as specified herein. Circulating condenser cooling water shall be provided using cooling tower. Sanitary waste, oily operational wastes, and industrial wastes shall be treated within the Site.

The following documents are attached to these Employer's Requirements to provide additional clarification for the equipment and systems design criteria, including:

1. **Attachment A1** (Technical Schedule of Submittals) of these Employer's Requirements.

2. The proposed indicative General Layout of the power plant is as per drawing number 10-PM-PAY-01 and 10-PM-PAY-02, attached as in **Attachment B4** of these Employer's Requirements which also shows the Site arrangement for the Power Station and also the Future 2 Units and facilities.

3. The proposed Fresh Water Supply diagram is indicated in drawing number 10-PM-PAY-14, attached in **Attachment B4** of these Employer's Requirements.

4. A proposed indicative of Plant Control System Configuration diagram is indicated in drawing number 10-PE-PAY-03, attached in **Attachment B4** of these Employer's Requirements.

5. A proposed Single Line Diagram is indicated in drawing number 10-PE-PAY-01 and 10-PE-PAY-02, attached in **Attachment B4** of these Employer's Requirements and shows the proposed electrical system arrangement.

6. Coal data for coal supply sources is included in **Attachment B3** of these Employer's Requirements. The specified "Worst Coal" shall not form the basis for the Performance Guarantees but are coals which the Contractor must take into account when designing the boiler and other balance of plant systems. The Plant must be able to operate at base load and comply with statutory emission limits when burning any of these coals.

7. System Definitions are included in **Attachment C** of these Employer's Requirements and provide additional descriptions and criteria for the functions of the various systems comprising the Plant.

8. Site data, reports and files as described in Chapter 1 of Section 5, are attached in **Attachment D** of these Employer's Requirements which contains geotechnical reports, and **Attachment E1** of these Employer's Requirements which contains Water Analysis. The Site Survey data in included together with the General Layout Drawings in **Attachment B4** of these Employer's Requirements.

The Power Station shall be designed on the basis of the operational parameters as follows:

Number of cold starts per year:	4
Number of warm starts per year:	12
Number of hot starts per year:	48

The starts shall be defined as follows:

i. Cold start – steam section at ambient conditions (The unit out of service for 48 hours or more).
ii. Warm start – boiler bottled up (The unit out of service more than 8 hours but no more than 48 hours).
iii. Hot start – restart as soon as trip or down condition identified and addressed. Normally this is less than 8 hours after trip or shutdown.

The Power Station shall be designed for a twenty five (25) year life from the date stated in the Taking-Over Certificate including that for hot parts (high energy steam piping, turbine and boiler) except for parts expected to wear out and be replaced under normal operations. The Contractor shall provide Plant output and heat rate degradation curves for the design life of the Plant.

Detailed engineering shall appropriately address each of the following general criteria:

Maintainability and equipment access.
Availability.
Reliability.
Operability.

Space available on the Site including ash pond perimeter bund for use as laydown, fabrication yards, temporary offices, and other temporary construction facilities is limited. The Contractor will be responsible for obtaining any additional land off-Site required to support its construction activities.

2.2 FUTURE UNITS

The arrangement drawings and other attachments make reference to additional units of similar capacity that is proposed to be constructed in the future ("**Future Units**"). The Contractor does not need to furnish the equipment or facilities associated with the Future Units but information on the Future Units is provided in order for the Contractor to take the Future Units into consideration when developing the Site layout and engineering design for the Power Station. The Contractor will be expected to allow space in his layout and provide cross-ties for the Future Units, as indicated in the following table.

No.	Description	Tie-in location	Connection	Remarks
1	Two Feeders in SLD	At 6.6kV switchgear in electrical room of New Units	Cable terminal	See SLD (2 feeders for Future Units are included in the Base offer)
2	Demineralized Water	At the DM water tank of New Units	Flange	Designed for Unit 1 only. The tie only support temporary use of Future Units.
3	Raw Water	At the raw water pipe upstream of service/fire water tank of New Units	Flange	Designed for Unit 1 only. The tie only support temporary use of Future Units.
4	Service Water	At the service water header close to New Units	Flange	System capacity is designed for Unit 1 only. The tie only support temporary use of Future Units.
5	Fire Water	At the fire water header of New Units	Flange	
6	Potable Water	At the potable water header of New Units	Flange	System capacity is designed for Unit 1 only. The tie only support temporary use of Future Units.
7	Auxiliary Steam	At the auxiliary steam header in the turbine hall of New Units	Flange	
8	Service Air	At the service air header of New Units	Flange	System capacity is designed for Unit 1 only. The tie only support temporary use of Future Units.
9	Coal Forwarding Conveyor to Bunker	At the tripper floor of New Units	Belt	
10	Coal Forwarding Conveyor to Coal Yard	At the tripper floor of New Units	Belt	

2.3 PROJECT SCOPE & EMPLOYER’S RESPONSIBILITIES

2.3.1 PROJECT SCOPE

The Project includes all facilities required for an independent, electric power generating unit, excluding those facilities specifically stated as being provided by the Employer. The Contractor's services and scope of works shall consist of designing, procuring, manufacturing, furnishing/expediting/inspecting equipment and materials, constructing facilities, installing and checking equipment, system checkout, starting up, commissioning, and testing of the Plant.

The Power Station shall include the following major facilities provided by the Contractor unless otherwise instructed by the Engineer or the Employer but not limited to:

1. Central Control Building
2. 400kV substation
3. Jetty
4. Coal yard
5. Warehouse/Store Building
6. Fire Protection Pump House
7. Water and wastewater treatment facilities.
8. Oily wastewater collection.
9. Condensate Polishing System.
10. Potable water supply.
11. Demineralized water treatment and cycle makeup.
12. Steam Turbine generator and auxiliaries.
13. Boiler and auxiliaries.
14. Turbine and Boiler buildings.
15. Soot blowing.
16. Steam cycle sampling and analysis.
17. Auxiliary Steam System (Auxiliary Boiler)
18. Air quality control equipment including FGD and particulate removal equipment.
19. Continuous Emissions Monitoring System (CEMS)
20. Chimney (with steel liner and elevator)
21. Steam condensing and feedwater equipment, with capability for condenser water box removal and condenser access.
22. Circulating water system including but not limited to river water intake channel, structures, cooling towers.
23. HVAC System.
24. Closed Cycle Cooling Water System.
25. Service Water Supply and Storage System.
26. Fuel Oil Unloading, Storage and Supply System.
27. Fire protection equipment.
28. Coal Handling System.
29. Coal dust control.
30. Ash Handling Systems including 10 year ash pond (Boiler Bottom Ash and Fly Ash).
31. Control and electrical equipment for protection and operation of the generating unit.
32. Hydrogen and CO_2 Generator system
33. Compressed air systems
34. Generator step up, unit and standby transformers.
35. Complete auxiliary electrical equipment including transformers, switchgear and bus duct, motor control centers, secondary unit substations, batteries and chargers, inverters, grounding, motors, protective devices, cable and cable support system, lighting and communications.

36. Emergency diesel generator.
37. DCS system.
38. Uninterruptible Power Supply System
39. Cycle chemical feed equipment.
40. Temporary construction facilities.
41. Piping and equipment insulation.
42. Chemical cleaning (including chemicals and disposal of waste products).
43. Steam blowing.
44. Turbine hall electric top running crane.
45. Other permanent hoists, cranes and/or trolleys as specified herein.
46. Sanitary Waste Collection and Treatment System.
47. Industrial Waste Collection and Treatment System.
48. Spares
49. A boiler furnace inspection and portable boiler maintenance platform system.
50. A distributed control system “DCS” based boiler integral instrumentation and control system including boiler protection system, burner management system “BMS”, burner control panel, soot blower control system, burner level monitoring system
51. PLC based air heater automatic leakage control system with control connectivity to the DCS.
52. A turbine integral instrumentation and control system including, but not limited to turbine supervisory instrument, conditions monitoring system, turbine protection system with on-line protection testing system, automatic turbine run up systems “ATRS”, turbine stress evaluator “TSF”, electro hydraulic governor control “EHG”, HP-LP bypass system, boiler feed pump control system and interface with DCS shall be provided.
53. A comprehensive cathodic protection system using sacrificial anodes and/or impressed current

The Contractor shall also provide the following:

1. A separated 3-D model for each main package of the Plant including, but not limited to turbine hall, boiler, electrical buildings, cooling towers, coal handling, and civil works
2. Project management including scheduling and reporting.
3. Engineering services, including procurement, expediting and inspection, delivery of equipment and materials to Site, Site investigations and surveys, conceptual and detailed design (including engineering QA), resident (Site) engineering, QA/QC (both shop and field), start-up spare parts, start-up services, O&M manuals, and engineering completion including conformed to construction record “as-built” drawings.
4. Training and training materials, compliance and test records, Environmental, Health and Safety “EH&S” manuals and records, which shall be provided in the English language.
5. Construction services including construction management, construction, construction equipment, construction facilities, safety and loss prevention program, fencing, construction power and water, construction site security, preoperational checkout,

pre-commissioning, commissioning, testing and startup, performance testing, and construction close-out.

6. Site preparation for construction as required, including grubbing, excavation, fill, drainage, additional soil investigation if required and topographic surveying.
7. Building, construction and other permits except those furnished by the Employer, including permits associated with the off-Site man camp.
8. Temporary offices and facilities for the Employer during the construction phase.
9. Dredging operations necessary to complete the project implementation during construction period that relate to plant development.
10. Consumables and spare parts for construction, startup and testing to include maintenance materials, spare parts warehousing and management, except as specified in other parts of this specification. The first fills for permanent plant equipment lubrication oil, grease, and plant operational consumable chemicals shall be provided by the Contractor.
11. Collection and proper disposal of construction debris at a suitable off-Site facility.
12. Training and instruction of the Employer's Personnel.
13. Testing and inspection.
14. Correction of defects as required by the commercial terms.
15. Operating and maintenance spare parts for all equipment as approved by the Employer.
16. Instruction manuals for each piece of equipment. Manuals shall be complete. The O&M manuals shall be in the English language and shall include parts lists, maintenance procedures and operating instructions specific to the equipment. Electronic copies of manuals shall be provided to the extent available from subcontractors.
17. Adequate drawings as required to construct and maintain the equipment.
18. As-built drawing files in AutoCAD (.dwg) format for all design drawings, or format as further defined in Chapter 3 of Section 5.

2.3.2 WORK NOT INCLUDED UNDER THE EMPLOYER’S REQUIREMENTS

The following will be furnished or procured by the Employer:

1. Coal, electricity and distillate fuel for Tests on Completion in accordance with Chapter 38 of Section 5.
2. Coal for coal yard base
3. Transmission line structures and lines connecting to the grid system
4. Fuel transportation to the defined interface points.
5. Land acquisition for the Power Station.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 3 – GENERAL SPECIFICATION

3 GENERAL SPECIFICATION

3.1 GENERAL

The works and services to be provided by the Contractor shall include furnishing a complete Payra Thermal Power Plant (2 x 660MW) to be used for the new power plant, including design, procurement of equipment, materials, transportation, erection, construction, and services as specified herein. Whenever the terms “provide”, “furnish”, “supply”, “furnish and/or install’, etc. are used, it is intended that the Contractor shall install the equipment and systems unless specific notation is made that the equipment, device, or system is to be installed by others.

The Works shall include all temporary and permanent works in place from initial site preparation to start-up and testing as required for a complete operable plant, including electrical power for construction activities.

The Services will include Contractor’s and Vendors’ services of technical instruction as required for placing the new plant into successful operation and for training of the operation and maintenance personnel of the new plant.

Here in Chapter 3, general requirements are specified. The Contractor shall comply with the specification specified in this Chapter.

3.2 CODES AND STANDARDS

3.2.1 GENERAL

All components, systems, and equipment shall be designed, manufactured and tested at manufactures’ workshops, installed and, after installation at the Site, shall be tested and commissioned, in accordance with applicable internationally recognised standards, and statutory codes and regulations, including those specifically listed in this specification. The Contractor shall provide with its proposal a schedule of all the codes and standards he proposes to use for the Project. If the Contractor proposes alternate codes or standards to those listed below, he must demonstrate that the alternate is of equal or superior stringency than the comparable code or standard system listed in this specification, and obtain the Employer’s approval, approval will be solely at the Employer’s discretion. No proof of equivalence is required for the use of STG and Boiler manufacturer’s own standards for pre-designed equipment and systems within the STG and Boiler packages, including the electric generator. Where specific codes are specified without the option for equivalent standards, the Employer’s approval must be obtained to use another standard or code.

The codes, standards and specifications referenced in this Document (including addenda, amendments and errata) shall govern in all cases where references thereto are made. In case of conflict between these codes (or standards or specifications) and the requirements specified in this Documents, the letter shall govern.

The codes, standards or specifications applied in each case shall be the latest revision adopted and published at the bid closing date. Any conflict between standards shall be referred to the Employer who will determine which standard shall govern and the Employer's decision will be final.

In the case of the Standards and Codes not published in English, the Contractor shall obtain English translation when required and send them to the Employer at no additional cost.

All interfaces with the Power Grid Company of Bangladesh (PGCB) national grid shall comply with the requirements of PGCB. The natural gas supply system shall comply with all national standards and regulations.

The fire detection and protection systems shall provide coverage of the Site and shall comply with NFPA codes (or equivalent) in addition to all statutory and local authority requirements. The Contractor shall cooperate with the Employer's insurance carrier's requirements to finalise the fire protection design.

The Plant shall be constructed, installed and commissioned and be operable and maintainable in full compliance with relevant health and safety at-work orders, all related acts, regulations, codes and statutory requirements. All warning and instruction notices shall be in English.

3.2.2 LIST OF REFERENCES

The full name of the listed reference codes and standards are:

Reference Abbreviation	**Name**
AASHTO	American Association of State Highway and Transportation
AABC	Associated Air Balance Council
ACI	American Concrete Institute
ADC	Air Diffusion Council
ABMA	The American Bearing Manufactures Association
AGMA	American Gear Manufactures Association
AISC	American Institute of Steel Construction, etc.
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Institute
AMCA	Air Movement and Control Association International, Inc.
ANSI	American National Standards Institute
AIJ	Architectural Institute of Japan
API	American Petroleum Institute
ARI	Air Conditioning and Refrigeration Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASME	American Society of Mechanical Engineers

ASNT	American Society of Non-destructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BNBC	Bangladesh National Building Code
BS	British Standard
CEIAC	Coastal Engineering Defence Information Analysis Center
CGA	Compressed Gas Association
CMAA	Crane Manufactures Association of America
DIN	German Institute for standardization
EN	European Committee for Standardization
FED SPEC	Federal Specifications, Standards and Commercial Item Descriptions
FM	Factory Mutual Insurance Co.
HEI	Heat Exchange Institute
HIS	Hydraulic Institute Standards
HMI	Hoists Manufacture's Institute
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Institute of Petroleum
ISA	Instrument Society of America
ISO	The International Organization for Standardization
JASS	Japanese Architectural Standard Specification
JIS	Japan Industrial Standard
MBMS	Metal Building Manufactures Association, USA
MSS	Manufacturers Standardization Society of The Valve and Fitting Industry Inc.
NAAMM	National Association of Architectural Metal Manufacturers
NACE	National Association of Corrosion Engineers
NBS	National Bureau of Standards, USA
NEBB	National Environmental Balancing Bureau
NEMA	National Electrical Manufacturers Association
NERC	North American Electric Reliability Council
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act.
PFI	Pipe Fabricators Institute
SAMA	Scientific Apparatus Manufacturer's Association
SAE	Society of Automotive Engineers, USA
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association, Inc.
SSPC	Structural Steel Painting Council
TEMA	Tubular Exchanger Manafacturers Association, Inc.
UBC	Uniform Building Code of USA
UL	Underwriters laboratories, Inc.

3.3 LANGUAGE AND UNITS

All correspondence, drawings, catalogues, illustrations, specifications, and other documentation related to the project shall be in the English Language. The units of measurement shall be expressed in the SI system.

The following units of measurements and symbols are reference to use for the project:

Quantity	**Unit Description**	**Unit Symbols**	**Remark**
Acceleration	Meter per square second	m/s^2	g: acceleration gravity
Area	Square metre Square centimetre Square milimetre	m^2 cm^2 mm^2	 for cable cross section
Bolts & Nuts	Milimetre	mm	Inch is not acceptable
Capacitance	Farad Microfarad	F µF	
Capacity	Mega Volt Ampere Kilo Volt Ampere Volt Ampere	MVA kVA VA	
Computer Storage Capacity	Byte Kilo Byte Mega Byte/Giga Byte	byte kb MB/GB	
Concentration	Part per million Part per billion	ppm ppb	
Conductivity	Micro Siemens	µS	
Density (mass)	Kilogram per cubic metre Ton per cubic metre	kg/m^3 t/m^3	 1 ton = 1000 kg
Electrical Current	Kilo Ampere Ampere Mili Ampere	kA A mA	
Electrical Energy	Kilowatt hours	kWh	
Fineness	Micro meter	µm	
Flow	Kilogram per hour Cubic metre per hour Cubic metre per second Cubic Centimetre per hour Litre per second	kg/h m^3/h m^3/s cm^3/h l/s	e.g. for steam/solid substance e.g. for liquid or gas Normal =(N) for Natural gas at 1.01 bar and 15°C
Mass (weight)	Ton (metric) Kilogram Gram	t kg g	
Frequency	Hertz	Hz	

Quantity	Unit Description	Unit Symbols	Remark
GD^2 Effect	Kilogram Metre-square	kg m^2	
Heat	Kilo Joule	kJ	
Inductance	Henry	H	
Length/thickness	Kilometre Metre Centimetre Milimetre Micrometre	km m cm mm µm	No gauge, such as BWG for thickness
Force	Newton Kilo Newton	N kN	
Moment (torque)	Ton metre Kilogram metre	tm kgm	
Noise	Decibel	dB	
Pipe Rating	Schedule	Sch.	
Power	Watt Kilowatt Megawatt	W kW MW	
Pressure	Bar	Bar	Absolute = (abs) or (not mentioned)
Strength, stress	Kilo Newton per square meter	kN/m^2	
Pressure (Head)	Metre of water column Milimetre of water column Milibar	mWC mmWC mbar	Bar or milibar could also be accepted
Printer Speed	Character per second Line per minutes		
Resistively	Ohm	Ohm, Ω	
Rotational Speed	Revolution per minute	rpm	
Temperature	Degrees of Celsius	°C	
Time	Hour Minute Second	h min s	
Valves & Fittings Rating	Bar	bar	ANSI Rating lbs (#) is also acceptable but bar is preferable
Velocity	Kilometre per hour Metre per second Centimetre per second	km/h m/s cm/s	
Viscosity	Poise (dynamic) Stokes (kinematic)	P St	
Voltage	Kilo Volt Volt	kV V	
Volume	Litre	L	
	Cubic metre	m^3	

Quantity	Unit Description	Unit Symbols	Remark
	Cubic Centimetre	cm^3	Or cc

3.4 BID DRAWINGS AND DATA

3.4.1 GENERAL

Employer’s Drawings included in Attachment B4 of Section 5, are Bid drawings.

3.4.2 BID DRAWINGS

Drawing issued with this Employer’s Requirement known as Bid drawings show the arrangements of Plants and Systems required by the Employer.

The Bidder is requested to bid the Works in accordance with the Employer’s arrangements.

If the arrangements of the Plant proposed by Bidder are different from the Employer’s arrangements, such differences shall be fully explained and justified in the proposal.

The Bidder shall arrange the equipment, panels, piping and other system components in such a way to give an ample maintenance space.

The overall flow diagrams shown in the Bid Drawings are preliminary only. Bidder shall make all complete P & IDs optimized to meet the requirement of standards, codes applicable and the specifications to associated system.

3.4.3 DATA AND DRAWINGS SUBMISSION WITH PROPOSAL

3.4.3.1 GENERAL

The Bidder shall submit with his proposal all data, information and drawings specified herein. Data and curves related to the performance of the Plant items and equipment shall be a part of the Contract.

3.4.3.2 DATA AND DRAWINGS REQUIRED WITH PROPOSAL

The Bidder shall submit at least the following data and drawings with his proposal.

3.4.3.2.1 GENERAL ARRANGEMENTS

Layout with elevations and sections showing the Plant arrangement, principal dimension, parts to be assembled on Site, and shall also clearly indicate the laydown areas and major component removal routes. The general plant arrangement drawing shall include sufficient plan and elevation views to show the arrangement of all equipment both horizontally and vertically in relation to each other.

- General arrangement of all significant items of plant to be supplied, including cross section drawings and details.
- General arrangement of all control panels, switchboards, motors and power control centers, and transformers. The layout of instruments and control functions shall be shown.
- Proposed foundation concept (showing extent of piling), arrangement and detail drawings for all major plant equipment and buildings structures supplied under this Contract.
- Layout and arrangement showing principal power cable, control cable, piping and duct routes.

3.4.3.2.2 DESCRIPTION OF ALL PLANT EQUIPMENT AND SYSTEMS

Description of all plant equipment and systems including start-up and shut-down procedures, operation mode, control philosophy and special features of the equipment and systems.

3.4.3.2.3 DIAGRAMS

- Process and flow diagram for all systems supplied under this Contract.
- Functional logic diagrams representing the major components and system of the Plant. The diagrams shall be in the form of standardized P & IDs and shall be completed in every detail, represent of equipment and piping system including valves, instruments, etc.
- Electrical single line diagrams of Substation and Plant electrical system, including protection diagrams.
- Heat balance diagram for three (3) guarantee cases, 100%, 75% and 50% plus 80/60/40%.

3.4.3.2.4 TECHNICAL DATA SHEETS

Technical data shall be fulfilled as the data sheet indicated in Section 4 Bidding Forms.

3.4.3.2.5 PERFORMANCE DATA AND CURVES

Performance Data and Curves for the Coal Based Power Plant, systems or plant items supplied under this Contract which shall include, but not be limited to, the followings:

- Steam turbine performance curves
- Generator and excitation performance curves
- PA, FD, ID fans performance curves
- Correction curves due to ambient and cooling water temperature, pressure, level, frequency change, different types of coal, etc.
- Specific coal consumption curve.
- Derating curves of Plant Heat Rate for 25 years period.

3.4.3.2.6 QUALITY ASSURANCE AND QUALITY CONTROL DATA
Quality assurance and quality control data.

3.4.3.2.7 PROPOSED CONSTRUCTION SCHEDULE
Proposed construction schedule.

3.4.3.2.8 STATEMENTS OF DESIGN INTENT FOR STRUCTURE, CIVIL AND BUILDING WORKS
Statements of design intent for civil works which define the extent and purpose of works to be designed and include description of the philosophies that governs the design.

3.5 DATA AND DRAWING SUBMISSION

3.5.1 GENERAL

Following the award of the Contract, the Contractor shall prepare and provide to the Employer for review and approval all drawings, schedules, calculations, documents, data and information necessary for proper supervision by the Employer of the work involved and to provide a detailed and comprehensive record of all aspect of the Works.

The extent of these submittals shall include, but not be limited to, those specified, and shall be sufficiently comprehensive to fully establish that all parts and procedures to be used in performing the Works comply with the objective of the Contract and with requirements for installation, operation and maintenance.

The Employer shall have the right to require the Contractor to submit such additional information as may reasonably be required.

All drawings and documents prepared by the Contractor or his Subcontractors shall bear an approved contract reference and title and title block and Employer’s reference drawing number.

All documentation whether letters or drawings shall show the project title and number.

The Employer will not normally require to receive copies of detailed manufacturing drawings but the Contractor shall make this available to the Employer if so requested.

All drawings shall be to scale and fully detailed and dimensioned. The material of which each part is to be constructed shall be indicated. Each drawing shall be clearly stamped to indicate the applicable status e.g. For preliminary, For Information, For Review, For Approval, For Construction, and As Built.

3.5.2 SIZE

With the exception of drawing and certain other forms such as certificates, all other documents shall be size A4. The maximum sheet size for drawings shall be size A1. Documents sized A0 are not acceptable.

Except in instances where the original drawing is size A4, drawings for inclusion in technical manuals should be size A3, double folded to size A4. If drawings of size larger than A3 are required to drawings shall be folded with title visible and bounded along with the left hand side.

All documents greater than size A3 must be capable of reduction to size A3 with no loss of symbol, lettering legibility, etc. Such drawings shall also have a minimum left-hand margin of 25 mm at size A3 to ensure that no information is obscured by binding.

The Contractor shall provide electronically versions of all documentation and drawings.

3.5.3 SYMBOLS

Symbols shall comply with relevant international standards for Construction Drawing Practice Graphical Symbols for General Engineering and Electrical Power, Telecommunications and Electronics Diagrams. This includes but is not limited to:

- ISO 1000 The International System of Units (SI) and its Applications.

3.5.4 UNITS AND SCALE RATIOS

All drawings shall be supplied in SI metric units using one of the following scales 1:1, 1:2, 1:5, 1:10, 1:25, 1:50, 1:100, 1:200, 1:500, 1:1,000, or 2,500. Third angle projection shall be used throughout. All drawings shall be provided with a scale bar.

3.5.5 CONTROL

The Contractor shall, for all works to be performed under the Contract, establish and maintain a comprehensive computer-based document control system ensuring that, at all phases of the work the identification, revision, status and location of documentation is determined. The Contractor's system shall also provide for all Subcontractors' and Bidders' documents.

At the end of each reporting period the Contractor shall provide to the Employer a complete hard and electronic record and electronic copies of all drawings, submissions, documents and correspondence delivered in both hard and electronic form during that reporting period.

3.5.6 IDENTIFICATION

The Contractor shall develop and maintain an identification system for all project documentation for permanent inclusion in the Works which shall enable the Contractor to control the documentation in the live phase of the project and enable the employer to fully, efficiently and to the standards required by the contract, operate and the Plant by providing ready access to the system. The Contractor shall therefore develop a method to identify documents to their specific process/pressurised system and any interfaces appertaining thereto. This philosophy shall be maintained in the assembly of the required Engineering, Plant Operations, Maintenance, Spares and Quality Records.

The Contractor’s adopted computer based system shall be transferable to standard personal computers and transferred to the Employer at the completion of the Works as part of the documentation.

Provision shall be made by the Contractor to provide full training in the use of the identification system by the Plant Operator in readiness for hand over the system.

3.5.7 QUALITY

Paper used for documentation shall be suitable for long term storage (minimum 80 g/m^2). All drawings shall comply with the relevant standards.

All drawings shall be stored in electronic format in AutoCAD.

3.5.8 VERIFICATION

When submitting all documentation including any prepared by a Subcontractor, the Contractor shall verify that he has fully examined such drawings and that they comply with the requirements of the Contract.

3.5.9 ENGINEERING REPRESENTATIVE

If the Contractor intends to divide or subcontract any part of the Work he shall ensure that the design is fully coordinated between all the parties involved prior to submission of relevant drawings and documents for review and approval. For this purpose he shall designate an individual or group of individuals charged with the execution of this coordination work. The Contractor shall provide an organization chart clearly indicating the interfaces involved and identifying the individual to whom the Employer can refer as the “single point of contact” for this design coordination effort. The Contractor shall have their engineering representative in their office in Dhaka and/or the Project Site available to the Employer for technical discussions during the entire duration of the Project. The subject engineering representatives shall cover mechanical, electrical, civil/structural and instrumentation and control engineering disciplines and shall have full knowledge of the design requirements with full authority to resolve any discrepancies and to act to implement all design resolutions and Employer’s directives. The time required to consult to Contractor’s head office shall be minimized.

3.5.10 DOCUMENTATION SCHEDULE

The Contractor shall provide a detailed schedule of documents to be produced during the Contract in accordance with the Document Schedule for submission to the Employer. The schedule shall indicate, by generic type, those supplied for approval (specifications, procedures, etc.) and those for information. Typical documentation to be provided shall include, but not be limited to the following:

- Copy of topographical and soil investigation results and interpretation
- List of design codes to be followed
- Detail of all loadings, both actual and assumed, incorporated into the designs. Where an interpretation of codes of practice is necessary, e.g. for wind and seismic loading, the assessment and conclusion shall be clearly stated.
- Material data to include strength of materials and source of manufacture of all structural elements (include details with Tender)
- Calculations for all structural, civil and building work
- Specification of equipment
- Manufacturer’s test certificates
- Lay out drawings
- P & I drawings
- One-line drawings
- Protection drawings
- Equipment sizing calculation
- Control diagram
- Process diagram
- Others as specified in the individual specification

The schedule of documentation shall also indicate to the Employer those specific design, safety and related elements required for third party verification and, where possible, the proposed third party.

The detailed drawing list shall comprise all drawings and documents the Contractor will produce on which the Employer will decide which drawings or documents will have to be submitted for approval, information or any other purpose. The list shall be reviewed and up dated from time to time in progress of the design and construction.

3.5.11 SUBMISSION AND APPROVAL

3.5.11.1 GENERAL

The Contractor shall submit total six (6) hard copy including two (2) reduced (A3 size) copy if larger than A3 size and one (1) soft copy of all documents and drawings at all stage of the Contract.

If the Employer is satisfied with the drawing, one (1) copy will be returned to the Contractor marked with “Approved” stamp. If the Employer is not satisfied with the drawing, one (1) copy stamped “Approved as Noted” or “Not Approved” will be returned to the Contractor with comments marked thereon and the drawing shall be amended, the revision letter affixed to the Drawing Number revised and re-submitted for approval.

Revised drawing shall have indicated on them the nature of the change, the reason for the revision and the location of the revision.

The Contractor shall allow at least fourteen (14) calendar days from the receipt of hard copy, plus appropriate transit time, for each review by the Employer unless otherwise stated in the Contract.

The Employer’s comments on these drawings and data shall be resolved by the Contractor and returned to the Employer within two (2) weeks from the date of Employer’s comments. Upon receipt of approval by the Employer, the Contractor shall arrange for the “Revision column” of the drawings to be marked “approved by Employer on (date)” revised the issue letter of number and forward four (4) copies to the Employer for his use.

Review of, comments on, approval of, or expression of satisfaction with the Contractor’s drawings or calculations by the Employer shall not relieve the Contractor of any of its obligations to meet all the requirements of the Contract or relieve the Contractor of the responsibility for the correctness of such drawings. The Contractor shall make any changes that are necessary to make the work conform to the provisions and intent of the Contract.

No works shall be made without Employer’s prior approval to the drawings, calculations or procedures selected by the Employer.

Any work done before the review of the drawings and data shall be at the Contractor’s risk and any necessary design changes to comply with the requirements and objectives of the Contract shall be made at no additional cost to the Employer or without any delay to the Project execution.

The Contractor shall submit to the Employer for review and approval the following data and drawings:

a) Detailed design criteria of structural and architectural work.
b) Description of cleaning, checking and testing procedure.
c) Description of environmental assurance procedure.
d) Analysis report of safety and health for each requirement.
e) General specifications covering type and design of all principal components of the equipment.
f) Materials fully identified by referencing the appropriate Standard of material, specification number and grade or each size.

g) Detailed specifications covering construction and materials used in the equipment and description of special equipment, if included, for dismantling and assembly of equipment.

h) A complete bill of material and a list of all accessories furnished for each equipment category or specification.

i) An itemized list of all tools furnished with the equipment that is required for maintenance and repair of equipment.

j) Complete field erection drawings which detail the location of installation and connection of all items not permanently installed by the factory; each item to be field assembled shall have the same identification both upon the drawings and upon the item itself.

k) Calculations for all flow elements; information shall include data for both design and operating conditions; permanent pressure drop of the element shall also be included.

l) Detailed erection procedures and start-up and commissioning procedures for all equipment as requested.

m) Any other information required by the Employer.

3.5.11.2 DESIGN REVIEW MEETINGS

When the design has achieved sufficient progress periodic Design Review meetings will be held between the Contractor and the Employer/ the Engineer.

In order to shorten the time required for Design Review and to allow the earliest possible time for site mobilization, it is expected that the Employer and the Engineer will meet the Contractor's design staff in the Contractor's home office on several occasions to expedite drawing/ design approval. The Bidder shall therefore allow in its bid all costs associated with five of the Employer's personnel and five of the Engineer attending two such meetings, each meeting lasting 10 days. All costs shall include the cost of business class airfares, accommodation, transport, meals, medical, incidental pocket expenses for the Employer's personnel of USD 150 / person / day including travel time etc. The actual number of such meetings will be discussed and agreed during the Contract Negotiations.

3.5.11.3 DESIGN DISCREPANCIES

The Contractor shall be responsible for the correction of incomplete design data, omissions and design discrepancies which become apparent during construction. The Contractor shall provide the Employer with a proposed recommendation for correcting a design error within three (3) calendar days after notification by the Employer. The Employer will notify the Contractor of any detected non-compliance with the foregoing requirements.

The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the worksite, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Employer may issue an order stopping all part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

3.5.11.4 DATA AND DRAWINGS TO BE SUBMITTED WITHIN ONE (1) MONTH

Within one (1) month of the Contract Effective Date, the Contractor shall submit the following, but not limited.

- General description and technical specification of all major equipment item.
- Contact network schedule.
- Overall layout and general arrangement of all major plant (including switchgear, control and relay panels) giving foundation requirements showing locations, dimensions, loads and details of cable trenches required.
- Contract program.
- Four (4) copies in English of all codes and standards approved for use on this Contract.
- Inspection Test Plan (ITP) and quality test procedures at factory for all equipment supplied under this Contract.
- Equipment and system identification numbers using standardized KKS (Kraftwerks Kennzeichen System/Identification system for Power Plant) Number System.

3.5.11.5 DATA AND DRAWINGS TO BE SUBMITTED WITHIN TWO (2) MONTHS

Within two (2) months of the date of the Contract Award the Contactor shall submit the following, but not limited.

- Detailed foundation/civil drawings providing all necessary information for the detailed civil works and building design for all plant, together with a schedule of built-in items.
- Complete equipment list of all plant items and equipment to be supplied together with the name of the manufacturer or Subcontractor, country of origin, and FOB delivery date.
- Instrument lists, functional logic diagrams for control, alarm and sequence interlocks.
- Drawing list summarizing all existing and proposed drawings of principal items intended for submission to the Employer by the Contractor together with the submission dates.
- Schedule of all AC and DC loads.

3.5.11.6 DATA AND DRAWINGS TO BE SUBMITTED WITHIN THREE (3) MONTHS

Within three (3) months of the date of the Contract Award the Contactor shall submit the following, but not limited.

- Piping layout drawings.
- Cables and Conduits routing.

- Plant cable diagrams and diagrams of connections for all plant items, marshalling boxes and control panels and itemized cable schedule.
- Electrical Schematic diagrams including power, control, indication, protection and alarms.
- Detailed general arrangement and construction drawings for all major plant items.
- All welding procedures (both at site and during manufacture).
- Access and supporting steel arrangement drawings.
- Schedules of consumable items, lubricants and chemicals.
- Standard format schedules for orifice plates, all valves, control valves, safety valves, strainers, motors and drivers, etc. using the approved KKS number.
- Detailed drawings of turbine buildings including services.

3.5.11.7 DATA AND DRAWINGS TO BE SUBMITTED WITHIN FOUR (4) MONTHS

Within four (4) months of the date of the Contract Award the Contactor shall submit the following, but not limited.

- Full manufacturer's data sheet on every type of device, equipment, or module which the Contractor proposed to utilize in the instrumentation and control system including computer hardware and software.
- Functional group control diagrams.
- Schedules of instruments, valves, input and output signals (analogue and binary), using the approved system of plant item referencing and nomenclature.
- Evidence of submission of plans for approval, where necessary, to local authorities.
- Heat balance diagrams for various load conditions of 100%, 75%, 50% MCR the Plant using design coal.
- Detailed dynamic and steady state response data.

3.5.12 REVISION OF CONTRACTOR'S DRAWINGS AT SITE

During the erection and commissioning period it may be necessary on the approval of the Employer to make revisions to already approved construction drawings. In such case the Contractor shall provide to the Employer at Site without delay two (2) marked-up prints detailing any revision made. Normal revisions of these drawings shall then be made and issued to the Employer as described earlier.

3.5.13 AS BUILT DRAWINGS

Following the installation of the equipment, the Contractor shall revise his drawings as necessary to show the "as built" status. The Contractor shall send three (3) copies and one (1) soft copy (pdf) of the "as built" drawings to the Employer.

All drawings shall be also provided on computer based software compatible with the Employer's existing system where drawings can be viewed or printed/plotted. A package of the software used for producing the drawings to be provided and loaded on the PC provided by the Contractor. All as built drawings shall be made available on CD or DVD.

3.5.14 Erection Procedure

The Contractor shall submit copies of the erection procedure for all Plant, equipment and systems to the Employer for information prior to such erection being carried out on the Site.

3.5.15 PRE-COMMISSIONING PROCEDURES

The Contractor shall prepare detailed standalone pre-commissioning procedures necessary to cover mechanical and electrical completion, testing and pre-commissioning of equipment and systems to state of readiness for star-up and operation in accordance with the procedures, test details and criteria contained in the Conditions of Contract and the Technical Specifications. The Contractor shall review equipment systems and provide specialist assist as required.

Pre-commissioning shall be carried out on a system by system basis. The Contractor shall, in accordance with the procedures, test details and criteria referred to above, prepare a separate procedure for each system to be pre-commissioned, bound in an A4 size file. It is important that where Contractor packages/equipment pre-commissioning procedures are written that all relevant Contractor drawings and documentation are included in the relevant procedure file. Each system pre-commissioning procedure shall contain:

- Title and system number to which the procedure refers.
- Index
- Status / approval signature sheet.
- Equipment test record sheets including pre-commissioning test records.

The Contractor shall submit each system commissioning procedures and all documentation for review by the Employer not later than three months before the commencement of pre-commissioning of that system. Each System pre-commissioning procedure shall contain all correction curves and tables necessary for the pre-commissioning and testing of that system.

3.5.16 COMMISSIONING PROCEDURE

The Contractor shall submit copies of the Procedure for Commissioning to the Employer for review at least one hundred and twenty (120) days prior to the scheduled commencement of the Commissioning of the Plant, detailed procedures and protocols to be used during the corresponding testing shall be submitted.

3.6 IMPLEMENTATION SCHEDULE

3.6.1 PROJECT SCHEDULE WITH PROPOSAL

The Employer's requirement of the project schedule is provided in Section 8 Contract Form.

Overall construction schedule is 1126 days and 1309 days for respective units from the Contract Effective Date to Operational Acceptance as designated in Section 6 GCC 8. Defect liability period shall be 24 months after Operational Acceptance.

The Bidder shall provide with his proposal as required in Technical Proposal designated in Section 4 Bidding Forms.

Proposed Schedule shall be a network form with critical path including following information:

- Date for Commence of Work
- Dates for start and completion of design engineering for all disciplines.
- Dates for the placing of orders for material, receipt of material, fabrication and manufacture, factory testing.
- Date for soil investigation.
- Dates showing start and completion of site construction of each activity.
- Dates for delivery of major equipment.

3.6.2 CONTRACT SCHEDULE

The Schedule provided in accordance with sub-clause 3.6.1 above shall be reviewed in detail by the Contractor to reflect any changes in scope of work or scheduled dates agreed during contract negotiations and to a format acceptable to the Employer suitable for computer application.

The reviewed schedule shall be submitted to the Employer as part of the Contract Document to be signed and will become the Contract Schedule.

Detailed programs for all Work to be executed during the first twenty-four (24) weeks of the Contract shall be submitted.

These programs, which shall embrace design, procurement, manufacture, testing, shipping and erection on Site shall be based on the Contract Schedule and shall be used as target programs possibly subject to revision.

The detailed programs shall be submitted to the Employer at twelve (12) week intervals, updated to reflect the changes that have accrued in the previous twelve (12) weeks and to show the detailed program of Work for the next twenty four (24) weeks.

3.7 PROGRESS REPORT

3.7.1 MONTHLY PROGRESS REPORT

The Contractor shall prepare and submit to the Employer within 15 days after the first day of every month, a written Monthly Progress Report summarising the progress of the various sections of the works both in the factory and at Site. Such progress reports shall indicate accurately the status of different activities covering design, major procurement, manufacture, factory tests, shipping, erection, testing and commissioning and shall be related to key dates identified in the programs referred to sub-clause 3.6. The report shall also include data on labour strength and equipment employed at the Site.

The Monthly Report shall include the Contract Schedule indicating progress and individual component progress made in the proceeding month.

Such schedules shall show cumulative progress towards scheduled completion (expressed as a percentage) of all items shown in the Contract Schedule.

The report shall indicate the degree of criticality in each section of the work together with the slippage or impending slippage on any key event and shall be directly related to the Contract Schedule and Supporting detailed network for sections of work.

Six (6) copies of the Monthly Progress Report shall be submitted to the Employer in English in a format approved by the Employer.

The monthly progress report shall include executive summary containing to, but not limited, as follows:

- Physical Progress including overall progress and site progress.
- Payment status including overall payment status and each portion status in case of the consortium.
- Listing of activities more than two weeks late.
- Listing of all items on the critical path and next sub-critical path.
- Explanations for late activities which are having, or are likely to have, impact on the project schedule.
- Details of measures proposed to bring late activities back on schedule.
- Outstanding interface data and measures proposed to expedite the issue of critical interface data.
- Confirmation of the achievement of near term milestones.
- Confirmation of the achievement of the completion date.
- Detailed risk analysis of the programme.
- Financial status (progress of payment) and disbursement “S” curve

The monthly progress report shall include, but not be limited to the following:

- Details of any accident or injuries during the reporting period and overall accident, safety and injury statistics for the construction phase, in the reporting period and to date. Management report on and status of compliance with, the Health and Safety Plan.
- Management report on and status of compliance with, the Environmental Management Plan.
- Details of any industrial relations issues.
- Details of any complaints or comments made by external bodies or individuals.
- Problem areas (and details of measure being taken to resolve problems)
- A statement of the number of site personnel engaged in during the reporting period and, where relevant, details of erection equipment in use or held in readiness.
- Document index marked up to show document status.
- Purchasing schedule marked up to show status of procurement activities.
- Copies of those inspection and test reports which identify any deviation from the quality standards in the Contract and a statement of corrective actions.
- A Schedule of all other inspections and tests performed.
- Copies of quality assurance audit reports which identify the need of corrective actions and evidence of the implementation of corrective actions.
- Progress on compilation of manuals.
- Colour photographs showing the progress of construction.
- Update of manning histograms.
- Update of progress “S” curves (for e.g. Engineering, Procurement, Erection, Commissioning, etc.)

3.7.2 WEEKLY SUMMARY REPORT

The Contractor shall prepare and submit to the Employer six (6) copies of a weekly summary report covering all the site activities. This report shall include projected Work activities for at least 14 days after those being reported upon.

In addition this report shall include a weekly site labor return giving expatriate and local labor and each Subcontractor’s labor broken down into trades.

Constructional Plant, machinery, offices and materials and include Site and weather conditions which may affect the progress of the Works. This weekly summary report shall also include percent complete information by discipline and bulk commodities installation information: cubic meters of concrete, linear meters of cable, tonnes of structural steel, cable terminations, etc.

The weekly report shall include also a four (4) weeks look ahead schedule and detailed works completed in previous two (2) weeks.

In addition to the above weekly summary report, the Contractor shall prepare and submit to the Employer on a daily basis indicating the activity of the day to the site work.

3.7.3 PHOTOGRAPHS

Twelve (12) colour photographs showing progress on Site shall be provided with each monthly report. Each photograph shall not be less than 240mm by 180mm shall carry description, serial number and dates.

Location for photographs shall not be changed and the progress shall be clearly confirmed as the records.

Soft copies in jpeg format of all photographs shall be handed over to the Employer at the completion of the contract at which time the Contractor shall also hand over three sets of photographs in separate albums.

3.8 PLANT IDENTIFICATION

3.8.1 GENERAL

Plant Identification shall be defined as the requirements, conventions and guidelines for assigning numbers and titles to the equipment that is to be numbered.

The Contractor shall prepare comprehensive Plant Identification Schedule showing the name and number, and add any additional items necessary to fully identify the Plant.

This schedule shall be subject to the Employer's approval.

All equipment in the designated system shall be assigned with equipment numbers. A single, comprehensive equipment numbering system shall be applied uniformly to all plant equipment.

The same equipment number shall not be applied to more than (1) equipment.

Equipment number shall be depicted on the P&IDs, physical piping and general arrangement drawings, specification, system or functional diagrams, electrical drawings, schedule, civil and structural drawings, etc.

Plant identification and equipment number shall be derived from European Identifications system for Power Plant (KKS). The implementation of the KKS code shall be initiated from the project award for and all aspects of the project implementation, commissioning, operational and maintenance aspect.

3.8.2 NUMBERING SYSTEM

The direction of identification number or letter advancement shall be to Site North and to Site West to the Compass.

This means that the equipment or plant item located on the Site North has a higher identification number than the equipment located on the South side, and equipment located on the Site West side has a higher number than one which is located on the Site East side.

The direction of identification number of equipment of plant items that is installed in the vertical arrangement, advancement shall be to the upper side.

3.8.3 NAMEPLATES AND LABELS

The Contractor shall supply all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the Plant and all inscriptions shall in the English language and the size of the lettering shall be to the approval of the Employer.

The inscriptions on all plates shall be engraved with black-filled lettering either at site or in the manufacture’s works after the equipment designations have been finalized.

Where application plates and labels shall provide a white background to the inscriptions. Approved, temporary labelling is to be provided until such time that this rationalization is complete.

Inscriptions shall be to the approval of the Employer and where applicable shall include the Plant nomenclature in addition to the alphanumeric plant designation code as described above.

The plates and labels shall be non-deteriorating and non-warping under site conditions. Stainless steel is to be used on outdoor equipment. Traffolyte, or an approved equivalent, may be used for individual component labels inside panels and desks.

All labels, nameplates, instruction and warning plates shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives or cable ties will not be permitted.

Warning plates shall be manufactured from stainless steel with a matt or satin finish, engraved with red lettering and located in a position that shall afford maximum personnel safety.

All equipment within panels and desks shall be individually identified by satin or matt finish stainless steel labels or laminated plastic labels where approved.

Each circuit breaker panel, control panel, relay panel and the like shall have a circuit designation label mounted at both front and rear. Corridor type panels shall additionally have circuit designation labels within the panels. The function of each relay, control, indicating and alarms device, fuse, etc. shall be separated.

All unfired pressure vessels and lifting tackle shall have permanently attached to them or stamped on them, in a conspicuous position, a rating plate giving such details as the design code, design parameter, test parameter, date of test, etc. to the approval of the Employer. Plate shall be installed on vessel’s insulation so as to be visible after insulation is applied.

Each valve shall be fitted with a stainless steel nameplate indicating the valve service and reference number in accordance with the valve schedules as approved by the Employer. The color of the nameplate engraving shall correspond to the service of the pipe work in accordance with the requirements of appropriate standards.

Where possible valve nameplates shall be circular and fitted under the hand-wheel captive nut. On check valves and small valves the Contractor may provide rectangular nameplates fitted to brackets on the valve or attached to a wall or steel work in a convenient position adjacent to the valve.

Generally the plate material shall be stainless steel, for the water treatment plant plastic plates shall be used.

Size of plate and lettering shall be to the approval of the Employer.

3.8.4 COLOR CODE

The Contractor shall submit color classification for equipment, facilities and piping with color sample for approval. In case of insulation for equipment, facilities and piping, full color painting is not be required but band color shall be required. Color classification shall include shape of allow (flow direction) for piping and width of band for piping, tanks etc.

Name of equipment, facilities and piping shall be painted clearly to recognize and the name and font shall be approved prior to print.

3.9 INSTRUCTION MANUAL

3.9.1 GENERAL

All instruction manuals described below shall be submitted to the Employer in its final version before not later than one hundred and twenty (120) days before the Operational Acceptance.

All final documentation which shall be used or referred to by the Employer’s operation and maintenance staff shall be in the English language.

The Contractor shall submit to the Employer, all drawings in master hard copy format and electronic format. All scripted documents, A4 manuals, etc. shall be provided in hard copy format from the master and electronic format.

The manual format shall be on standard metric A4 sheets. Drawings and schedules, which are to be bound into the manual, shall also be A4 or A3 folded to A4 sizes.

As a minimum a complete self-standing manual shall be submitted.

All documents produced specifically for the project shall be in Microsoft Office 2013 format, i.e. Word, Excel and Access. Drawings shall be produced using AutoCAD.

Standard and reference documents not already available in electronic format shall be converted to rasterised computer files in a standard world-wide compatible format.

Ten (10) copies and Two (2) soft copies of the final manual shall be provided.

The Contractor shall provide a permanent library of the hard copy master copies within the permanent Site offices ensuring that the area is sufficiently protected and equipped with viewing and printing facilities. The atmospheric storage conditions within this facility shall be such as to prevent deterioration of the data. The facility shall provide secure storage of the data.

The masters in electronic format shall be submitted to the Employer in CD ROM read/writable format.

The Contractor shall provide the manuals listed below:

3.9.2 COMMISSIONING MANUAL

This manual shall be developed from the individual plant items and assembled by system in accordance with the plant start-up/shutdown, maintenance and operational philosophy.

The manual shall include the agreed commissioning procedures within the appropriate sections. The manual shall be accurately indexed to facilitate retrieval of information by plant system in accordance with the operational philosophy.

3.9.3 DESIGN MANUALS

The volume(s) comprising the design part to the manual shall be laid out as follows:

Preliminary pages including index, preface, amendment record sheet and illustration of the complete equipment.

General description of the system including:

- System diagrams and blocks diagram showing sub-systems and interconnection with other systems.
- System description, including design basis, function, location, and modes of operation.
- Design data including performance curves, heat balance diagrams, materials specification and running clearances and settings, limitations, etc.
- Instrument and valve list itemizing function, type, number, range and alarms.

3.9.4 OPERATIONS MANUALS

The volume (s) comprising the operation part of the manual shall be laid as follows:

- Preliminary pages including index and amendment record sheets
- Equipment identification by plant name, unit number and by function name
- Recommended procedure for operating and instruction for commissioning, start-up, normal operation, shut-down, standby, emergency (including loss of normal power) and fault conditions, and other information such as normal range of system variables, operating limits and hazards conditions for all equipment and systems.
- General Arrangement Drawings
- Final performance and design data sheets and performance curves for all equipment
- Testing and checking requirements

3.9.5 MAINTENANCE MANUALS

The volume(s) comprising the maintenance part of the manual shall be laid out as follows:

- Preliminary pages including index and amendments record sheets
- List of names and addresses of liaison offices for all equipment
- Preventive Maintenance and Inspection Schedule for all equipment covered by this Specification
- Lubrication Schedule showing requirements, and specifications for all equipment covered by this Specification and showing equivalent lubricants available in Bangladesh.
- Recommended procedure for assembly and dismantling with associated tests and check-ups prior to returning equipment to service
- Detailed construction, assembly drawing to complement assembly procedures mentioned above, including part list and numbers for replacement ordering
- Setting and running clearances and tolerances
- Methods for trouble shooting
- Cleaning and Conservation procedures
- Instrumentation calibration requirements and procedures

The listing of all replacement parts/spare parts list identifying the following:

- Name of spare part
- Identification number
- Manufacturers drawing number
- Installed quantities and spare quantities
- Outline sketch diagram
- Materials
- Required period delivery.

Drawings showing space provided or equipment maintenance for all equipment and any fixed facilities for maintenance such as trolley beams, etc.

3.9.6 DIGITAL SYSTEMS MANUAL

For digital control systems the Contractor shall also submit a manual describing the digital system, system generation, software and hardware to include the following as a minimum:

- The manual shall include functional descriptions including intended use, capabilities, limitations, control logic diagrams, control set points and correction curves, etc.
- The manual shall contain the procedure required to generate the system software.
- The software portion of the instruction manual shall describe the software provided with the system including the self-diagnostics, operating system, the utility software and the application software. This shall also include reference user and programming manual for all software supplied.
- The hardware portion of the manual shall contain physical descriptions of system hardware, functional characteristics, capabilities, specifications data sheets and special characteristics. Assemblies and sub-assemblies shall have unique part numbers that shall be referenced in the documentation including in the manuals. This shall also include theory of operation and general overview of the system hardware furnished.

3.9.7 SPARE PARTS MANUAL

A separate volume, cross-referenced to all tagged items of equipment, detailing the spares recommended by the Contractor for commissioning, operation and insurance purposes. This manual shall also include a schedule of required lubricants and any special requirements relating to the handling and storage and disposal thereof.

3.10 COMPLIANCE WITH LOCAL STATUTES AND REGULATIONS

The Contractor shall give all notices and pay all fees required to be given or paid by any national or provincial or local statute, ordinance or other law or any regulation or by law of any local or other duly constituted authority in relation to the execution of the Works or of any

Temporary Works and by the rules and regulations of all public bodies and companies whose property or rights are affected or may be affected in any way by the Works or any Temporary Works.

The Contractor shall comply in all respects with provisions of any such statute, ordinance or law aforesaid and the regulations or by laws of any local or other duly constituted authority which may be applicable to the Works or to any Temporary Works and with such rules and regulations of public bodies and companies as aforesaid and shall keep the Employer indemnified against all penalties and liability of every kind for breach of any such statute, ordinance or law, regulation or by law.

The Contractor shall keep himself fully informed of all laws of the Government of Bangladesh, all local laws, ordinances, safety codes, regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority which in any manner affect the Contractor, those engaged or employed on the Works or which in any way affect the conduct of the Works. He shall at all times observe and comply with all such laws, ordinances, safety codes, regulations, orders and decrees and shall protect and indemnify the Employer against any claim or liability arising from or based on the violation thereof.

3.11 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

3.11.1 QUALITY ASSURANCE/QUALITY CONTROL SYSTEM

3.11.1.1 QUALITY ASSURANCE/QUALITY CONTROL SYSTEM DESCRIPTION

The Bidder shall submit with his Bid Proposal, a preliminary list of the Quality Control Procedures, Special Process Procedures, and Quality Control Documentation which applies to the Work and which he intends to submit to the Employer. The preliminary list will be reviewed during the bid evaluation.

A mutually agreed upon, detailed list of the Quality Control Procedures, Special Process Procedures and Quality Control Documentation shall be developed and will be included as part of the Contract requirements.

The Quality Assurance Program shall meet the requirements of ISO 9000 or equivalent, as applicable.

In all cases, the Quality Assurance Program must address the organization of the Contractor.

3.11.1.2 DETAILED QUALITY CONTROL PROCEDURES

Detailed Quality Control Procedures for the Works shall be submitted to the Employer for approval not later than six (6) weeks after Award of Contract and at least four (4) weeks before the start of fabrication of installation whichever is earlier. Prior to the start of any work affected by the procedures, the Contractor shall revise all or any portion of the procedures, as required by the Employer and shall submit the procedures as many times as required until satisfactory to the Employer and shall submit the procedures as many times as required until satisfactory to the Employer.

To maintain the equipment and other items in a corrosion-free state, the Contractor shall submit the Employer with instructions for storage and maintenance for his equipment and other items prior to installation, as well as for the period between the completion of the installation and the time that the equipment and other items are placed in service.

The Contractor shall provide a Site Quality Control Program including requirements for Site Quality Control surveillance, hold points and in-progress inspection points.

3.11.1.3 OVERALL INSPECTION POINT PROGRAM/CUSTOMER NOTIFICATION POINT PROGRAM

Within three (3) months after Award of Contractor four (4) months prior to the start of fabrication whichever is earlier, Contractor shall submit to the Employer an Overall Inspection Point Program (OIPP) which shall include pertinent fabrication and inspection operations which will be of interest to the Employer relative to Quality Control.

OIPP shall clearly identify the manufacturer and the items/sub-item of plant to which they apply.

OIPP may be of any form to suit the Contractor's system, but it shall be as minimum:

a) Indicate each inspection and test point and its relative location in the production cycle including incoming, packing and site inspections.
b) Indicate where Subcontractors services will be employed (e.g. Subcontractor NDT or heat treatment).
c) Identify the characteristics to be inspected, examined and tested at each point and reference drawings, procedures and acceptance criteria to be used.
d) Indicate the inspection, test and hold points established by the supplier, Subcontractor and Contractor, which require verification of selected characteristics of a document, item or process before this work can proceed.
e) Allow for witness, hold and review points to be established by the Employer, which require his verification of selected characteristics of a document, item or process before this work can proceed.
f) Define or refer to sampling plans if proposed and where they will be used.
g) Where applicable, specify where lots or batches will be used.
h) Relevant acceptance criteria.

The Employer will indicate the inspection requirements on the agreed inspection programme in accordance with the following:

- Hold point requires a mandatory inspection by the Employer. This inspection or test shall be witness by the Employer and further progress in manufacture shall not be made until the Plant is approved by the Employer.
- Witness point inspection or test of material may be carried out by the Employer at his discretion.
- Document review certification of materials and functional test shall be approved by the Employer before dispatch from the works.

The Employer shall be entitled to witness of factory acceptance tests on the major components or part thereof which is specified on sub-clause 3.11.3.7 below.

The Contractor will give the Employer at least one (1) month prior notice in writing of the date on and the place at which any plant will be ready for testing. Unless the Employer shall advise the Contractor within seven (7) days of the date which the Contractor has stated in his notice the Contractor may proceed with the tests which shall be deemed to have been made in the Employer presence, and shall forthwith forward to the Employer duly certified copies of the test readings.

3.11.1.4 SUBCONTRACTOR’S QA/QC SYSTEM AND PROCEDURES

The Contractor shall be responsible for the review, comment and acceptance of the Quality Control System, Quality Control of his Subcontractors. Subcontractor and suppliers are required to comply with the requirements for quality assurance and quality control to be applied to goods and service. In addition, Contractor shall be responsible for his Subcontractor’s work. The Contractor shall submit to the Employer a list of any or all of the work to be sub-contracted. Subcontractor’s quality control system and procedure shall also be submitted in accordance with sub-clause 3.11.1.2 herein.

3.11.1.5 CONTRACTOR NON CONFORMANCES

Non-conformances to the Contractor requirements shall be promptly submitted to the Employer in writing for resolution.

The Contractor shall action all non-conformance reports and re-inspection shall not be notified until the completed non-conformance report, together with any applicable re-work or concession application has been accepted by the Employer.

Where applicable, rejection of materials, equipment and/or components will be made as promptly as practicable following any inspection or test involvement by the Employer. Failure to inspect and/or reject materials, equipment and/or components shall neither relive the Contractor from responsibility for such item which may not be in accordance with the specified requirements, nor impose liability for them on the Employer.

The Contractor and Subcontractor's quality assurance programme shall identify and isolate raw materials and components not conforming to specifications. All such items shall be reported to the Employer via a non-conformance report.

3.11.1.6 RADIOGRAPHS

The following procedures shall be followed in the radiography of the applicable equipment and materials.

All shops/field radiographs, with appropriate reports, shall be submitted to the Employer for review, within ten (10) days after completion of radiography. The double film technique shall be employed if the Contractor considers it necessary, otherwise a single film technique is sufficient. All radiographs shall become the property of the Employer. All radiographs, not properly identified, will be rejected. Packaging and shipment of radiographs shall be in accordance with sub-clause 3.11.2 herein.

All documentation shall be clear, legible, and of suitable quality for storage for the life of the Plant. Radiographs will not be microfilmed.

3.11.1.7 HONORING OF INVOICES

Invoices for equipment received on Site will not be honored until all documentation have been received and complies with Contract documents.

3.11.2 STANDARD PROCEDURE FOR PACKAGING AND SHIPMENT OF RADIOGRAPHS

3.11.2.1 GENERAL

This procedure covers the packaging and shipment requirements for Contractor's submittal for radiographs to the Employer (for shop radiographs) for review and comment when required by the Specification.

Each radiographic film package shall be identified as follows:

a) Employer
b) Plant and Unit No.
c) Specification No. and Latest Amendments
d) Component Name and Identification No.
e) Heat No., Piece No. Register No., Serial No. (as applicable)
f) Weld or Seam No., (if applicable)

3.11.2.2 PACKAGING OF RADIOGRAPHS

Preparation for packaging: The radiograph shall be assembled in accordance with the equipment supplier's standard practice for handling and filing radiographs.

Inner carton: The assembled radiographs shall be inserted into a heavy fiberboard or cardboard carton, and all openings sealed. Radiographs must not be folded.

Outer box: The inner carton shall be packed in a wooden box constructed to protect the radiographs from shipping damage and the elements.

3.11.2.3 SHIPMENTS OF RADIOGRAPHS

Shop Radiographs:

a) Radiographs shall be shipped with a transmittal letter to the Employer via a carrier that can trace its shipment.
b) The radiographs shall be insured for a nominal amount.
c) Contractor shall request a return receipt from carrier to verify shipment was received.

Field Radiographs:

a) Radiographs shall be packaged as required by sub-clause 3.11.2.2 above except outer box, and taken to the Employer on Site.

3.11.3 SHOP INSPECTIONS

3.11.3.1 GENERAL

a) All plant shall be subjected to type, sample and routine tests at the manufacturer's factory in accordance with these clauses and conditions of the Contractor.
b) Type, sample, routine tests and factory acceptance tests shall be to the relevant ISO and IEC Standards or other approved standards for equipment where the test requirements are not specified in these clauses.
c) The Contractor may offer type test results for identical equipment in lieu of the type tests specified, in which case the specified type tests may be waived by the Employer. If type test results for identical equipment are offered in lieu of the specified type tests, the Contractor shall also provide evidence as to the similarity of the equipment tested and the Contract equipment.
d) The Contractor shall submit evidence to the Employer that the instruments used for the testing shall have been calibrated at an approved testing laboratory within a period of up to six months for a portable instrument and twelve months for a fixed instrument.

e) The tests mentioned in this section are not intended to form a complete list of the numerous tests which the Contractor would normally perform to ensure equipment quality and reliability of the Facilities.

3.11.3.2 SHOP INSPECTION AND TEST PLAN

The Contractor shall submit a coordinated detailed shop inspection test plan (ITP) covering all quality control procedures required including at least the following information in a format to be approved by the Employer:

- Component description
- Individual inspection or test item
- Reference document and / or acceptance criteria
- Verifying documents type
- Who witnesses (Contractor, sub vendor, Employer etc.)
- Location of inspection or test
- Estimated test date (month, year)
- Test record submission (at test, at shipment, or none stored by Contractor)
- Remarks (any clarifications, etc.).

The plan shall show all Contractor, Subcontractor or supplier items shop inspections and tests at all stages of manufacture, including raw materials, such a steel plant from the mill, etc.

The Contractor may provide other relevant information in addition to the above and shall submit his proposed format for the inspection and test plan for Employer's approval within two (2) months of Contract signing, and the completed plan within four (4) months of Contract signing. Separate plan shall be submitted for both domestic and overseas manufacturing activities.

3.11.3.3 SHOP INSPECTION SCHEDULE

The Contractor shall also provide a coordinated inspection schedule covering all customer notification points update regularly for changes in schedule, giving the expected week a specific inspection is expected to take place.

3.11.3.4 SHOP INSPECTION PROCEDURES

For all shop manufactured items, shop inspection procedures shall be submitted for the Employer's approval not later than one (1) months prior to the estimated inspection date. The Employer shall give final approval before relevant actual inspections are scheduled.

3.11.3.5 SHOP INSPECTION NOTIFICATION

The Contractor shall notify the Employer of the scheduling of shop inspection activities to be witnessed by the Employer at least one (1) month before the scheduled activities for overseas manufactured items and fifteen (15) calendar days before for domestic manufactured items. The notifications letter shall be submitted in accordance with project correspondence requirements and in parallel by fax. The notification letter shall include as a minimum:

- Equipment or material to be inspected
- Location of inspection
- Contact person at factory
- Date of inspection
- Inspection procedure, document number
- Approved design drawing numbers(s)

It is important that this information be submitted completely as specified in order to provide for efficient, timely and effective the Employer's monitoring of the inspection process and attendance at key inspection points and tests.

3.11.3.6 DOCUMENT APPROVAL STATUS

As required in sub-clause 3.5, manufacturing shall be performed based only on approved drawings. Inspections shall be based only on final approved drawings. The Contractor shall not schedule such inspections or ship any material or equipment prior to receiving final approval.

3.11.3.7 WITNESS SHOP INSPECTION

The Employer shall be entitled to witness factory acceptance tests on each of the major components (or part thereof).

The Bidder shall include in its bid, all costs associated with two members of the Employer's personnel and one Engineer's personnel, i.e. a total of three engineers, attending and witnessing each of the factory acceptance test. When travel outside Bangladesh is required, all costs shall include business class airfares, accommodation, medical, transport, meals, incidental pocket expenses for the Employer's personnel of USD 150/ person/day including travel time etc. Travel schedules shall be mutually agreed between the Employer and the Contractor but shall include adequate time for the travellers to recover from their flights, for the tests/inspections and preparation and review of the test.

Should the equipment or any part thereof fail under these tests, then the cost of any further tests shall also be borne by the Contractor, including all costs relating to the Employer/ the Engineer attending the re-tests.

Number of witness outside Bangladesh is estimated as total fifteen (15) times for three (3) person and eight (8) days at one time for bidding purpose.

Times, number, duration allowed for witness may be increased, reduced or allocated to a larger or small number of personnel for different time duration. Adjustment for under run or over run will be by deduction or addition at the relevant adjustment rates, Price Schedules of Section 4

Such inspection / witnessing of factory acceptance tests shall not relieve the Contractor from any obligation to perform the work in accordance with the Contract documents. Work not so constructed shall be removed and made good by the Contractor at its own expenses.

Major Components are:

a) Steam turbine
b) Generators
c) Generator Step-up transformers
d) High voltage switchgear
e) DCS with data logging system
f) Protective relay panel
g) Draft fans (PA, FD and ID Fans)
h) Boiler feed water pump
i) Condensate Extraction Pump
j) Fuel pump
k) Circulating water pump
l) Cooling tower forced draft fan
m) Bus-tie transformers
n) Any other equipment, of which factory tests and inspections may be required by the Employer

3.11.3.8 QUALITY CONTROL RECORDS, CERTIFICATES AND CERTIFICATE OF CONFORMANCE

At the end of each visit to a manufacturer's shop to carry out quality control activity, the Employer will complete a Quality Control Record and hand over one copy to a responsible representative of the Manufacturer.

The Quality Control Record (QCR) will identify the item inspected, the stage of manufacture, and the nature of the QC carried out, and will list all points which require remedial action by the manufacturer before the subject item can be released.

When each item of equipment is ready for dispatch from the place of manufacture and Employer has verified compliance with specified requirements up to that point, a Quality control certificate will be issued to the Contractor.

The Quality Control Certificate (QCC) will identify the item to which it applies and will release that item from the Employer control only. The QCC does not constitute any form of acceptance of the item by the Employer.

The Contractor shall provide a Certificate of Conformance confirming compliance with the Contract requirements and as detailed in the manufacturing record data book.

Sets of all test records, test certificates and performance curves, whether or not they have been witnessed by Employer shall be supplied for all tests carried out in accordance with the provision of this Contract.

Sets of all test certificates shall be endorsed with sufficient information to identify the material or equipment to which the certificates refer, and shall carry in the top right hand corner the following reference.

- Employer’s name:
- Project title:
- Employer’s reference number

All test documentation shall be in the English language.

No materials or equipment shall be shipped to the Site until all tests, analysis and inspections have been made and the Contractor’s Certificate of Conformance has been reviewed and released by the Employer.

3.11.4 GOVERNMENT AND THIRD PARTY INSPECTIONS

The Contractor must be fully conversant with the Government of Bangladesh inspection regulations and certification requirements. The Contractor shall be responsible, at its cost, for obtaining all necessary certificates and licenses to permit operation of the Facilities. The Contractor shall, at its cost, retain the services of a single Government of Bangladesh approved Third Party Agent who shall perform the required Government of Bangladesh certification for all Plant and Equipment. Such Third Party Agent shall be approved by the Employer. The request for the Government of Bangladesh approval of this Third Party Agent shall be prepared by Contractor on Employer’s letter pad and submitted to the Employer for approval and signing.

The Contractor is responsible for the arrangement and costs of transportation and lodging of all Thirty Party Agent(s) and Government of Bangladesh personnel, as required for all inspections and tests.

3.12 TRAINING

3.12.1 GENERAL

The Contractor shall provide formal comprehensive training for the Employer's operation and maintenance personnel. Configuration and maintenance of all Equipment and systems of the Project designed and supplied by the Contractor. It shall consist of both classroom training and on the job training.

The formal training classes shall be conducted by experienced instructors on equipment identical to that installed, using materials (including video presentation) prepared by the Contractor that have been specifically prepared for this Agreement.

Each trainee shall receive a full set of all materials used in the classroom as personal equipment to be used by the trainee. Six additional sets shall be provided. One master copy on DVD of all the training material (include slides, videos and other instructor's material) shall also be provided.

Training certificates shall be issued by the Contractor to trainees who pass the final test and are allowed to operate the new plant with a high level of confidence. If necessary, remedial classes shall be conducted for trainees that fail the final test.

Training material and class tuition shall be in English.

The training programme shall be structured and shall:

- Provide all the knowledge and skills required to perform the required operation and maintenance activities
- Demonstrate that each trainee has acquired the necessary skills and knowledge
- Document that the Contractor has tested each trainee to the required level and qualified the trainee to operate or maintain the plant.
- Issue certificates of competency for various components.

The objective of the programme shall be to maximize learning and minimize maintenance and operational errors.

The Contractor shall submit, within four (4) months of the Contract Effective date, a detailed training plan including scope and timing for review by the Employer. The Contractor shall submit, two (2) months prior to the start of each classroom lesson, a Course Description and Lesson Plan for review by the Employer.

The training programme shall be coordinated with pre-commissioning and commissioning so that the operation and maintenance staff use and consolidate their training skill by assisting the Contractor in the pre-commissioning and commissioning phases under the direction of the Contractor.

The Contractor shall provide all the materials, training aides, venue and all facilities required for the training.

3.12.2 TRAINING WORK SCOPE

The training shall include but not be limited to:

Lecture style Training for Foreign Training

	Major items of interpretation on basic outline
1	Design philosophy of Coal Based Plant
2	Basic philosophy of operation (including start up and shut down, emergency mode, plant trip/load shedding operation etc.)
3	Basic philosophy of maintenance
4	Key point of Construction
5	Steam turbine and auxiliaries
6	Generator and major Transformers
7	Boiler and auxiliaries (including Boiler Protection System)
8	Electrostatic Precipitators (ESP)
9	Flue Gas Desulfurization System (FGD)
10	Air Quality Monitoring System
11	Substation and transmission line
12	Electrical Protection
13	Water Steam Cycle
14	Water supply system (including demineralizer, waste water treatment system, circulating water system with cooling tower etc.)
15	Bulk Material Handling (coal and ash handling system)
16	Fire-fighting philosophy with system interpretation
17	Main pipe line (including steam control methodology and auxiliary boiler)
18	Electrical system based on single line diagram
19	Plant DCS system
20	Control and Instruments (including DC, AC, UPS)
21	Chemical dosing and laboratory

Each of the above items shall be split into several modules, and major equipment shall have separate modules.

Job Style Training

	Major Items	**Major Contents**
1	Operation	Operation procedure through test run and heat run Auxiliaries operation through test run and heat run.
2	Mechanical maintenance	Inspection procedure with technology transfer of check point. Observation on assemble and disassemble.
3	Electrical maintenance	Inspection procedure with technology transfer of check

		point. Observation on assemble and disassemble.
4	Electrical Protection	Inspection procedure with technology transfer and check point observation on relay settings
5	Control And Instruments maintenance	Observation on tuning procedure of plant operation (including software and hardwire tuning).
6	Chemical systems	Technology transfer of analysis by installed chemical equipment in the laboratory.
7.	Fire-fighting	Practical training for operation and maintenance of overall fire-fighting system

3.12.3 FOREIGN TRAINING

The Contractor shall provide training in the equipment manufacturers and/or Contractor's factory/premises as appropriate for the following Employer's personnel.

- 20 (twenty) Engineers on operation, electrical maintenance, mechanical maintenance, I & C, DCS.
- 8 (eight) Engineer on Planning & Design, Environment & Safety Construction Methodology and Project Management.
- 2 (two) of the Employer's software personnel shall participate in developing the DCS. This training shall include:

a) Formal Training :

- Information technology i.e. the broad functional areas of LAN principles, layers, protocols, protocol (IP) addressing, network utilities, database concepts, network security etc.
- Display and database generation, management and maintenance
- Computer system hardware

b) Practical Training:

To supplement formal training, the Employer's software personnel shall participate in developing the DCS database, displays and application software during the Contractor's software implementation and database generation phase. The Employer's personnel shall work in the factory for one month and then participate in the Factory Acceptance Tests.

The total Man-Months for training will be 60 (sixty) man months. An outline of the training programme in the respective disciplines shall be finalization prior to contract finalization.

The trainees will be appointed by the Employer who will be responsible for payment of their salaries. All living, accommodation, food, transport expenses of the trainees during the period of training including airfares, incidental expenses, medical expenses, medical insurance etc will be covered by the Contractor including pocket allowance of US$ 100/day/person including travel time.

The Bidder shall indicate in its technical offer the proposed methodology and the practical arrangements proposed for ensuring a comprehensive training programme.

Number of Trainees and man-month mentioned above are estimation only for bidding purpose.

The number of man months proposed for training may be increased, reduced or allocated to a larger or smaller number of trainees for a different time duration. Adjustments for under run or overrun of total man months will be by deduction or addition at the relevant adjustment rates in Price Schedules of Section 4.

3.12.4 JOB SITE TRAINING

The Employer will make available, to the Contractor the suitable number of staff members for the purpose of:

- Formal Site Training- This shall include formal classroom training supported by audio and/or visual aids and to a larger extend practical “hand on” exercises with the equipment supplied under the Contractor.
- On-the Job Training, at the Site during installation, testing, commissioning and initial operation of the Plant for three (3) months.

Formal class room training shall be held at the design stage, Installation Stage and Pre-commissioning Stage. Training programme shall meet that of each stage including not only power block but also BOP systems.

The Contractor shall provide instructors of the discipline required by the Employer during Job sites Training periods. The maximum Job sites Training period by instructors shall be six (6) months accumulative.

It shall be the responsibility of the Contractor to train the Employer’s personnel adequately and property in a planned manner so that they can take over the responsibility of operation and maintenance of the Plant and equipment at the time of handing over of such plant and equipment.

3.13 SPARE PARTS, TOOLS, TEST EQUIPMENT AND CONSUMABLES

3.13.1 SPARE PARTS

The spare parts are generally classified into the following three (3) categories of consumable, and overhaul and contingency spare parts in accordance with ISO 3977-9: 1999(E).

a) Consumable Spare Parts

The consumable spare parts are defined as ones to be consumed for normal operation such as filter elements for air intake facility, lube and control oil systems, hot section flexible expansion bellows, brushes in contact with rotary parts including ones for provision for the random failures of minor components due to normal tear and wear between inspections such as metal seal rings, gaskets, "O" rings, thermocouples, temperature and pressure switches, level switches, cylinder rings of reciprocating machines, etc. lubricants for lube oil systems and chemicals for dosing of water treatment are not defined as "consumable spare parts", but as "consumables".

b) Overhaul Spare Parts

These are spares needed at the various types of scheduled inspections, and could include as fuel nozzle blocks, thermal shield plates, turbine blades, and turbine casing tightening bolts and nuts, etc.

c) Contingency Spare Parts

These are spare parts to cater for components which may unexpectedly fail such as bearings, air compressor rotary and stationery blades, pump impellers, DCS / PLC cards, plugs with stem and seats of control valves, heat transfer tubes, etc.

Two (2) types of spare parts shall be considered for the Plant, the one to be mandated by the Employer and the other to be recommended by equipment suppliers.

Mandatory Spare Parts

The mandatory spare parts shall be specified considering that the actual operating hours of the Plant will be approximately 6,500 hours per year and that the Plant shall be subjected to the one (1) time minor inspection during the period. The spare parts to meet such requirements as mentioned above are listed as the mandatory spare parts in Attachment A2.

The Bidder shall submit the Mandatory Spare Parts List in which unit and total prices are completely filled with as the breakdown of each item followed by summary in Price Schedules of Section 4.

The Contractor will be allowed to use such spare parts during the pre-commissioning, commissioning and defect liability periods by the permission by the Employer subject to condition that the Contractor shall replace the same within two (2) months from the date of such allocation.

(Note)

a) The expression of “one (1) fleet” means that the quantity of the mandatory spare parts to be provided is the same as the quantity of parts to be mounted on the Plant.
b) The expression of “each” means each type, each size and each material, as the case may be.
c) In case that any out of spare parts listed in the Mandatory Spare Parts List are deemed not applicable to the Bidder, he shall notify with the word of “NA” to the effect that they are not applicable in the corresponding columns of the List.

Recommended Spare Parts

The mandatory spare parts specified in this Clause could not necessarily cover the spare parts to meet the intent of philosophy for all the Bidder. Therefore, where the Bidder will deem that the specified mandatory spare parts will lack spare parts for fulfilments, which are required for the overhaul within the Defect Liability Period (2 years), he shall propose the spare parts as the recommended ones in the on Schedule No. 6 Recommended Spare Parts of Section 4.

(Notes)

a) The Bidder shall list up the spare parts consuming and wearing under severe conditions which the Bidder recommends the Employer to purchase required in addition to the mandatory spare parts under Schedule No. 6 Recommended Spare Parts of Section 4.
b) Quantity of Spare Parts can be described like “200%” of the Plant incorporated.

The Contractor shall carry sufficient inventories to ensure an ex-stock supply of consumable spares for the Plant. Other spare parts and components shall be supplied as promptly as possible, but at the most within six (6) months of placing the order and opening the letter of credit. In addition, in the event of termination of the production of spare parts, advance notification will be made to the Employer of the pending termination, with sufficient time to permit the Employer to procure the needed requirement. Following such termination, the Contractor will furnish to the extent possible and at no cost to the Employer the blueprints, drawings and specifications of the spare parts, if requested.

3.13.2 INSPECTION AND STORAGE

All spare parts shall be inspected and witnessed when opened by Employer along with the OEM representative’s presence. On completion of witness and inspection of parts all packaging shall be replaced as per original delivery state. Any special storage requirements shall be identified by the Contractor e.g. instrumentation and electrical equipment.

Any spare parts procured and delivered by the Contractor under the Contract shall be deemed fit for purpose and they shall be guaranteed to be free from manufacturing defects and any failure occurring within the defect liability period shall be replaced at no cost to the Employer.

The individual spare parts must be labelled with an identification number, easily legible from the outside. The Contractor shall follow a system of designating and tagging each and every spare part for ease of store keeping. The final consolidated spare parts list shall bear sufficient tagging particulars as required for convenient identification of the spare part-without undue loss of time. When the final spare parts inventory is complete the Contractor shall present to the Employer five (5) hard copies and two (2) soft copies of said inventory. This shall be also be made available in the computerized maintenance and management system.

Such inventory shall also include the unit price, quantity, description, catalogue number, part number, drawing references, etc. for each spare part to completely identify the items and the equipment component for which it is recommended.

All spare parts supplied as part of this Contract shall be suitably protected and packed in cases or crates suitable for long-term indoor or outdoor storage on the Site warehouse without deterioration of the contents. The method of protection and packing to be employed shall be inspected and approved by the Employer.

3.13.3 TOOLS

The Contractor shall supply within this Contract all necessary maintenance and inspection tools including special tools required for the disassembly, maintenance inclusive but not limited to, alignment tools for all rotating equipment, flexible borescope inspection equipment or video scope, torque wrenches capable of meeting all torque-tightening requirements.

These tools shall be listed on Schedule No. 1 or 2, Section 4 as the Plant and Mandatory Spare Parts.

The price of tools shall be listed on Price Schedules of Section 4.

The workshop should comprise all equipment and tools suitable for all maintenance activities including but not limited to spanner sets, socket sets, wrenches, precision taps & dies, slings, wire ropes, power/ air operated hand tools including impact wrenches, masonry and metal drill bit sets of various sizes, chain hoists of various sizes, portable electrical/electronic instruments.

Tools shall be of a suitable brand, new and unused and shall be stored in the correct manner and appropriate locations.

All Precision and Special Tools shall be required to be accompanied with a Certified Calibration document for twelve months.

Tools and test equipment shall be supplied separately for section of the Works as follows:

- Steam turbine generator unit and associate auxiliary equipment

- Boiler and associate auxiliary equipment
- Instrument and control system equipment
- HV, MV and LV electrical equipment
- Each ancillary plant

When tools or test equipment is common to more than on (1) section, then sets shall be provided for each section.

Tools and test equipment shall be new and of good quality and shall be neatly arranged in a box and shall be shipped to the job in suitable, separate container clearly marked with the name of equipment for which the tools and test equipment are intended.

In general these tools and test equipment shall not be used during erection and commissioning.

The Contractor shall furnish a complete set of tools for erection and commissioning at his own expenses.

However, if major special tools and test equipment become necessary during erection, the Employer will, if agreed, hand over the tools and test equipment to the attention and responsibility of the erection supervisor.

The tools and test equipment shall be returned in good condition or shall be replaced at the Contractors expenses.

3.13.4 CONSUMABLE PARTS AND MATERIALS

The Contractor shall furnish a sufficient quantity of consumable parts and materials such as gaskets, seals, lubricants, hand hole covers, computer papers, recorder charts, ink, chemicals, etc. during erection, pre-commissioning, commissioning and the defect liability period. These consumable parts shall include initial charge of all lubricating oil and greases, etc.

These consumables shall not be quoted as spare parts furnished under the Contract and shall be included in the equipment cost.

The Contractor shall submit to the Employer six (6) months before commissioning, a schedule of consumable items, listing items and the quantities required per month for the Plant.

All hardware which has a life of less than one (1) year shall be replaced by new hardware by the Contractor within a life during the Contract and shall be tested prior to replacement.

3.14 PACKING INSTRUCTION, STORAGE AND TRANSPORT IDENTIFICATION

3.14.1 GENERAL

The Contractor shall package all equipment and materials furnished by him in such a manner to ensure protection against damage and deterioration during shipment and storage which includes local transportation, air and ocean freight, and Site storage. Procedure and details shall be submitted to the Employer for review prior to start of shipment.

The Contractor shall provide necessary storage facilities such as warehouse, protective covering, etc. for the purpose of proper Site storage. Storage procedures shall be submitted to the Employer and such kind of storage shall be accomplished after Employer's approval.

All of the packages are liable to be opened for examination by the Customs Authority, or the Employer and all such opening and subsequent re-packing shall be at the expense of the Contractor. The Contractor shall retain responsibility for the prevention of pilferage, proper repacking and storage.

3.14.2 PACKAGING INSTRUCTIONS

All parts, packages and crates shall be adequately marked in order to enable identification. Each item contained in package shall be clearly identified on the packing list by its description and part number and assembly drawing reference, and each item shall be marked or labelled to correspond with the packing list. The identification system to be used will be as instructed by the Employer.

All spare parts shall be packaged separately and be crated in a manner suitable for permanent storage as specified in sub-clause 3.14.

All equipment including electrical cabinets and parts shall be packaged for extended storage.

Small items shall be packed in seated transparent plastic bags with desiccator packs as necessary.

Before shipment all parts of the equipment shall be thoroughly cleaned of all mill scale, rust, grease and other foreign matter and shall be painted in accordance with the must protection requirements. The color of the primed coat shall be the Contractor's standard. No paint having an asphaltic base shall be used. Rust inhibiting solutions used internally shall be easily removable. Contractor shall ship a sufficient quantity of paint for touching up where prime coat has been damaged during shipment and erection.

The Contractor shall provide protection for all equipment before shipment as follows:

- All openings in equipment furnished by Contractor shall be securely plugged, capped or otherwise blanked off, sealed with tape and suitably protected against damage and entry of foreign materials and moisture. For shop fabricated equipment this shall be done as soon as possible after shop cleaning.

- Weld ends on all valves, fittings, pipes, nozzles, etc. shall be capped and sealed with suitable, firmly attached protectors. Butt weld ends and ferrous materials shall be coated with anti-corrosion paint prior to capping, back to a ring 50mm from the end.
- Protectors for beveled ends designed for backing ring or consumable insert shall have a plywood or hardboard liner disc held securely against the beveled end. Protectors shall not be welded to weld end.
- All flange facings, bolt holes and other machined surfaces of ferrous materials (except butt-weld end preparation) shall be coated with a suitable removable antirust compound.
- All flanged connections and loose flanges shall be provided with suitable full face flange protectors bolted in place and sealed.
- All machined surfaces shall be protected with wooden blocks or similar means and reinforced externally with metal bands or plates.
- All protectors for openings and all braces, brackets, spares, ties, bindings and other shipping, packaging and packing materials and appurtenance's used for protection in shipping, storing and handing of nonferrous piping and materials shall be of such design, type and / or arrangement as to prohibit contact between ferrous and nonferrous metals.
- Each section of pipe for lube oil systems and other systems, if specified in the Specification, shall be coated properly and scaled.
- All wheel bearings surface shall be properly protected. Shaft bearing surfaces shall be properly protected in accordance with the submitted procedures.
- Each section of equipment to be shipped in sections shall be reinforced to minimize distortion during shipping and handling. Disconnected piping and wiring shall be properly supported and braced for shipment.
- All moving parts requiring lubrication shall be greased in the shop before packing.
- All materials and equipment shall be packed for storage with adequate and suitable precautions to prevent any damage or deterioration in tropical and coastal environmental conditions.
- Materials susceptible to deterioration from climatic conditions shall not be used for the Plant unless otherwise approved by the Employer. These materials, if used for the Plant, shall be permanently protected from deterioration under the climatic conditions, or, with the approval of the Employer, be coated with suitable surface treatment to protect the Plant and equipment for a minimum period of twelve (12) months. The Contractor shall state the period of protection and specify treatment procedures and the recommended intervals between retreatment.

Prior to shipment, surface of wiring and all other parts susceptible in any way to moisture absorption or fungus attack shall be treated with fungicidal varnish.

The Contractor shall follow additional procedures as specified elsewhere in this Bidding Document as required in the judgment of the Contractor.

3.14.3 RECEIVING

Observations for unusual conditions encountered during transit shall be made by the Contractor or his representative to evidence the following.

- Tie down failure
- Rough handling
- Environmental damage
- Excessive exposure
- Fire or high temperature damage

Receiving Records
The Contractor shall assign qualified personnel to maintain control of the receipt, protection, and delivery of the Employer's equipment and materials. The Contractor shall give notice to the Employer upon receiving date. The Employer will be present at all equipment and material delivery inspections. A record shall be made of all equipment and material that is received, accepted or rejected. The record shall be as agreed upon with the Employer.

Shortage
Upon receipt of shipments of equipment and materials, quantities shall be checked against the shipping invoices. Shortages shall be immediately reported to the Employer.

Marking
Received materials in temporary storage shall be clearly marked, so that it can be readily located when required for installation.

Schedule Commitments
The Contractor shall be aware of the fact that the shortage or un-repairable damage to the equipment or materials may cause delays in the project schedule.

Storage of Damage Equipment
The Contractor shall be responsible for further damage to the rejected equipment and shall also store the equipment in a suitable area which will prevent further damage.

3.14.4 STORAGE

The Contractor shall provide detailed information for short term and long term storage and maintenance of his equipment prior to installation as well as for the period between completion of installation and the time that the equipment is placed is service.

Each type of preservative used by the Contractor shall be identified as to quality, life expectancy and type. Complete information shall be submitted to the Employer.

The Contractor shall load and unload the equipment and materials at the storage area and provide the maintenance of the storage and warehouse as required at his expenses.

The Contractor shall supply storage work material such as dunnage, sheet cover, nitrogen gas, silica gel, torch-up paint, etc.

The Contractor shall provide necessary equipment for inspection and safeguarding of stored equipment and materials and shall perform periodical inspection and repair work of stored equipment as required to maintain the equipment in warrantable condition.

The Contractor shall provide all manpower necessary for storage and removal at his expense. This shall include but not be limited to store clerks, inspectors, guards, handlers etc.

Management of storage shall be provided by the Contractor. This shall include but not be limited to organizations, storage control, check sheets for storage conditions, inspection records and security.

All storage areas shall be well drained while indoor storage area shall also be ventilated.

Materials and equipment shall be stored above grade.

The equipment stored outdoors shall be covered with waterproof heavy duty canvas or plastic sheets. Storage covers whether canvas or plastic shall be fire retardant. The sheets shall be tightened to the equipment itself or its container with the rope passing through eyelets along the edge of the sheet, to prevent the sheet from being blow off by strong winds. After rains the Contractor shall temporarily remove the sheet to dry out any dew formed underneath the sheets.

Upon the arrival of the packages at Site the Contractor shall inspect and check each item of equipment as soon as possible. If any damage or deterioration is found, the Contractor shall take adequate and immediate remedial action. The Employer will also check the arrival of goods at Site and the Contractor shall facilitate Employer’s inspection of the goods.

The Contractor shall provide weatherproof store house with air conditioning for instrumentation and electrical equipment. Other equipment to be installed indoor shall be stored properly and protected from damage, deterioration or contamination.

3.14.5 SPECIAL PROTECTIVE MEASURES

Certain items, by their nature or size, may not be stored in an area which provides the required level of protection and therefore the Contractor shall provide special measures.

Terminal bushings for high voltage transformers and high voltage circuit breakers may be stored outdoors in accordance with the manufacturer’s instructions. Since bushings may be easily damaged, they shall be well protected and stored in a location out of the way of normal activity and traffic.

3.14.6 HEATER

Outdoor power transformer enclosures for tap-changers and cable terminal cabinets require internal protection for condensation, as do circuit breaker mechanism housing, outdoor switchgear, large motor windings, etc.

These may be provided with electrical heaters. The Contractor shall provide temporary power and an external pilot light to monitor the supply feed at each item.

If the required heaters are not provided by the manufacturer or are incapable of preventing condensation during severe conditions, adequate heaters shall be provided, monitored and energized as above by the Contractor.

3.14.7 CABLE ON REELS

Both ends of electrical cable on reels shall be regularly inspected by the Contractor who shall ensure they are well sealed such as with several wraps of electrical tape before and during outdoor storage.

Protection against sun ageing, for cable on reels stored outdoors, shall be provided by a protective covering around the outer layers and furnished by the Contractor if not already provided by the cable manufacturer.

3.14.8 INSTALLED EQUIPMENT AND MATERIAL

All installed equipment and materials shall be protected from deterioration, condensation, physical damage and vandalism until the Work under the Contract is accepted in its entirety by the Employer.

The Contractor shall ensure that installed items are protected with the same level of protection accorded them while in storage.

Heaters shall be energized with temporary power and provide with external pilot lights to monitor the feeds. Dust contamination shall be avoided by suitable temporary coverings, with provisions for re-sealing on control panels and similar items.

Protection shall be provided by the Contractor for electrical cables in trays, ducts, risers and other electrical equipment when and where required, by means of fireproof covers or barriers to prevent damage from weld splatters, fires, water damage, falling debris, moving equipment, etc.

3.14.9 TRANSPORT IDENTIFICATION

Any transhipment of materials and equipment through countries adjacent to Bangladesh shall be the Contractor's responsibility. Any costs associated with transhipment of materials and equipment shall be deemed to be included in the Contract Price.

Identification, reinforcement or upgrading of roads/bridges for access to the Site and for transport of equipment and materials shall be the responsibility of the Contractor. Any Costs associated with identification, reinforcement and upgrading of roads and bridge shall be deemed to be included in the Contract Price.

3.15 ERECTION MARKS

All members comprising multipart assemblies, e.g., steel frameworks, piping installations, etc., shall be marked with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks, if impressed, must be completed before painting or galvanizing, shall be clearly readable afterwards.

Colour banding to an approved code shall be employed to identify members of similar shape or type but of differing strengths or grades.

3.16 CLEANING AND PAINTING

3.16.1 GENERAL

Following award of the Contract, the Contractor shall submit the name of the proposed paint supplier and applicator, together with a quality assurance programme, for approval. All paints for the outdoor equipment on the Contract shall be provided by one manufacturer and preferably shall be manufactured in one country to ensure compatibility. All painting of outdoor equipment shall be carried out strictly in accordance with the paint system manufacturer's recommendations and the application shall be checked and approved, in writing, by an authorized representative of the paint manufacturer.

The painting of the Plant shall be carried out in accordance with the schedules in Attachment B2 of Section 5 “Coating System”. The works are generally covered in this attachment but where particular items are not referred to specifically, they shall be treated in a manner similar to other comparable items as agreed with the Employer.

The Contractor shall ensure that precautions are taken in packing and crating, to avoid damage to the protective treatment during transportation to the Site. Any damage to paintwork which occurs during transport shall be made good at Site.

The schedules indicate standards of surface preparation and painting which are intended to give a minimum life of 10 years in a severe environment, with need for only minor remedial work in that period.

Steel sections and plate shall be free from surface flaws and laminations prior to blast cleaning and shall not be in worse condition than ISO 8501-1.

Where paint coatings are proposed for the protection of surfaces of equipment exposed to corrosive conditions, such as plant items exposed to brine or sea water, or immersion in liquids or wet gases, the coatings shall be formulated to be suitably corrosion resistant and shall be high voltage spark tested at works and at Site prior to commissioning. The test procedure shall be based on the use of a high voltage direct current. The voltage used shall be 75% of the breakdown voltage of the coating. This breakdown voltage shall first be separately determined using test plates coated with the specified coating formulation and thickness. The coating on the test plate shall also be micro-sectioned by the applicator to show that it is free from vacuoles and other defects likely to invalidate the test procedure.

If the defects revealed by the above test procedure do not exceed one per $5m^2$ of coating surface, the coating need not be re-tested after the defects have been repaired. If the defects exceed one per $5m^2$ of coating surface, the repairs shall be re-tested after any curing is complete, and this procedure shall be repeated until the defects are less than one per $5m^2$ of coating surface. After repair of these defects, the equipment can be placed in service without further testing.

All coatings proposed for the internal protection of domestic water storage tanks shall be certified by an approved independent Authority as suitable for use in potable water installations and shall meet the non-tainting requirements of BS 3416.

The Employer will consider alternative paint schemes to meet the requirements of fabrication using modern automated materials handling systems, provided that the Contractor is able to demonstrate that they offer the same standards of surface protection and service life as those intended by the schedules.

All paints shall be applied by brush or spray in accordance with the schedules, except for priming coats for steel floors, galleries and stairways where dipping will be permitted.

Where paint is to be applied by spray, the applicator shall demonstrate that the spray technique employed does not produce paint films containing vacuoles.

All polished and bright parts shall be coated with grease, oil or other approved rust preventative before dispatch and during erection and this coating shall be cleaned off and the parts polished before being handed over.

Where lapped or butted joints from part of an assembly which is assembled or part assembled prior to final painting, the jointed surfaces shall be cleaned free from all scales, loose rust, dirt and grease and given one brush applied coat of zinc phosphate primer before assembly.

Paint shall not be applied to surfaces which are superficially or structurally damp and condensation must be absent before the application of each coat. Painting shall not be carried out under adverse weather conditions, such as low temperature (below 4˚C) or above 90% relative humidity or during rain or fog, or when the surfaces are less than 3˚C above dew point, except to the approval of the Employer or his duly appointed representative.

Priming coats of paint shall not be applied until the surfaces have been inspected and preparatory work has been approved by the Employer or his duly appointed representative.

No consecutive coats of paints, except in the case of white, shall be of the same shade. Thinners shall not be used except with the written agreement of the Employer.

On sheltered or unventilated horizontal surfaces on which dew may linger, more protection will be needed and to achieve this an additional top coat of paint shall be applied.

The schedules differentiate between "Treatment at Maker's Works" and "Treatment at Site after Completion of Erection" but the locations at which different stages of the treatments are carried out may be modified, always providing that each change is specifically agreed to by the Employer and the painting is finished or made good at Site to the Employer's satisfaction.

The schedules also refer to "Indoor" and "Outdoor" locations. In this context the interiors of all buildings without air conditioning, heating or forced ventilation shall be treated as "Outdoor".

All paint film thicknesses given are minima and refer to the dry film condition. All thicknesses shall be determined by the correct use of approved commercial paint film thickness measuring meters.

All outdoor painting shall be checked prior to issue of the final certificate and no visible corrosion or spotting shall be present. Slight loss of gloss may acceptable. In the event of visible corrosion being present, the Employer will retain the right to withhold such an amount from the Contractor as may be necessary to repaint the entire exterior part of the works.

The painting requirements shall be interpreted in accordance with the requirements and recommendations of the Standards and Codes of Practice referred to and the paint manufacturer's special instructions where applicable, colours being in accordance with BS 1710 and BS 4800, or equivalent material standards.

3.17 ENVIRONMENTAL PROTECTION & TROPICALISATION

3.17.1 GENERAL

All equipment shall be designed to operate in the environmental conditions specified. Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Where applicable, equipment should tolerate the effects of freezing and air pollution.

Where personnel have to be in attendance frequently, or maintenance has to be regularly carried out, permanent means weather protection or sunshades shall be provided.

Where the performance, reliability or life of the Plant would be adversely affected by solar radiation, including the effects of prolonged exposure to ultra violet light, suitable sunshades shall be provided. Such sunshades shall be constructed from materials that are able to withstand the effects of the ambient conditions on Site without suffering any deterioration in material strength or effectiveness.

Sunshades need not be provided on outdoor plant or equipment provided the manufacturer can satisfy the Employer that the materials employed will not be adversely affected or the temperature rise due to internal heat generation plus that due to solar radiation will not exceed the equipment design temperature. However equipment requiring manual operation shall be provided with sunshades to ensure that surface temperatures will not exceed 50°C.

Sunshades shall protect plant and personnel when the sun is more than 45°C above the horizon. They shall not impede the operation or maintenance of the Plant or the movement of ventilating air and shall include adequate artificial light as necessary.

Facilities such as lighting, lifting beams and rainwater drainage shall be provided wherever necessary to the approval of the Employer as an integral part of the sunshade structure.

3.17.2 TROPICALISATION

In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which equipment shall work, and good proven practices shall be followed unless otherwise approved by the Employer. Some relaxation of the following provisions may be permitted where equipment is hermetically sealed but it is preferred that tropical grade materials should be used wherever possible:

Metals: Iron and steel are generally to be painted or galvanised as appropriate. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an approved manner to prevent rusting.

Screws, Nuts, Springs, Etc.: The use of iron and steel shall be avoided in instruments and electrical relays wherever possible. Steel screws shall be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of corrosion-resisting steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting material, e.g., phosphor-bronze or nickel silver, as far as possible.

Rubbers: Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 4 – CIVIL, STRUCTURAL AND ARCHITECTURAL

CONTENTS

4 CIVIL, STRUCTURAL AND ARCHITECTURAL

This specification covers the design, manufacturing, supply, erection, commissioning and handing over of the complete civil works for the entire specified power plant. The configuration shall cater for all units, with number of units and capacities as specified in Attachment A1 of Section 5. If not mentioned otherwise, the given numbers of equipment is per unit.

It is to be emphasized, that this specification does not enumerate or describe all the materials and equipment to be supplied and all the services to be performed. However, the civil works shall be complete in every respect and shall ensure safe and reliable operation of the Plant. This means, all material and equipment shall be provided as required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

4.1 GENERAL

This section covers the design, construction and supply of all civil works internal plumbing works of the specified power plant. This section describes quality standards required, functions and certain philosophies for the Contract but is in no case a detailed specification. Therefore the requirements are not limited to the descriptions hereafter; items not mentioned shall be in the same best quality range as for the entire works of the project.

The various buildings and parts of the Project must form an architectural, structural and functional unit. Special attention must be paid, in addition to basic design and construction, to the aspects which are specific to climate and local requirements.

The buildings and structures shall be designed with due respect regarding the need for inspection, maintenance, cleaning and repair and able to operate for long-time periods with a minimum of inspection, adjustment and repair.

All material shall be new and of the best quality suitable for working under the conditions, variations in temperature and load encountered in service without undue distortion or deterioration or the occurrence of undue stresses in any part, such as to affect the efficiency and reliability of the plant.

The Contractor is not allowed to use the works, materials or furniture or parts thereof for temporary purposes without the written consent of the Employer.

4.1.1 LAYOUT

The limits of the power plant are depicted in Attachment B4 of Section 5.

The conceptual and detailed plant configuration of the various components shall be proposed by the Contractor, subject to the approval of the Employer to suit the requirements of the supplied equipment, under consideration of the existing situation, as well as the tie-in points. In doing so, adequate safety clearances, fire compartments, favorable layout of the plant components for monitoring and maintenance and any other requirements of up-to-date power plant construction shall be taken into account.

4.1.2 SOIL CONDITIONS

The soil descriptions and ground conditions are as described in the Attachment D. Contractor shall accept the Site and soil condition as it is and make his own interpretations and conclusions from the information provided to determine the basis of his own design and construction method and procedures. Employer assumes no responsibility for the accuracy and / or completeness of this information and will not entertain any claim arising from any discrepancy found in these reports.

Services of Professional Geotechnical Engineer or Consultant shall be engaged to interpret and advise on Soil Investigation Work and carry out design and construction of site preparation, piling, foundation and other sub-structure works.

Contractor shall be responsible for further carry out soil investigations work which may be required to confirm the subsurface conditions for civil and structural design.

4.2 CIVIL DESIGN CRITERIA

4.2.1 DESIGN CODES AND STANDARDS

The engineering and execution of all the civil works shall be based on the latest editions and revisions of the applicable codes and standards as listed in chapter 3 of section 5.

If any standard contains a provision, which is inconsistent with a provision in another standard, the more stringent in respect of quality shall apply.

4.2.2 ARCHITECTURE

Architectural Design and detailing aspects of all buildings shall be rendered through professional services of an Architect of reputation having experience in similar kind of works and familiar with vernacular architecture of Bangladesh.

The overall architectural character of main plant and other functional buildings shall be architecturally treated in such a way that it presents an overall image befitting the image of the Employer as a reputed international Power Company, comparable with international buildings of repute and yet, incorporates a pleasing composition of mass and void with suitable and functionally designed projections and recesses.

All external and internal finishes shall be modern finishes as per international standards and latest construction technology. Buildings shall be designed considering the climatic condition, building orientation, landscape design, interior design, to meet the International Building

Code and the vernacular architecture. The overall architectural character shall be in sympathy with the local environment and in harmony with the local culture

All buildings shall be provided with toilets and drinking water facilities as per international building code requirements.

Interiors of the buildings shall be designed based on functional requirements and shall interface smoothly with Mechanical & Electrical Services, so as to have an ergonomically designed and visually stimulating environment.

The Bidder shall submit preliminary architectural concept for major buildings along with tendering documents.

Detailed working drawings, perspective views, and walkthrough views of the entire plant shall be submitted for Employer's approval after contract award.

4.2.3 DESIGN LOADS

The following design loads shall be considered for the design of buildings and structures:

Dead Loads
Dead load is defined as the weight of all permanent construction including walls, foundations, floors, roofs, ceilings, partitions, stairways, and fixed service equipment and shall be calculated according to BS EN 1991-1-1 or equivalent (e.g. DIN EN 1991-1-1) and the Bangladesh National Building Code, whichever is more stringent.

For heavy industrial work, this would include equipment, vessels, including internals, pipes, valves, and accessories, electrical and lighting conduits, switchgear, instrumentation, fireproofing, insulation, ladders, platforms, and other similar items. Equipment and piping should be considered empty of product load when calculating dead load. The gravity weight of soil overburden shall be considered as dead load.

Erection dead load
The erection dead load is the weight of the equipment at time of erection plus the weight of the footing, pedestal and overburden soil.

Live load
Live load is defined as the weight superimposed by the use and occupancy of the building or other structure, but not permanently attached to it. For industrial design, live load can be defined as the load produced by personnel, moveable equipment, tools, and other items placed on the structure, but not permanently attached to it. Design shall be done for the actual plant live loads or the live loads specified in according to BS EN 1991-1-1, (or equivalent DIN EN 1991-1-1) or the Bangladesh National Building Code, whichever is more stringent. Unless specified otherwise, or required due to erection, operation and maintenance the minimum live load values for floors and roofs given in Table below shall be considered.

The Employer's consent is required in all carrying capacities and for exceeding the permissible stresses.

Minimum requirements for live loads [kN/m2]

		Slabs and secondary supports	**Gratings 2)**	**Main girders**	**Supports (e.g. columns, walls, brackets, etc.)**	**Foundations**
1.	**Reinforced concrete structures**					
1.1	At road level in areas used by large vehicles	15 SLW 30 3)	5	15 SLW 30 3)	10	10
	In areas of major assembly works and access roads	SLW 60 3)		SLW 60 3)		
1.2	Machinery floor for storage of heavy machine parts	30	10	20	20	20
1.3	Heavy intermediate floor slabs	10	5	10	7,5	7,5
1.4	Medium intermediate floor slabs	7,5	5	7,5	5	5
1.5	Light intermediate floor slabs	5	5	5	5	5
1.6	Roofs	1,5		1,5	1,5	0,75
2	**Steel structures**					
2.1	Heavy platforms	15	10	15	10	10
2.2	Medium platforms	5	5	5	5	5
2.3	Platforms and walkways in Conveyor galleries	5	5	5	5	5
2.4	Light platforms and walkways	2,5	2,5	2,5	2,5	2,5
2.5	Roofs	1,5		1,5		0,75

1) Figures in kN/m²
2) The loads shown are used for determining the load for structural analysis but not for dimensioning the gratings
3) Truck loads according to DIN 1072

Areas designated for different loadings on the same floor shall be clearly and permanently marked.

Crane/hoist load

Crane/hoist loads shall be considered as live loads. The vertical and horizontal loads from cranes/hoists shall be a data. In the absence of specific information, the following minimum horizontal loads shall be considered at the location of each wheel:

a) transverse surge = 20 % of static wheel load
b) longitudinal surge = 10 % of static wheel load.

Product load

The load shall be defined as the gravity load imposed by liquid, solid, or viscous materials in vessels, tanks, equipment or piping during operation.

Test load

The test load shall be defined as the gravity load imposed by any method necessary to test vessels, tanks, cranes, equipment or piping.

Thermal load

Thermal loads shall be defined as forces caused by changes in temperature. The primary source of thermal loads in an industrial plant is the expansion or contraction of vessels and piping. Another source of thermal loads in a structure is the expansion or contraction of the entire structure or individual structural components.

Truck load

Structures accessible to trucks shall be designed to withstand the gravity, lateral and impact effects of truck loading. Truck loading shall be SLW 60 or equivalent as per relevant standards or codes.

Soil load

Soil loads shall consist of lateral earth pressures. Active and passive coefficients for lateral pressures shall be obtained from the project soils report. The weight of soil shall be considered as dead load.

Hydrostatic load and buoyancy

Hydrostatic load is the load due to water pressure. The design of structures shall include hydrostatic loads when applicable. The buoyancy load is equal to the weight of the volume of displaced water.

Wind load

The wind load calculation for the buildings and structures shall be as per relevant stipulations in Bangladesh National Building Code -2012.

Basic wind Speed, V, shall be taken as 73 m/s, Three-second gust at 10 m above ground in exposure C, having a return period of 50 years.

Earthquake load

All buildings, structures and foundations shall be designed and adopt necessary earthquake design criteria. The Project site is exposed to seismic conditions. The area is in Seismic

Zone 1 as determined by the Bangladesh National Building Code (BNBC-2012). Related to Soil Type as identified to Soil Investigation Report, the effect of local soils on earthquake ground motion shall be determined. For site class S1 and S2, as expected for this project, site specific studies shall be carried out to determine Design acceleration response spectrum. Values regarding Soil Factor shall be verified during Soil Investigation.

Dynamic loads

Each structure shall be designed to withstand the effects of vibration and impact to which it may be subjected. Each structure and foundation supporting a compressor, turbine, pump or other machinery having significant dynamic unbalance shall be designed to resist the peak loads specified by the manufacturer. Vibration amplitudes of the supporting structure or foundation shall be kept within acceptable limits for dynamic forces that occur during normal machine operation. In the case of a tall and slender structure, there may be a need to investigate the dynamic effects of wind gusts. The vibration pad for absorption of vibration due to rotating or reciprocating machine shall be suitably designed to reach maximum thickness of material required and its complete spreading below entire foundation.

In the dynamic analysis, the following codes are to be considered: DIN 4024, ISO 1940-1 and ISO-10816. The vibration amplitudes & velocities, if not specified by the manufacturer, shall follow ISO-10816.

Impact loads

When a structure, structural component or connection is subjected to moving or vibrating loads which do not warrant a dynamic analysis, the following impact loads shall be considered:

1. Elevator machinery:	100% of machinery weight
2. Shaft or motor driven machinery:	20% of machinery weight
3. Reciprocating machinery:	50% of machinery weight
4. Overhead travelling crane:	Crane load shall be considered as live load. When applying this load, the following impact load shall be considered as per BS 6399: Part 1 EN 1991 or equivalent
• Vertical force:	25% of maximum wheel loads for cab operated crane 10% of maximum wheel loads for pendant operated crane.
• Lateral force:	20% of the weight of trolley and lifted load (but exclusive of other parts of the crane)
• Longitudinal force:	10% of maximum wheel loads
5. Truck loads:	Impact effects of truck loading shall be considered according to BS EN 1991-1-76399: Part 1 or equivalent (e.g. DIN EN1991-1-17)
6. Vertical force:	20% of lifted loads.

Load combinations

Design load combinations shall be generally in accordance with the relevant British Standard or equivalent. The load combinations shall include the erection loads and crane test loads also.

4.2.4 DEFLECTIONS

The maximum allowable deflections under the serviceability loads shall be as given below, if not other requirements due to functionality of the structures shall be followed, e.g. for transfer points and trestles of conveyor belt:

a) Structural steel

Cantilevers	L/180
Beams carrying plaster	L/360 or 20mm, whichever is less
Other beams (except purlins and sheeting rails)	L/200
Top of columns (single floor)	H/300
Top of columns in each floor (more than one floor)	H/300
Crane gantry girders	
Vertical	L/600
Horizontal	L/500
(where L: span/H: Height)	
Purlins and sheeting rails	L/200

b) Concrete structures

L/500 or 20 mm (whichever is less)

4.2.5 SETTLEMENTS

Settlements have to be calculated according to BS EN 1997-1 or equivalent and to be monitored.

The following requirements for settlements shall be applied:

- Max. settlement 25mm,
- Max. differential settlement 1/500 rad.

4.2.6 STABILITY

All ground stability analysis should be based on data given in the soil investigation report. Ground stability of structures has to be calculated according to BS EN 1997 -1 or equivalent. Embankment stability analysis shall be calculated according to BS 6031 or equivalent. Stability of masonry wall shall be checked according to BS 5628 or equivalent. The structures shall be designed and checked using a factor of safety of 1.50 for stability against overturning and sliding under the permanent loads and 1.2 under the temporary loads.

4.2.7 MISCELLANEOUS METAL WORKS

Stairways
Main stairways shall be min. 1250mm wide. Riser max. 180mm, tread min. 260mm, and local stairway shall be min. 1200mm wide. The number of steps between each flight shall be limited to 12. Head clearance min. 3000mm for air conditioned buildings, and min. 3500mm for non-air conditioned buildings.

The requirements of the specific local codes of procedures and the Local Authority requirements have to be respected by the Contractor.

Steel ladders other than companion way ladders

- Rung: round bars of 20 to 50mm diameter
- Rise: 250mm
- Width: 400mm

Safety cages shall be provided if height exceeds 2.5m and the ladder design shall comply with BS 5395: Part 3.

Handrails
Handrails shall be min. 1100mm high. Design to follow BS 5395: Part 3 or equivalent.

Gratings
Gratings shall be hot-dip galvanized and comply with BS 4592: Part 1 & 2 or equivalent.

Chequered plates
Chequered plates shall be minimum 6 mm thick mild steel.

4.2.8 DRAINAGE SYSTEMS

General
The drainage systems will consist of open reinforced concrete drains for storm water and surface drainage and piping for other drainage systems and reinforced concrete culverts for street crossings. In general, drainage systems shall be designed in accordance with BS 6367 or equivalent, the Bangladesh National Building Code 2012 and all relevant Local Authority requirements.

The drainage shall be separated into the following systems:

- storm water and surface drainage
- sanitary sewage reticulation
- oily water drainage
- chemically polluted water drainage.

Rain run-off
Rainwater run-off shall be determined in accordance with the relevant Bangladesh Standards by considering the maximum rainfall intensity of 95mm/hr for a one hour rainfall with 50 year return period. The maximum surface rainfall shall be considered with 349mm per day.

The water shall be collected in storm water ponds located outside the Plant before releasing the water to natural water courses. In addition, retention basins for rainwater to be used for spraying the coal stockyard and landscape irrigation could be provided on the plant area.

Sizing of ditches and pipes shall be determined by using Manning`s formula, using the following Roughness coefficient N for the various types of material:

Type	Roughness efficient N
Concrete pipe	0.014
Plastic pipe	0.013
Vitrified clay pipe	0.013
Smooth concrete channels	0.014

Gradient
Drains shall have the following minimum gradient:

- open ditch for storm water drainage I/250
- sanitary sewage drainage pipes I/150
- oily water drain pipes I/200
- chemically polluted water drains/pipes I/250
- other drainage systems I/400

However, the sectional shapes have to be determined by the water carrying requirements and must have the most favorable hydraulic qualities so as to remove the drain water in a proper manner without settlements.

Velocity of flow
Minimum velocity 0.80m/s (to maintain self-cleaning)

4.2.9 ROAD WORKS

General Criteria
Design of the road and paving courses shall be approved standards and also be based on the results of the geotechnical investigation.

Plant access roadways shall be designed to accommodate AASHTO HS-20 semi-truck loading with impact added. Parking areas for cars and light trucks shall be designed for AASHTO H-10 loading. The roads shall be designed to sustain the maximum loads from the vehicles likely to use them during construction and throughout the life of the facility including articulated vehicles and transporters used for the removal and replacement of major items of equipment during maintenance.

The following minimum requirements shall be met:

- access road (Double Lane) 10m with solidly compacted shoulders of 2.0m at each side all along
- single lane 4.0m with solidly compacted shoulders of 1.50m at each side all along
- double lane 7.0m with solidly compacted shoulders of 2.0m at each side all along
- patrol roads 4.0m with solidly compacted shoulders of 1.50m at one side all along
- minimum kerb radius at junctions to be 10m
- cross-falls to be 1～2.5% from one side to the other
- maximum longitudinal slope shall be 1:10.
- The roads and paving shall be laid to falls leading the storm water to gullies and to the discharge system and shall also comply with the Local Authority requirements.

The following road/pavement types shall be adopted:

Type I	Concrete wearing surface
Type II	Interlocking concrete blocks within the Plant area, suitable for heavy traffic.
Type III	Bituminous road (access road)

Road construction shall consider all required measures to avoid different settlements.

4.3 SCOPE OF SUPPLIES AND SERVICES

This section sets out the scope of civil works and installations covered by this specification as well as the requested supplies and services, but without excluding other necessary components and services not mentioned.

4.3.1 GENERAL

The Contractor shall supply and erect all buildings, structures and systems which are necessary to support, to protect and to provide the required environmental conditions for the entire plant including roads, security fencing and any other measures needed for safe and practicable operation of the plant.

The following types of works have to be considered, but without excluding other necessary works and services not mentioned:

- all necessary surveys
- all necessary soil investigation required in addition to the investigation works carried out prior to the EPC Contract
- all other investigations and studies necessary for the design and execution of civil works (drainage system, flooding possibility of the site, safety measures, etc.)

- site organization works for the entire project execution phase including but not limited to:
- arrangements of all temporary and permanent surfaces allocated for the new plant
- temporary buildings for offices, stores, workshops, sanitary rooms, canteen and kitchen, first aid station, etc. offices for the staff of the Employer, safety centre & field quality assurance lab, prayer room, visitor habitations
- open area for future maintenance works
- security installation on the site, including temporary fencing; temporary bridges, etc.
- access roads and outdoor storage facilities
- temporary water
- temporary electricity supply
- temporary storm water drainage and sewage system
- final cleaning of the temporary and permanent plant sites to the full satisfaction of the Employer
- housekeeping and cleaning of the sites during construction and equipment erection/testing works
- temporary firefighting facilities for the entire execution phase of the project
- provision and maintenance of lay-down area including access roads
- site fill on the location of all required buildings and areas
- structural and civil engineering design of all buildings, structures, foundations including the complete structural and dynamical analysis, design, execution and workshop drawing
- Third Party Verification of structural documents, including the complete structural and dynamical analysis, design, execution and workshop drawings
- removal of all debris, underground obstacles (if any) and surplus materials to approved dumping locations
- earthworks, permanent drainage works, soil exchange (if needed), refilling works on the plant site and on the additional areas allocated for temporary works
- all ancillary works and installations necessary for the execution of civil works, such as but not limited to: sheet piling, dewatering, fencing, signs, scaffoldings, etc.
- permanent roads, paved areas, footpaths, etc. on the plant site
- piling works
- execution of complete building, foundations and structures necessary for the installation of the indoor and outdoor equipment of the plant
- execution of all finishing and indoor installation works (such as doors, windows, wall cladding and rooting) painting and coating works, sanitaries, plumbing, ventilation-and air conditioning works, firefighting, sanitary works, sewage, electrical lighting-and lightning, earthing, etc.
- supply of all necessary furniture, housekeeping small equipment (kitchen, refrigerators, exhaust installations, etc.), laboratory equipment, etc.
- every working place shall be equipped with a computer, connected to a local network with connection to the plant computer network.

- execution of all necessary outdoor works for water supply, sewage and drainage works, firefighting, earthing etc.
- all necessary crane and hoist girders, pipe and cable bridges and supports according to the requirements of the electrical and mechanical installations.

4.3.2 BUILDINGS AND STRUCTURES

4.3.2.1 STEAM TURBINE BUILDING

The steam turbine building shall be sized to accommodate the steam turbine generator(s) together with all associated facilities and ancillary plant installations.

Measures shall be taken to avoid the transmission of vibrations due to equipment and rotating machines (mainly steam turbines, feedwater pumps) to the building structure. These measures shall mainly be separate reinforced concrete foundation to be insulated from the remainder of the structure either by shock absorbing joints or vibration control systems typically consisting of spring elements and viscodampers to prevent the transmission of vibrations.

The building shall be served by overhead traveling crane(s). Capacity and Number of cranes as per requirements of heaviest lift.

At ground floor level access ways for traffic with heavy trucks shall be provided.

At operating floor level toilet for operation and maintenance staff shall be provided.

Within the Steam Turbine Building the main electrical components of the project shall be accommodated:

- unit switchgear and I&C
- auxiliary switchgear

Next to the Central Control Room additionally to the required technical rooms such as switchgear room, relay rooms for electronic panel battery rooms, relay rooms, computer room, UPS and DC equipment room, DCS engineering rooms, the following rooms have to be provided:

- 1 (one) office
- tea kitchen
- archive/storage room
- engineering diagnostic room
- toilets for operators (male and female).

Description of building:

- flooring: reinforced concrete with suitable hardener and special oil resistant coating; TG hall

	granite or heavy duty vitrified tile
• foundations:	according to the soil investigation report and Special Technical Requirements of Foundations; special attention has to be paid for the safe transmission of dynamic loads and vibrations to the underground
• external wall:	230 mm thick brick walls or autoclave aerated concrete blocks with plaster finish up to 3.0 m or autoclave aerated concrete blocks from floor level and double skin metal cladding above. For architectonical appearance, inside in addition single skin metal cladding from operating floor up to EOT Crane girder
• internal wall:	230 mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
• roof:	Double Skim Metal Roofing
• doors:	composite steel plate door , fireproof door
• roller shutters:	As required (motor driven)
• windows:	Double glazed aluminium
• entrances:	Steel door
• ventilation:	Natural/mechanical
• louvers:	Aluminium alloy
• lifting equipment:	Travelling crane (see mechanical section)

The battery room shall be equipped with:

- acid resistant floor and drain
- sink outlets and floor drains shall be chemical resistant and piped into the chemical drain system.

False floors and suspended ceilings wherever required.

Electrical hoist designed for the transport of the electrical and control panels.

Finishes: The control room shall be of noble appearance. Flooring of the control room shall consider electrostatic problems (suitable earthing mats where required). Powder coated metal false ceiling with noise reduction factor (0.5) shall be implanted. Airlocks of glass or at least with visions shall be provided. The lighting shall be adequate and in accordance with the arrangement of the individual working places.

The design of finishing works will comply with the requirements of the code of procedures with regard to the mirroring effects, lighting of working places, shadowing etc.

Turbine Generator foundation shall be finished with chemical resistant, anti-slip, abrasion resistant flooring. Areas considered for maintenance purpose shall be marked permanently including the allowable bearing capacity as per structural calculation. Bearing Capacity shall consider maximum loads as per Operation and Maintenance Concept.

4.3.2.2 BOILER AND AIR HEATER BUILDING

The Steam Generator and Air Heater Building may be of open or semi-open installation.

Description of building:

- Foundation: according to the soil investigation report and Special Technical Requirements of Foundations
- Floors: as required for proper O&M access
- Flooring: reinforced concrete in ground floor, metal grating in other floors
- Structure steel structure
- Walls: double skin metal cladding (if necessary, else single skin metal cladding)
- Roof: double skin metal roofing (if necessary, else single-skin metal casing)
- Lift: 1 passenger & goods lift with a minimum capacity of 4,000 kg to the highest accessible platform
- Hoist: outdoor hoist arrangement at one side for long items

4.3.2.3 CENTRAL CONTROL BUILDING

Central control building is placed between two boilers and extends into the bunker bay, designed as 2 to 3 storey building. There are battery room, DC and UPS room, diesel engine generator room, air compressor room, instrument and condensate treatment control room; Switchgear room, relay protection room, communication room, cable mezzanine; unit control room and its attached rooms, engineer room, SIS room, electronic equipment room, shift room, gas extinguishing equipment room and power equipment room, air-conditioned room etc.

Description of building:

- Structure: Steel structure
- Floors: Five to six
- Flooring: reinforced concrete with hard screed topping carborundum type with oil resistant epoxy coating; WCs tiled; offices with PVC flooring

- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230 mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
- Internal wall: 230 mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
- Roof: Reinforced concrete structure roof
- Doors: composite steel plate door , fireproof door
- Windows: Double glazed aluminium
- Air conditioning: Centralized air conditioning, where functionally required
- Ventilation Natural/mechanical
- sanitary equipment in the office area: -Showers in changing room
  -WC with cleaning brush in toilet
  -Bowl urinal in male toilet
  -Wash basins in toilet

4.3.2.4 OVERHAUL WORKSHOP

General:
The area for the workshop shall be about (but not limited to) 2,500m^2 overall, designed for all maintenance facilities with related services e.g. offices, locker and sanitary rooms. The clear height shall be minimum 6m.

The workshops will allow all required works for daily maintenance and repair, which can be executed at site. The building will have enough capacity for the personnel of the plant which usually is employed in the workshops and for external personnel in case of major inspections or repairs.

Partitioned areas with suitable work benches, equipment and racking shall be provided for:

- mechanical workshops (welding, machine, overhaul)
- electrical workshops
- I & C workshops
- tool rooms
- 1 meeting room minimum 35m^2 area
- 5 offices for technical and admin. personnel (15 m^2 each)

The complete workshop areas shall be designed for the use of fork lifters with a minimum lifting capacity big enough for the heaviest part to be handled.

Suitable overhead EDT crane shall be provided in the area of the mechanical workshop.

Description of building:

• Structure:	Reinforced concrete structure
• Floors:	Three
• Flooring:	reinforced concrete with hard screed topping carborundum type with oil resistant epoxy coating; WCs tiled; offices with PVC flooring
• Foundations:	according to the soil investigation report and Special Technical Requirements of Foundations
• External wall:	230mm thick brick walls
• Internal wall:	230mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
• Roof:	Reinforced concrete structure roof
• Doors:	composite steel plate door , fireproof door
o Main entrance:	folding doors
o External:	self-closing sandwich steel doors with insulation
o Internal:	wooden doors with steel frames
• Windows:	Double glazed aluminium
• Air conditioning:	Centralized air conditioning,
• Ventilation	Natural/mechanical
• sanitary equipment in the office area:	-Showers in changing room -WC with cleaning brush in toilet -Bowl urinal in male toilet -Wash basins in toilet

Special Design Criteria

The minimum load bearing capacity of ceilings and floors shall be as defined in BS 6399: Part 1 or equivalent requirements of this Specification.

The live loads for ground floor shall be min. 50kN/m^2.

4.3.2.5 COAL BULLDOZER WAREHOUSE

General:

The area for the Coal bulldozer warehouse shall be about (but not limited to) 500 m2 overall, designed for all routine maintenance on mobile equipment with related services e.g. washing area, storage area locker and sanitary rooms.

Description of building:

• Structure:	Reinforced concrete structure
• Floors:	One
• Flooring:	reinforced concrete with hard screed topping carborundum type with oil resistant epoxy coating; WCs tiled; offices with vitrified flooring
• Foundations:	according to the soil investigation report and Special Technical Requirements of Foundations
• External wall:	230mm thick brick walls
• Internal wall:	230mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
• Roof:	Reinforced concrete structure roof
• Doors:	composite steel plate door, fireproof door
o Main entrance:	folding doors with motor drive
o External:	self-closing sandwich steel doors with insulation
o Internal:	wooden doors with steel frames
• Windows:	Double glazed aluminium
• Air conditioning:	Decentralized air conditioning,
• Ventilation	Natural/mechanical
• sanitary equipment in the office area:	-Showers in changing room -WC with cleaning brush in toilet -Bowl urinal in male toilet -Wash basins in toilet

Special Design Criteria

The minimum load bearing capacity of ceilings and floors shall be as defined in BS 6399: Part 1 or equivalent requirements of this Specification.

The live loads for ground floor shall be min. 30kN/m^2.

4.3.2.6 MATERIAL STORAGE

General:

The area for the Operation and Maintenance storage shall be about (but not limited to) 2,500m^2 overall, designed for required storage with related services e.g. locker and sanitary rooms.

Partitioned areas with suitable, equipment and racking shall be provided for:

- small spare parts store
- spare parts pallet store

- large spare parts store
- 2 (two) offices for store keeper (15m² each)

The dimensions of the building shall be adequate to accommodate all different types of racks for goods and spare parts necessary for the operation of the Plant.

A part of light material store shall have facility for storing electronic equipment/instruments.

Lifting devices shall be provided as required for heaviest part.

Description of building:

- Structure: Reinforced concrete structure
- Floors: Two floors
- Flooring: reinforced concrete with hard screed topping carborundum type with oil resistant epoxy coating; WCs tiled; offices with PVC flooring
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230mm thick brick walls
- Internal wall: 230mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
- Roof: Reinforced concrete structure roof
- Doors:
  - Main entrance: folding doors with motor drive
  - External: self-closing sandwich steel doors with insulation
  - Internal: wooden doors with steel frames
- Windows: Double glazed aluminium
- Air conditioning: Centralized air conditioning,
- Ventilation Natural/mechanical
- sanitary equipment in the office area: -Showers in changing room
  -WC with cleaning brush in toilet
  -Bowl urinal in male toilet
  -Wash basins in toilet

Special Design Criteria

The minimum load bearing capacity of ceilings and floors shall be as defined in BS 6399: Part 1 or equivalent requirements of this Specification.

The heavy loads of spare parts shall be considered for the calculation of the pallet racks and for the floor slab.

4.3.2.7 DM WATER TREATMENT BUILDING AND LABORATRY BUILDING

The buildings accommodate the water and DM water treatment facilities with a laboratory and sanitary facilities.

Description of building:

- Structure: Reinforced concrete structure
- Floors: one floors
- Flooring: reinforced, water tight concrete, with acid-resistant coating or tiling, as applicable
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230mm thick brick walls
- Internal wall: 230mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
- Roof: Reinforced concrete structure roof
- Doors:
  - External: self-closing sandwich steel doors with insulation aluminium glazed doors and
  - Internal: wooden doors with steel frames
- Windows: Double glazed aluminium
- Air conditioning: Decentralized air conditioning,
- Ventilation Conditioning, mechanical

Laboratory with suspended ceiling tiled walls and floor. Laboratory has to be air conditioned and provided with fume extraction hood cabinet

- Structure: Reinforced concrete structure
- Floors: two
- Flooring: reinforced, water tight concrete, with acid-resistant coating or tiling, as applicable
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External and internal wall: 230mm thick brick walls
- Roof: Reinforced concrete structure roof

Ring foundations for tanks shall be provided.

Special requirements for R/O building/room regarding HVAC shall be considered.

Pits, tanks and basins shall not require covering.

All wet areas (indoor and outdoor) and acid-alkali prone areas shall be provided with chemical-resistant catchments pits systems connected to the waste water tanks of the process waste water system. Acid resistant coating or tiling shall be provided in the catchments zones, subject to the approval of the Employer.

All water retaining structures shall be constructed as water tight concrete as per applicable codes and standards.

4.3.2.8 MINI FIRE STATION

The mini fire station shall be one floor.

In addition office, small duty room shall be provided.

Space for fire engine truck and other equipment, such as trailer etc. as required, shall be provided.

Description of building:

- Structure: Reinforced concrete structure
- Floors: one floors
- Flooring: Reinforced concrete with hard screed topping carborundum type with oil resistant epoxy coating;
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230mm thick brick walls or autoclave aerated concrete blocks with plaster finish
- Internal wall: 230mm thick brick walls or autoclave aerated concrete blocks with plaster finish
- Doors:
    - Main entrance: Motor driven folding door
    - External: self-closing sandwich steel doors with insulation
    - Internal: double plain steel doors
- Windows: Double glazed aluminium with internal sun
- Air conditioning: Shades centralized air conditioning,
- Ventilation Mechanical/louvers

For further details on the mini fire station, please refer to Chapter 40 of Section 5.

4.3.2.9 PUMP HOUSES

The structures of the following pump houses are included under this item:

- Circulating water pump house
- Raw water pump house
- fire water pump house
- Fire water booster pump house

- Foam pump house
- portable water pump house
- ash water recirculation pump house
- HCSD pump house
- service water pump house
- Fuel Oil pressurizing pump house
- Fuel Oil unloading pump house
- other specified pump houses not included above
- concrete structure with fill-in blockwork and concrete roof.

All buildings in the table will be reinforced concrete structure.

The building is divided in sections including a local switchgear room, if required.

Pump Houses shall be provided with electric rail crane with the capacity of the heaviest lift.

All requirements to enable Operation and Maintenance shall be considered. Adjacent to pump houses maintenance bay shall be provided.

4.3.2.10 ASH REMOVAL COMPLEX BUILDING

The building shall accommodate the equipment as described in Chapter 9 of Section 5.

Description of building:

- Structure: Reinforced concrete structure
- Floors: three floors
- Flooring: Reinforced concrete
- External wall/roof: 230mm thick brick walls/reinforced concrete structure roof
- Ground floor: Reinforced concrete
- Doors: double plain steel doors
- Windows: Double glazed aluminium
- Air conditioning: Decentralized air conditioning
- Ventilation Mechanical

4.3.2.11 STACK

One chimney with one outer structure (outer shell) of reinforced concrete, designed to be free standing against static and dynamic wind loads for two internal separate steel flue gas ducts shall be provided, including all necessary foundations, coatings, insulations, etc.

The height of the chimneys shall depend on the air dispersion study, which shall be prepared by the Contractor, but shall be minimum 275m.

The diameter of the chimneys depends on the diameters of the inserted flue gas ducts. In all levels a clear space of at least 1m between the chimney structure and the flue gas ducts shall be maintained. In this area the lift and staircase shall be integrated.

Reinforced concrete designed in accordance with the recommendations of ACI-307 and CICIND (International Committee on Industrial Chimneys). Standard and strong anti-corrosion protection, UV-resistant and acid and heat resistant paint shall be applied on the outside. Color and selection of bands shall be to the requirements of the relevant authority.

Roof area shall be tiled with acid resistant tiling.

The structure shall be sturdy and well founded to enable it to support both the expected wind and earthquake loads as well as the temperature stresses. Preferably the structural analysis of the system shall be done in one system including outer shell, foundation plate and piles.

All concrete parts below ground level shall be protected outside by a waterproof membrane and protection board as specified.

The lift shall be of industrial type concrete surface with a nominal carrying capacity of 500 kg. It shall travel from ground floor to each platform for service and maintenance up to the roof.

Inserts shall be provided as required for monitoring the stack gases.

Flue gas monitoring platforms, intermediate duct supporting provisions, landings and maintenance platforms with access shall be provided.

Galvanized steel ladder located in the space between the concrete shel1 and ducts shall be provided from the ground level to the top of the stack. Galvanized steel floor grating landings shall be provided, as required for Maintenance and operation, including a 360 degree landing at the test ports and at aircraft warning lights levels.

Additional external platform at aircraft warning lights levels shall be provided, if required due to operation and maintenance works.

Installations necessary for rescuing persons have to be assured in the whole area of the chimney.

The flue gas pipe can be either be of GRP or alternatively of carbon steel coated externally and with a suitable internal liner (Pennguard System or similar) or Stainless Steel. The liners shall be designed to with stand all internal and external loads and shall be adequately insulated.

Expansion joints shall be implemented as per requirement. Construction of joints shall follow international codes and standards.

A stainless steel stack cap and galvanized louvers, doors, and other openings with miscellaneous steel frames shall be provided.

Drainage system for condensates (inside the flues) and rainwater (from the roof top) shall be provided with appropriate treatment.

Aircraft warning lights, earthing, lightning protection, lighting and other electrical installations for maintenance shall be installed. The local regulations and ICAO regulations shall be followed.

Description of building:

- Structure: Reinforced concrete structure
- Surfaces: coating and protection painting inside and outside
- Foundation: a reinforced concrete ring beam or block/slab on piles as stipulated by the results of the soil investigations
- Flooring: galvanized steel gratings on structural steel, all galvanized and painted
- Stairs: open grid steel flooring mounted on galvanized steel structures inside the concrete structure
- Railing: Along the steel gratings, around the various openings and for the stairs and ladders tubular steel railings of galvanized and painted tubular steel shall be provided
- Access and escape routes: Access shall be made by galvanized steel ladders with safety cages. For all escape routes the local regulations have to be followed. All ladders and stairs shall be secured by platforms and railings.

4.3.2.12 LABORATARIES

Laboratories shall be incorporated in the main buildings as required, such as water treatment building etc. The laboratory rooms shall have suspended ceilings and tiled floors and shall be air conditioned. It shall be furnished with work benches, chemical fumes exhausting systems, acid proof sinks linked with acid collecting tanks- respective connected to neutralization systems and shall have different rooms for different tasks e.g. for tests related to the water and waste water treatment or test related to coal or oil, etc. Secure storage rooms for chemicals and emergency shower facilities are required.

4.3.2.13 OIL UNLOADING STATION AND FORWARDING PUMP HOUSE

The oil unloading station shall be possible to unload several road tankers at the same time. Final requirements are to be determined by Contractor according Chapter 9 of Section 5. The unloading pumps shall be installed 45cm above the road level.

The station shall consist of a reinforced concrete slab (treated against oil leakages) and sunshade of about 6m height. The sunshade shall be of steel covered with trapezoidal steel sheets. The floor scale shall be provided with retaining and discharge facilities for oil leakages.

The pump house shall be of solid reinforced concrete structure towards the tank yard and lightweight steel structure in the opposite site. The requirements of the valid rules and standards for the design and construction of fuel unloading stations especially with regard to the fuel oil catchment pit and fire protection have to be strictly respected by the Contractor.

4.3.2.14 400KV GIS SWITCHGEAR ROOM AND RELAY PROTECTION BUILDING

The sizes of the building have to be determined according to the requirements for the electrical and instrumentation/control equipment.

The following rooms shall be accommodated in this building:

- battery room
- switchgear room
- Communications room

Description of building:

- Structure: Reinforced concrete structure
- Floors: One floors
- Flooring: Reinforced concrete, vitrified tile flooring
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230 mm thick brick walls
- Internal wall: 230 mm thick brick walls with plaster
- Roof: Finish insulated-watertight RC roof
- Doors:
    - External: fireproof door
    - Internal: fireproof door
- Windows: Double glazed aluminium
- Air conditioning: Centralized air conditioning,
- Ventilation Natural/mechanical
- Sanitary equipment: Toilets for ladies and gents consisting of
  -WC with cleaning brush in toilet
  -Bowl urinal
  -Wash basins

4.3.2.15 FUEL AND ASH HANDLING BUILDINGS

Beside Coal bulldozer warehouse and Ash removal complex building, Fuel and ash handling buildings include Dry limestone shed, Coal transfer tower, Coal crusher room, daylighting rooms, coal sampling room, coal conveyor gallery, conveyor tunnel and Coal handling complex building. Coal handling complex building is steel reinforced concrete structure, others are reinforced concrete structure.

4.3.2.16 MAIN GUARDHOUSE

The main guardhouse located inside of the plant site serves for control of the entrance. From the working place the security personnel shall be able to watch the area in the front and behind the guardhouse and to release the pedestrian and vehicle gates.

The main guardhouse symbolizes the entrance of the plant and shall be of a good esthetical appearance.

Electrically operated road barrier/gates are included in the scope.

The following rooms shall be accommodated in this building:

- security staff offices
- time office incl. time machine
- reception area
- lounge
- safety induction center.

Description of building:

- Structure: Reinforced concrete structure
- Floors: One floors
- Flooring: Vitrified tile flooring
- External wall: 230mm thick brick walls or autoclave aerated concrete blocks with metal cladding
- Internal wall: 230mm thick brick walls or autoclave aerated concrete blocks with plaster
- Doors:
    - o External: Self-closing sandwich steel doors with insulation
    - o Internal: Wooden doors with steel frames
- Windows: Double glazed aluminium
- Air conditioning: Decentralized air conditioning,
- Ventilation Mechanical
- Sanitary equipment: -WC with cleaning brush
  -Wash basins

4.3.2.17 SECONDARY GUARD HOUSES

The gate houses, serves for control of the entrance. From the working place the gate keeper shall be able to watch the areas in the front and behind the gate house and to release the pedestrian and vehicle gates. The building shall be provided with the guard room a small office and a sanitary room. Electrically operated road barrier/Gate is also included in the scope.

Description of building:

- Structure: Reinforced concrete structure
- Floors: One floors
- Flooring: Vitrified tile flooring
- External wall: 230mm thick brick walls or autoclave aerated concrete blocks with metal cladding
- Internal wall: 230mm thick brick walls or autoclave aerated concrete blocks with plaster
- Doors:
    - External: Self-closing sandwich steel doors with insulation
    - Internal: Wooden doors with steel frames
- Windows: Double glazed aluminium
- Air conditioning: Decentralized air conditioning,
- Ventilation Mechanical
- Sanitary equipment: -WC with cleaning brush -Wash basins

4.3.2.18 FORCED DRAFT COOLING TOWER

The structure of the forced draft cooling tower shall consist of substructure part and super structure part.

The substructure part will be underground reinforced concrete basin structure. The super structure part will be reinforced concrete frame structure. The cast-in-place reinforced concrete is used for the beams, plates and columns.

All requirements to enable operation and maintenance shall be considered. Stairs and handrails etc. shall be provided.

4.3.2.19 WATER BASINS

The following water basins are included under this item, as required:

- Reuse water basin
- Service water basin
- Fire water basin
- Chemical water basin
- Portable water basin
- Filter water basin
- Clarification water basin
- Raw water basin

- other specified water basins not included above

The water basins shall be reinforced concrete structure.

All requirements to enable Operation and Maintenance shall be considered.

4.3.3 OUTDOOR FOUNDATIONS AND STRUCTURES

4.3.3.1 TRANSFORMER BAYS

Oil-filled transformers shall be supported on reinforced concrete foundations.

Provision shall be made for the catchment of oil spillage and fire deluge water. Appropriate measures are to be made to prevent pollution of the environment by the oil leakage / spillage.

The foundation supporting the transformers shall incorporate transformer rails. Each transformer foundation shall be provided with slope and raised borders, enclosing an oil retention basin pit in which the oil content of the transformer can be carried in the event of an oil leak. The oil retention basin shall be sized to hold the oil capacity of the largest transformer, rainwater and water from firefighting system. The basin shall be adequately coated. Above the oil pit a min. 20cm thick gravel layer on a steel grating shall be provided. The retention basins shall drain into a central oil separator conforming to VDE-Standard or equivalent. Water from the separator shall drain to the site drainage system.

The transformer bays shall have reinforced concrete fire walls towards the neighboring buildings and between each other –if applicable- and security fencing on the other sides with personnel gates to the front.

4.3.3.2 400/230KV GIS

The civil portion of the 400/230kV GIS consists of foundations, control building, GIS building, bus duct supports, tower & gantries and equipment support structures etc.

The size of the control building shall be determined according to the requirement for electrical and instrumentation/control equipment. It shall be constructed as reinforced concrete and brickwork building.

The GIS buildings shall consist of a steel structure with trapezoidal metal panels for external walls and roofs. The floor shall be a concrete foundation.

Details for tower and gantries and support details of outdoor substation equipment will be described in Chapter 33 of Section 5.

The complete Area shall be fenced off from site. The access shall be from Main Plant. Additional access from outside direct to the 400/230 GIS is not required.

4.3.3.3 OTHER OUTDOOR FOUNDATIONS

The following foundations shall be also included:

- dust filter (electrostatic precipitator or fabric filter plant)
- flue gas desulphurization plant
- supporting structures of pipes/cables, etc.
- outdoor switchgear supports and gantries
- air condensers and coolers (as applicable)
- other outdoor structures not explicitly mentioned above.

The foundations shall be of reinforced concrete designed and constructed according to the recommendations of the soil investigation report.

4.3.3.4 FOUNDATIONS OF VARIOUS STORAGE TANKS

The following storage tanks shall be provided with foundation:

- demineralized water storage tanks
- condensate tanks
- neutralization buffer tanks - if applicable
- other tanks not explicitly mentioned above

The tanks shall be founded 0.30m above surrounding ground level on ring / concrete slab foundations and a well compacted layer of bitumen sand premix layer with min 50mm thickness.

4.3.3.5 LFO/HSD STORAGE TANK

Care shall be taken to ensure that no pollution of groundwater through oil may occur and that all precautions for fire protection are taken. The LFO/HSD storage tank has to be installed as individual tank farm bund. The dewatering system of the oil catchment area of the substation shall be provided with a locking system, which should be activated during the unloading phase at the tanks.

- tank foundations:
  The tank shall be founded 0.40m above tank yard level on ring foundations of reinforced concrete and a well compacted layer of fine graded asphalt concrete of 50 mm thickness.

- bund of LFO/HSD:
  The bund and floor are to consist of reinforced concrete. The whole tank yard shall be isolated by a non-rotting oil and water-proof foil laid on the soil. The top protection for the insulating foil shall be achieved by concrete slabs. The joints responsible for absolute water and oil tightness between foundations and oil bund must not be endangered by possible settlements.

- In case of storage tank including a double bottom, a double wall (second wall in steel serving as spilling basin) up to the top of the tank and a roof covering the two walls, the bund can be omitted.

- drainage:
  The tank yard floor is to be sloped and provided with drainage channels so that trouble-free drainage of rainwater into the oil separators is possible. No oil should get into the rain water line even when an oil separator is overfilled.

4.3.3.6 CABLE AND PIPE DUCTS/PIPE BRIDGES

For cables and pipes, the Contractor shall provide ducts in such areas where installation above ground is not possible or advisable. Cables and pipes shall be laid in separate ducts. In general, ducts shall be avoided, as appropriate.

Pipe bridges shall be provided for supporting and routing of various pipes and electrical cables between the plant components.

4.3.3.7 COVERED CAR PARKS

The following parking provision shall be foreseen:

- in the area of the administration building: min. 75 shaded car parking lots and 75 unshaded car parking lots
- in the area of the service building: min. 75 shaded car parking lots and 100 unshaded car parking lots
- in the workshop and other areas: min. 50 unshaded car parking lots
- in different areas of the plant: min. 50 shaded motor-bicycle parking lot
- dividing stripes shall be marked.

4.3.3.8 OPEN STORAGE AREA

A free area of min. 2500m², paved with interlocking blocks (for heavy traffic) shall be arranged in the immediate vicinity of the workshop/store for the future installation of a camp of containers used during the maintenance works of the plant equipment.

The design of the area shall consider the loading and space requirement of minimum 20 standard containers. The scope of works include water, electrical power, and telephone facilities necessary for the connection of the above-mentioned area. The area shall be enclosed with chain link fence with pedestrian and vehicle gate.

4.3.3.9 UNDERGROUND SERVICES

Pipe & cable channels

Channels for pipes and cables shall be of reinforced concrete and must be watertight. Dimensions of the box shape channels shall be such that adequate working access and ventilation could be available to maintenance staff. The ducts shall be designed to comply with the fire protection requirements and shall withstand soil pressure and any live loads that may be imposed on the channels. Particular attention shall be paid to satisfactory expansion and settlement joints.

For drainage purposes the ducts shall be provided with slopes of a minimum 0.3% towards accessible pump sumps. An automatically controlled sump pump shall be permanently installed for any sump which is found to need pumping.

Hot dip galvanized anchor rails at a spacing of 1.5m shall be provided on the internal walls of the channels to support cable racks. Minimum required distance between power and instrumentation cables and between cables and pipes shall be observed. Heavy duty removable covers shall be provided at access points to the cable channel.

For smaller quantities of cables PVC pipe sleeves shall be placed from one manhole to the next.

Pipe laying under roads

Where it becomes necessary to lay a pipeline across and under a road the Contractor may install a permanent liner at a safe depth.

The liner shall be designed for the likely ultimate loadings and may be of spun concrete or steel. The diameter of the liner shall be adequate for the number of pipelines as required to accommodate and for possible maintenance requirements.

Cable and pipe ducts, trenches, tunnels outside building

Generally cables shall be placed directly below ground buried in a depth of at least 0.8m below ground. All necessary measures shall be taken at road crossings to protect cables against damage.

The necessity of providing cable and pipe ducts, trenches and/or tunnels and their possible routing are all as outlined in the relevant parts of the specification for electrical and I&C works.

General

For construction of cable and pipe ducts, trenches and/or tunnels the requirements of DIN 1045, DIN 1054 (or equivalent ISO –EN Codes), BS EN 1992-1-1, BS 6031 or approved equivalent standards shall be complied with.

For large numbers of cables and pipes the Contractor shall provide ducts, trenches and/or tunnels in such areas where installation by directly burying or above ground on racks is not possible or advisable. Cables and pipes shall be laid in strictly unit-wise separated ducts, trenches and/or tunnels.

The ducts, trenches and/or tunnels are to be constructed of reinforced concrete according to the requirement herein, and must be watertight and non-buoyant under the prevailing groundwater conditions. Particular attention must be paid to satisfactory expansion and settling joints. The walls and covers of the ducts, trenches and/or tunnels must be designed and reinforced to withstand the prevailing soil & water pressure, the relevant traffic loads and the weight of suspended cables and pipes.

The ducts, trenches and/or tunnels are to be provided internally with hot dip galvanized anchor rails every 1.5m for the easy attachment of clips and cable racks. Plugging and shooting of fixing devices are permissible only in isolated cases and are subject to the Employer's agreement. All trenches and/or tunnels covered by removable covers will have to be provided with metal protection angles protecting on one hand the edges of removable covers and on the other hand the edges of the duct walls beside the removable covers. Every attempt shall be made to locate the ducts, trenches and/or tunnels away from roads in order not to disrupt or endanger traffic during subsequent necessary work such as overhauls and repairs. The corners of the duct walls in the vicinity of junctions, inlets and bends must be rounded-off so that no damage is being drawn in, allowing for their minimum bending radii.

If the bottom of slab of a duct, trench or tunnel is below groundwater level, the slab shall have a slope and openings in the slab for natural drainage.

For drainage purposes the cable and pipe ducts, trenches and/or tunnels shall be provided with sumps and slopes (min. slope 0.3%) towards the sumps. Where necessary, pumps with automatic water level control shall be provided within the sump. Sumps which are likely to be dry most of the time may subject to the Employer's approval be designed portable pumps to be provided by the Contractor.

If a culvert(s), and/or tunnel(s), trench(s) or any other underground services are crossing streets, the street shall be constructed as a bridge for truck loading without effecting the underground structures.

All open trench concrete covers shall be pre cast (not cast in-situ) using straight moulds. Covers shall be adequately reinforced to withstand the induced loads; with cover to reinforcement not less than 15mm (reduced concrete cover due to weight constraints). The trench cover soffits shall receive a bituminous seal coat.

Small cable & pipe ducts/trenches
Where approved removable covers may be used for small ducts and trenches. The covers may be chequered plates, gratings internal or precast concrete slabs outside.

Dimensions of cable & pipe ducts trenches
Dimensions of ducts and trenches shall be appropriate to accommodate the installation of the cables and pipes with their required spacing and for the space required for their

maintenance. Ducts and trenches with removable covers may not have any access manholes

Covers, trash gratings, climbing irons
Shaft and manhole covers shall be made from cast iron or reinforced concrete, of watertight construction, with or without dirt traps, to suit local requirements. All covers shall be approved for loading as expected from the likely traffic conditions. The dimensions of trash gratings shall be those determined by proper structural design. Trash gratings shall be of cast iron.

The type and choice of climbing irons shall meet the requirements of

BS 1247 or other approved standards. Only corrosion protected materials shall be used. Where shafts are constructed of reinforced concrete, the step spacing shall be 330mm, and for brick shafts as close to that spacing as possible subject to the brick courses. Climbing irons shall be staggered, maintaining a horizontal axial spacing of 300mm.

4.3.4 OUTDOOR FACILITIES AND INSTALLATIONS

4.3.4.1 POTABLE WATER SYSTEM

The scope of this section is to supply with potable water all buildings, which require sanitary and potable water.

Foundations for storage tanks shall be provided.

The scope of this system includes all equipment required for the potable water system including piping for hot and cold water lines, water heaters, drinking fountains, valves, insulation and lagging, hangers and supports. Potable water will be supplied at emergency showers and eye wash stations as required in e.g. chemical feed area and station battery rooms.

4.3.4.2 SERVICE WATER SYSTEM

The scope of this section is to supply with service water to all locations which require service water.

Foundations for storage tanks shall be provided.

The scope of this system includes all equipment required for the service water system including piping, valves, insulation and lagging, hangers and supports.

4.3.4.3 STORM WATER DRAINAGE SYSTEM

For the entire plant, a complete storm water drainage system is required. A substantially maintenance-free and, above all, an operationally safe installation must be guaranteed. The surface water drainage shall include all necessary open channels, gutters, down pipes, gullies, traps, catch pits, manholes, etc. and shall incorporate the plant drainage requirements.

Storm water shall be drained by gravity. If this is not possible, necessary pumping stations with sand traps are to be provided.

Rainwater run-off from plant area shall be directed through drains, channels and culverts into a storm water collection pond. The size of the storm water collection pond shall be capable for rain water run-off. The volume shall be determined by the Contractor.

Any excess rain water during the monsoon season will overflow into the river.

4.3.4.4 SANITARY SEWEGE DRAINAGE SYSTEM

Sanitary sewage from administration, control, workshop buildings etc. shall be discharged in the sewage drainage system. The wastewater shall be treated in a Sewage Treatment Plant. For further details refer Chapter 25 of Section 6.

4.3.4.5 SEWEGE TREATMENT PLANT

The Sewage treatment Plant shall be provided as described in Chapter 25 of Section 6.

It shall comprise beside the required components also a small building for the pumps and the local electrical panels. The basins will be concrete structures and the building shall be a concrete /block work structure.

The plant shall be designed to ensure that the effluents will have the quality which is required to allow the re-use for irrigation.

For this purpose the water shall be stored in a storage basin of suitable size. The water will be removed periodically by means of tank truck or other suitable ways.

4.3.5 COAL AND ASH HANDLING AND STORAGE FACILITIES

4.3.5.1 COAL YARD

Coal storage

The coal storage shall be suitable for coal demand of 40days as mentioned in Chapter 9 of Section 5. The final size shall be determined by the Contractor.

The coal yard shall be constructed for 2 x 660 MW unit. Provision shall be made for expansion of the coal yard and shall be reserved in the Site Layout.

Soil replacement and ground improvement shall be carried out for the coal storage area to have the required safe bearing capacity with negligible relative and absolute settlement characteristics.

A fully covered coal storage area shall be considered. The covered coal yard shall be complete in all respect, including foundations and installation of steel structure and metal roof and sheeting. Sand piles and pre-loading of the entire storage area for a period as required may be the most economical and effective way to achieve the required results. The ground improvement work shall be started as early as possible to achieve the required results.

The improved sub grade shall be well compacted to the required lines and levels before sealing it with an impermeable layer of high density membrane. At least 300mm layer of clay of high plasticity index shall be laid on the impermeable membrane. The clay layer shall be covered with a minimum 250mm layer of well graded gravel sub-base. Perforated high intensity pipes shall be recessed into the gravel layer to form a close grid of drainage system. The drainage system shall be prevented from clogging by using suitable geo textile cover or proven filter design. Finally, the gravel layer shall be covered with a layer of inferior quality coal of a minimum 200mm thickness.

For collecting storm water and spray water from dust suppression, a drainage system shall be provided. The drainage system will drain into trenches around each coal pile thus be connected to drain into a separate coal drainage settling pond. The basin shall be founded on well compacted selected soil after removal of the existing top soil and weak subsoil. Complete with fully sealed reinforced concrete lining, the pond shall be constructed at a level that will be best suited for gravity flow of the drainage water. Slope of drainage lines shall consider long term settlement of coal storage area. Suitable removable type covers of the drains shall be provided.

Coal transfer towers/coal crusher building

The civil works for the coal crusher buildings, coal sampling units and all transfer towers and conveyer bridges shall comprise foundations and drainage systems.

Where necessary, pile foundations or other deep foundations shall be provided.

Provisions for regularly washing of structures and floors shall be made along with proper drainage.

All civil works for the crusher building and transfer towers shall be provided to meet the requirements of the mechanical and electrical installations.

Measures shall be taken to avoid the transmission of vibrations due to equipment (mainly crushers) to the building structure. These measures shall mainly be separate reinforced concrete foundation to be insulated from the remainder of the structure by vibration control systems consisting of spring elements and viscodampers to prevent the transmission of vibrations.

Unbalanced forces due to equipment shall be considered.

Building description:

- Structures: Structural steel frame
- Foundations: piled foundations for steel columns (see also and the results of the geotechnical investigation results)
- Base Floor: reinforced concrete with slopes to gullies and drainage, coating according to the regulations
- External wall: 230mm thick brick walls with plaster finish up to 0.9m or autoclave aerated concrete blocks from floor level and double skin metal cladding above.
- Roof: galvanized steel structure with metal cladding water proofing

Coal conveyor

All civil works for the coal conveyors shall be provided to meet the requirements of the mechanical and electrical installations. If for structural reasons required deep foundations shall be taken into account for conveyor belt supports.

The system shall be fully enclosed. Proper access shall be provided.

Provisions for regularly washing of structures and floors shall be made along with proper drainage.

Coal conveyor bridges

The civil works for the coal conveyer bridges shall comprise foundations, steel structure and drainage systems.

Where necessary, pile foundations or other deep foundations shall be provided.

The system shall be fully enclosed. Proper access shall be provided.

Provisions for regularly washing of structures and floors shall be made along with proper drainage.

Structural analysis shall be performed for both conveyors running with 100% loading.

All civil works for the crusher building and transfer towers shall be provided to meet the requirements of the mechanical and electrical installations.

Building description:

- Structures: Structural steel frame
- Foundations: piled foundations for steel columns (see also and the results of the geotechnical investigation results)
- Base Floor: reinforced concrete with slopes to gullies and drainage, coating according to the regulations

- External wall: 230mm thick brick walls with plaster finish up to 0.9m or autoclave aerated concrete blocks from floor level and double skin metal cladding above.
- Roof: galvanized steel structure with metal cladding water proofing

Coal stacker/reclaimer

The civil works for the coal stacker/reclaimer shall comprise all foundations and civil works required for the equipment described in Chapter 9 of Section 5. Where necessary, pile foundation or other deep foundations shall be provided.

Construction shall consider all requirements due to long term settlement, e.g. adjustments of the equipment runway.

4.3.5.2 ASH YARD

The primary dry ash yard shall be provided for storage of ash/slag and FGD gypsum. The system shall include initial ash embankment, inner drainage system, ash water storage pond, ash transportation roads and maintenance roads on top of ash embankment. The capacity of primary ash yard should be enough for 2 x 660MW units for 10 years.

The average ground level on proposed land is RL=2.0m. The height of the starter dyke shall be approx. 5.00m. Provisions shall be made for construction of further raising dykes to extend the storage volume of ash. The average height of ash storage heap shall be considered as about 8.5m in center of ash yard.

The starter dyke shall be constructed in such a way to maximize ash storage and considering seismic influence. Ash dyke embankments can be designed as an earthen dam as per relevant code. Depending on the type of the soil for the embankment construction, it may have either of the following sections:

I. a homogeneous section with internal drainage arrangement of sand and sand blanket
II. a heterogeneous section consisting of an inner impervious core and outer shell of available soil.

Based on the properties of soil and fill material, the stability and seepage analysis shall be carried out. The design shall be done for ultimate height and the unutilized ash to be stored. Soil Improvement shall be considered, if required to minimize settlements of the dyke and inside the pond. The bearing capacity in the area shall be as required, but not less than 100 kN/m^2.

The ash yard shall be provided with impermeable liner in compliance with legal regulations. The liner may be natural or synthetic depending upon the substrata encountered and the permeability of soil. Toe drain shall be provided all around the periphery of outer dyke, where applicable. An RCC peripheral drain shall be provided to guide the seepage water from toe drain into seepage water sump and the same shall be pumped into Over Flow Lagoon (OFL). Toe drain shall be connected to peripheral RCC drain suitably at regular interval.

Internal drainage arrangement and toe drain around the dyke shall also be provided. Suitable Protection measures from back water of river shall be provided all around the ash dyke.

In addition, on downstream (D/S) slope of the embankment, slope protection measures with inverted filter arrangement shall be provided from G.L. to HFL plus 1.0m height of dyke embankment. Provision shall also be made to protect the upstream slope of embankment. Rock-toe with toe drain shall be provided at the toe of the embankment all around the ash dyke.

The Contractor shall provide a simple and effective filling concept, which will allow proper settling effect during all stages of the progressing fill of the pond and which shall keep the exposed ash surface to a minimum at all times. In order to monitor the performance of ash dyke during construction and operation, instruments should be installed at suitable locations.

Weighbridge

A weighbridge for weighing bulk goods to be brought in or out of the plant shall be provided in the area of the main entrance/gatehouse.

The scope of supply includes the design, delivery, installation and commissioning of the mechanical civil and data capturing and transporting system for one weighbridge to be installed at the gate house and consist of the following:

- weighbridge with a length of 12.0m and 30 tones capacity
- reinforced concrete trough designed to support the weighbridge including drainage provision connected to the sewage system of the plant, all necessary embedded part for anchoring, sleeves, base plates etc.
- accessories including load cells, weigh indicators, arrestors and all devices necessary for proper operation of the weighbridge
- transponder system complete with all accessories
- 2 units of vehicle barriers with all accessories
- outdoor printer complete with printer stand with waybill depository boxes and accessories
- traffic light complete with all accessories
- message sign board to be installed in the gate house
- data processing system and communication equipment complete with computer, data switches and software for the control of weighbridge transactions
- all cabling between the weighbridge and the control desk.

4.3.6 ROADS, PAVING AND SURFACING

The road system must be arranged in such a way that free- flowing traffic is guaranteed.

All internal road within the plant area and some of the main roads are indicated on the Layout Plan. However, additional roads and access to individual building/structures/facilities which are not specifically shown in the layout but where access is necessary for inspection, operation & maintenance point of view, shall be provided by the Contractor.

Walkways shall be provided from roads to interconnect all facilities and all building doors. The walkways shall be reinforced cement concrete and shall be prepared with an adequate depth of compacted base course and shall be at minimum of 1.5m wide. Walkways will be formed with slopes and/or steps at the correct level to drain storm water.

The area around buildings and outdoor auxiliary plant, which are used infrequently, lay down areas for small loads, footpaths, parking areas, etc. shall be paved with interlocking concrete blocks.

The entire area of the Power Island shall be paved with reinforced cement concrete and sloped to drains.

Transformer Yard shall be paved with reinforced cement concrete.

Substation area excluding the internal access roads shall be filled with 150mm thick layer of 20mm to 40mm size gravel over a layer of 100mm thick lean concrete (M10).

Surfaces of unbuilt and remaining areas within the site boundary which are neither built nor paved shall be adequately leveled and covered with topsoil to allow proper landscaping. Road signs, traffic signs, road surface marking and guardrails shall be provided as per authority requirements for traffic in industrial areas.

The access and connecting road of Executive rest house, VVIP rest house and Helipad shall be constructed.

The works shall include temporary site access roads from the existing outer roads.

After finishing of construction works all temporary site access roads used by the Contractor shall be reinstated to the original standard i.e. the standard after refurbishment.

4.3.7 LANDSCAPING

There shall be comprehensive landscape development in entire Plant area to create a pleasant and healthy environment. The scope of work for landscape and horticulture work shall include supply and planting of trees, shrubs, hedges/edges/borders, grass lawn around different areas, buffer and peripheral plantation etc. The scope shall also include supply and installation of all landscape furniture i.e. park benches, gazebos, landscape fountain and water bodies, landscape pavers/ tiles etc. and all associated electrical and mechanical works/items and all other work required for completion of landscape development.

The landscape design and drawing shall be developed by competent Landscape Architect. The landscape shall use the suitable plants and trees preferably local trees, plants, and shrubs. There shall be provision of pathways in and around the landscaped area, with suitable provision for disabled persons.

Around the pathways and roads, trees shall be planted. Rainwater harvesting for the entire Plant Area shall be integrated within the landscape development. There shall be provision of irrigation system for irrigation of landscaped area.

All other open areas of plant, which are not covered by buildings, structures, roads, lay-down areas, graveled areas, etc., shall be planted with shrubs and grass.

Around the coal yard, trees shall be planted in order to limit dust contaminations.

Greenbelt around the main power plant, shown in the drawing 10-PM-PAY-01, shall be constructed with plantation of tall & dense trees after necessary treatment of recent fill material (dredge fill) to suitable soil for plantation in order to limit dust contamination.

4.3.8 MAIN ENTRANCE AREA INSIDE THE PLANT

Within the area of the main guardhouse, a welcome and waiting complex shall be provided.

The area shall consist as a minimum of:

- landscape area
- flagstaff
- 10 car parks, shaded
- 3 bus parks

The structures shall fulfill the technical requirements as stated in this specification.

All buildings shall be equipped with electricity, HVAC, telephone connection, etc.

4.4 SPECIAL TECHNICAL REQUIREMENTS

4.4.1 BASIC REQUIREMENTS FOR ALL CIVIL WORKS

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Employer.

Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers.

The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable to personnel, and will not cause damage to the machine or structure. The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.

The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.

Throughout the works, all floor slabs above rooms containing electrical equipment shall be watertight. No drain pipes or water pipes are permitted to pass through these rooms.

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Employer. The work shall be carried out by competent personnel skilled in their various trades.

Suitable access to the roofs of the buildings by means of galvanized steel stairs shall be provided for maintenance and firefighting purpose.

All rooms with fire hazard shall be provided with suitable emergency exits.

Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles which will be used (cars, forklifts, trucks/trailers etc.) to reach up to the point of unloading of the equipment.

Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc. shall be designed to suit the a.m. transport concept.

An appropriate serviceable and functional master key system for the whole plant shall be supplied and installed.

Before starting of design works, the Contractor shall submit to the Employer for approval a project design manual containing the design data, the design criteria and the standards for all civil works. All loadings considered in the design shall be justified with supporting details.

4.4.2 SITE PREPATORY WORKS

The dwellings of the site will be removed by the Employer. The demolition inside of the plant boundary is outside the scope of the Contractor.

The Site filling and ground improvement works for the power block area shall be up to +5.55m above MSL and shall be undertaken by the Employer and not in the scope of this Contract. The consolidation of the improved ground shall be minimum 85%. Areas where other facilities are to be located outside the power block area shall be levelled and compacted by sand filling (dredge fill) up to +5.55m above MSL by the Employer without any ground improvement.

The ash pond area will not be filled and improved. After checking the suitability of the site, the area shall be leveled and compacted by filling and cutting to a final level to be established upon a site survey.

Survey works

The coordinates of the envisaged site location are stated in Attachment B4 of Section 5.

The Contractor shall carry out close grid survey of the site to set up Plant Datum.

Plant elevation shall be defined as follows:

- finished ground level of the plant + 5.60 M above MSL
- power house building level + 5.90 M above MSL
- final level of road + 5.85 M above MSL
- final level of landscaping + 5.55 M above MSL
- final level of paving of power house block + 5.70 M above MSL.

Finished floors of the power island buildings at ground level shall be fixed at 0.00m Plant Datum (PD), subject to optimization by the Contractor, and this PD being at least 0.30m above ground level.

The Geotechnical Report performed on the existing ground is enclosed in Attachment D of Section 5.

Nevertheless the Contractor shall carry out the necessary topographical survey works in order to obtain the following information:

- location of the plant site relative to the existing bench marks of the area
- establishment of site boundaries with site levels
- installation of site bench marks
- preparation of a site survey report, with the description of survey works, methods applied and survey map(s) on scale 1:1000, showing the results with the location of bench marks. The levels have to be given in an adequate scaled grid line system.

Moreover the Contractor shall carry out a bathymetric survey and all investigations required for the off-shore structures.

The investigation data provided in this tender document shall be considered as preliminary and the full responsibility of the investigations to be carried out lies with the Contractor.

Geotechnical investigations

Geotechnical investigation at the site of the works has been carried out for the Employer (see Attachment D of Section 5). The investigation comprised boreholes with soil sampling, SPT testing in the main areas of the plant.

Geotechnical investigation data available as of now is of preliminary nature.

The existing information about subsoil conditions, quality of filling, water levels in the ground etc. are for information only, and is not binding during execution phase.

In case the Contractor needs more information for proper design of works during execution phase, additional investigations shall be performed at his own expense. There are no restrictions about the investigations.

The Bidder is responsible for any matter of subsoil, filling and water in the ground.

In general the subsoil conditions can be described as follows: top layer filled sand (with unknown silt content), underlying layers of clay, underlaying fine sand.

Hence, the Contractor has to carry out detailed geotechnical investigation at his own cost. Methodology and specification of the investigation is subject to approval by the Employer. Special attention should be paid to Seismic Parameters. Related to Soil Type as identified to Soil Investigation Report, the effect of local soils on earthquake ground motion shall be determined.

For site class S1 and S2, as expected for this project, site specific studies shall be carried out to determine Design acceleration response spectrum.

Seismic Study

The seismic study shall be performed by an accredited Engineer with adequate references and experiences in equivalent projects.

Study area

The study area is defined with a radius of 200km (incl. safe distance) around the Site location.

Geological structure model

The following data shall be obtained for the model:

- large-scale plate tectonic exposure for the study area
- small-scale micro plates are to be described or excluded
- existing faults, dislocations, drops and lineaments in the deeper and shallower subsurface
- lithological as well as stratigraphic structures for the deep subsurface layers up to Holocene boundary.

Based on the information, a litho-stratigraphic 3D model of the subsurface shall be developed up to the Holocene boundary.

Earthquake

All documented earthquakes in the study area shall be listed with their magnitude-height. A differentiation between the respective focal depth and the location of the epicenter (shallow or deep tremor) shall be considered. From the available seismic data, the energy values of the shear waves (maximum and average values) at the construction site shall be derived.

Furthermore, the wave intervals between 4.0 s up to 10 min must be taken into account. Subsequently the thus obtained values must be transferred to the soil parameters.

Soil parameters
The grain size distribution, density and water content for the depth profiles of the boreholes and / or soundings shall be described in order to assess the possibility of a tendency to liquefaction of the soil. The soil must be tested for its damping characteristics in the laboratory. Transformations in the geotechnical characteristics must be documented.

All test results have to be evaluated for every individual building component of the proposed power plant complex according to the British Standard or the DIN EN ISO 1998 sheets 1- 6. Based on this evaluation recommendations for the construction of the individual components have to be given.

4.4.3 EARTHWORKS

General
This section applies to all earthwork required for the construction of buildings, structures, pavements, road works, landscaping and burying service lines in the ground.

The Contractor shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner.

Furthermore, this division applies to excavation works in connection with pavement, roadwork and landscaping.

Fill materials
The fill materials used are to be examined and approved. Excavated materials can be used if they fulfill the requirements.

- **Select fill**
  Select fill shall have the following properties:
  Well graded, non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.
  The material shall be of such nature and character that it can be compacted to the specified densities. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution and of cinders or other materials which will corrode piping or other metal. The intention is to use select fill below structures, roads, parking areas etc.

- **Ordinary fill**
  Ordinary fill shall have the following properties:
  Natural inorganic soils: Organic matter less than 3%. For other properties see under 'Select fill'. The intention is to use ordinary fill for non-built areas.

- **Special fill**
  Special fill material shall be gravel or crushed rock.
  The intention is to use special fill e.g. as sub-base material for tanks, roads and substation areas.

Execution
The Works shall be excavated by use of excavating plant and tools acceptable to the Employer.

Safety precaution
The Contractor shall be responsible for all necessary safety measures. Proper strutting, sheeting and bracing, stabilization and protection of slopes, methods of excavation to reduce risks of slides, etc. shall be to the Contractor's debt.

Over excavation
If somewhere, and for any reason, excavation is executed beyond the established lines and without the Employer's previous approval, the Contractor shall at his own expenses backfill with approved material (including required compaction) or with lean concrete.

Stockpiles and disposal
Excavated material from the Works selected by the Employer for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on Site as directed by the Employer.

Preparation of foundations
All surfaces on which or against which concrete is to be poured shall be carefully cleaned and roughened and shall be free of any detrimental impurities, organic matter or unsuitable material to the Employer's satisfaction.

The surface shall be free of oil, stagnant or running water, mud, loose rock, residue and impurities or any other improper material.

Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Employer and then protected by means of a lean concrete layer, 75mm in thickness. No concrete is to be poured until formation is inspected and approved by the Employer.

Backfilling
Foundations and structures shall be backfilled with approved material compacted in layers by suitable equipment until optimum stability has been obtained to the satisfaction of the Employer. Compacting shall be carried out by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Employer.

Density requirements shall be as follows:

• Under buildings and structure foundations and slabs	85% relative density (ASTM D-4253 and D-4254) for free draining soils containing less than 15% by weight finer than 75 micron

• Under roadways and parking areas • Under transformers and other major foundations	sieve non plastic material or 98% of the maximum density as determined by ASTM D-1557 for soils containing more than 15% material passing the 75 micron sieve.
• Embankment	80% relative density (ASTM D-4253 and D-4254) for free draining soils containing less than 15% by weight finer than 75 micron sieve non plastic material or 95% of the maximum density as determined by ASTM D-1557 for soils containing more than 15% material passing the 75 micron sieve.

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Employer after compaction tests have been made.

Backfilling of foundation work shall be carried out only after foundations have been inspected by the Employer.

Soil replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favorable grain size distribution shall be used in exchange.

Prior to the commencement of work, samples shall be taken from the anticipated borrow area and tested in respect of Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

The fill material shall be placed in horizontal layers of no more than 25cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction.

The fill material shall be compacted by vibratory roller (min. weight 10t).

Tests and properties

The control of working and tests operations shall be carried out by the Contractor according to the respective standards in the presence of the Employer.

4.4.4 FOUNDATIONS

General

Foundation design shall be based on approved geotechnical investigation report. The Contractor shall submit a detailed design for the foundation to the Employer for approval. The bid price for the piling shall be lump sum and shall remain firm irrespective of the type design.

Once the final plant layout has been established by the Contractor, he shall carry out a more detailed geotechnical investigation. The scheme of geotechnical investigation shall be prepared by the Contractor and will be subject to the Employer's review and approval.

Information from the soil investigation performed during year 2014 at the Site is provided to the Bidder for information only. The Bidder may note the presence of thick deposit of soft clay as revealed through borelogs attached. The onus of correct assessment/ interpretation and understanding of the existing subsoil condition/data is on the Bidder. The Bidder should note that nothing extra whatsoever on account of variation between soil data collected by Employer and that found by the Bidder during additional soil investigation or during execution of works, shall be payable.

A study of soil liquefaction potential shall be performed using parameters from the geotechnical investigation performed by the Contractor and subject to the Employer's review and approval.

Special measures have to be taken if the results of soil and laboratory tests prove chemical aggressive conditions.

The soil conditions met during the foundation works are to be checked by the Contractor's soil engineer, recorded and compared with previous results. If essential differences occur, the Contractor has to take in to account of these data for his design / construction.

For the Foundations not supported on piles, the soil conditions met at the founding level are to be checked by the Contractor’s foundation designer, recorded and compared with the parameters assumed in the design of the foundation. If substantial differences occur, the Contractor has to take into account of these data and re-design the foundation accordingly. Also for major foundations unsupported by piles and susceptible to settlement, the Contractor shall arrange for proper testing of the bearing soil layer e.g. Plate Load Test, Mackintosh Probe etc.

Design of the foundations shall be in accordance with the latest DIN/Euro codes and/or other approved standards and codes of practice including the following:

- DIN 1054 — Subsoil: Permissible loading of subsoil; Load Testing of Piles (2005-01, Section 8).
- DIN 1626 — Welded circular steel tubes subject to special requirements, technical delivery conditions.
- DIN 1629 — Seamless circular steel tubes subject to special requirements, technical delivery conditions
- DIN 4014 — Part 1: Bored piles: construction procedure, design and bearing behaviour
  Part 2: Bored piles: large bored piles: construction procedure, design and bearing behavior
- DIN 4026 — Driven piles: Construction procedure, design and bearing behavior.

Furthermore, the ICE Specification for Piling and Embedded Retaining Walls (latest edition) shall be observed.

From the detailed study of the sub-surface ground conditions, the type of foundations required for each location shall be determined to suit the loads imposed.

The foundation/soil improvement could include any of the following:

- shallow foundations on existing ground/improved ground
- sand piles
- bored cast-in-place concrete piles
- driven piles
- vacuum consolidation.

The Contractor may propose any other type of foundation and ground improvement as required provided the proposal is based on proven engineering and acceptable standards and codes of practice. As a part of the design of the Works and after fully detailed ground investigations, the Contractor shall submit for the Employer's approval a comprehensive foundation plan for the Works proposing the type of foundation for each part of the works.

The turbine/generator pedestal foundations shall be independent of the enclosing turbine building foundations.

All large tanks shall be dimensioned so that their aspect ratio (height/diameter) is less than about 0.4. The tanks can then be supported on ring type foundation under perimeter walls. The Contractor shall demonstrate the adequacy of the ring beam foundation, without piles, from total and differential settlement and will be subject to Employer's review and approval.

Dewatering

During the foundation works the excavated areas, foundation levels and pits are to be kept free of water down to at least 1.0m below the foundation level.

Damp proof course and Waterproofing

All foundations, footings and slabs in contact with ground water shall be of water tight concrete in accordance with DIN 1045 or equivalent approved standards and shall be protected against water action and rising damp in accordance with:

- DIN 18195
- DIN 18336.

All foundations, footings and slabs in contact with ground shall receive a bituminous coating.

Damp proof course (DPC) thickness shall be applied to brick and block walls at about 300mm above ground level to check rising damp. The DPC shall be in accordance with DIN 18195 or equivalent approved standards.

Pitwall stability
The excavated pit sides, walls or slopes have to be stable and established with respect to safety regulations.

Settlement and expansion joints
Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc. do not adversely affect the structures. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width shall be at least 2cm.

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to BS EN 1997-1 or other equivalent standards.

Foundations at different depths
Foundations at different levels should be based beyond a load spread angle of 30° (against the horizontal).

Safety against uplift
For all parts of the structures extending into the ground water, safety against uplift has to be guaranteed during all execution stages.

Soil replacement
If unsuitable soils are encountered below the foundation level or basement floor, they are to be replaced by suitable layer-wise compacted material down to the bearing soil.

4.4.5 PILING WORKS

This section covers the requirements for materials, installation and realization of bored cast-in-place concrete piles with grouting at the base, if required, and driven piles.

The piling works and design shall be in accordance with BS EN 1997-1 or equivalent.

Two types of piles foundation can be proposed and quoted by the Contractor: driven piles or cast-in-place bored piles.

The net vertical pile capacity computed from the soil investigation report is used to determine the maximum test load in case of piles testing.

Bored cast-in-place piles
The piles are drilled up to the depth indicated by the pile drawing submitted by the Contractor and approved by the Employer. For each pile, the Contractor draws up the geo-technical profile of the drilling with description of the strata and samples taken for each stratum as mentioned in the piling record item of these specifications. A representative sample from each stratum will be kept in tight packing until the end of the works.

Rotary Auger Drilling shall be used and suitable type of drilling equipment shall be provided in order to penetrate obstacles (e.g. boulders) which may be met during the execution of the piles. Percussion method of installation shall not be permitted.

Generally, drilling operations shall be carried out in such a way as to avoid any disturbance of the surrounding soil. A temporary casing shall be installed as per site condition.

When drilling below the groundwater table inside the casing shall always be maintained above the natural groundwater level by at least 1.5m, i.e. water has to be added accordingly.

Just before reinforcing and start of concreting the pile foot is to be cleaned out so that no disturbed, loose or weak soil remains below the pile tip.

Driven piles

The weight of the falling mass must always be adequate to take down the piles at the depth defined at the project.

In case of damages to the adjacent piles, for example observation of concrete raising in the neighboring piles, the Contractor must alter the driving sequence.

The pile driving is carried out following a sequence in order to avoid, as much as possible, an increasing of the driving resistance for the last piles. Each pile has to be driven continuously until the specified depth has been reached.

The Contractor immediately inform the Employer in case any unexpected change in driving characteristics occur and the Contractor shall propose methods to solve the problem. A detailed record of the driving resistance over the full length of the nearest available pile will be taken if required by the Employer.

The Contractor gives adequate notice and provides all facilities to enable the Employer to check driving resistances; a set of blows recordings is taken only in the presence of the Employer unless otherwise approved.

The final set of blows has to be recorded for each pile either as the penetration in millimeters per 10 blows or as the number of blows required to produce a penetration of 25mm (see item on piling record of these specifications).

Staking out-tolerances

The landmarks to be used for the implementation of the piles must be effective, solid and well protected.

The method of locating the piles is the duty of the Contractor. The setting out has to be carried out from the main grid lines of the respective structures.

The maximum allowed deviation of the piles center from the theoretical location shown on the setting out drawing is 50mm in any direction. The maximum permitted deviation of the completed pile from the vertical is 20mm per meter (2.0%).

Cut-off

The piles are to be concreted up to a minimum of 60cm above the cut-off level. The cut-off must eliminate all polluted or poor characteristics concrete at the top of the pile and should be carried 10cm into sound concrete.

The concreting of the raft may start only after the cut-off of the pile and after obtaining a satisfactory resistance of the pile concrete.

The cut-off must be carefully performed according to a method approved by the Employer. The concrete in the head of the pile shall be carefully broken away from the reinforcement, which shall then be cleaned and bent as shown on the drawings or as directed. The concrete surface at the cut-off level shall be horizontal, plane and free from all loose aggregate.

Piling Records

For each pile, a piling record book giving the main checked values during execution shall be drawn up and updated by the Contractor with all the work hazards and incidents. That record book shall be submitted daily for the approval of the Engineer as the execution proceeds.

This record book shall include for each pile details on:

- location, reference number (corresponding to the number fixed on the drawing), type and diameter of the pile;
- length of the temporary casing;
- date and hour of start and end of each operation drilling, reinforcement setting, concreting;
- level from which the pile is bored or driven (platform level);
- level at the pile base;
- top level of the concreted pile before the cut-off operation;
- used materials (driving or drilling tools, concreting equipment);
- cleaning results of the bottom of the hole before putting down the reinforcement cage and before concreting;
- nature and description of the encountered soils;
- poured concrete volume and theoretical volume (measured concrete curves);
- behavior, workability, fluidity of concrete, results of the compression tests;
- water level within the hole before concreting;
- for driven piles, the refusals corresponding to the three last sets of blows (10 hammer blows) shall be noted for each pile; for one pile from each 20 piles, a driving diagram shall be drown up;
- type of boring-chisel, lengths of piles where chisel has been used.

Records shall be submitted in duplicate to the Engineer every following working day until 9 a.m.

The Contractor shall submit to the approval of the Employer/Engineer a proposal of piling record sheets including all the details mentioned above.

Pile tests

The Contractor shall carry out pile tests on a minimum of 0.5% of total no. of working piles of each type. The piles to be tested shall be to the approval of the Employer.

The tests shall include as minimum:

- compression load test at piles
- lateral load test & Tension Test at pedestal piles

In addition, at least one Test Pile for each of the main structures shall be tested and approved before the commencement of the working piles for that structure.

The maximum test load shall be 2.5 times the working load for Test Piles and 1.5 times the working load for tests on working piles.

The loading materials and equipment, the measurement devices and procedures shall all be to the approval of the Employer. All tests shall be carried out only under the supervision of an experienced and qualified supervisor familiar with the test equipment and test procedure. All personnel operating the test equipment will have been trained in that field. The number of increments of load shall be a maximum of 25% of the design load with a decreasing of load down to zero after each increment.

In the case of a test failing to meet the set criteria, the Contractor shall propose for the approval of the Employer his plan for the necessary changes in the pile design without any cost implication to the Employer.

4.4.6 CONCRETE WORKS

4.4.6.1 GENERAL

The concrete works shall be based on applicable approved codes and standards.

In general, the concrete for foundations shall be Grade 30. The type of cement to be used shall satisfy the requirements of the relevant international and local Standards or equivalent.

All materials used for concrete and reinforced concrete structures shall be of the best quality and free of defects likely to undermine the strength and shorten the service life of the works. The materials furnished shall comply with the agreed standards with the requirements of the soil investigation report regarding the aggressively of soil and water and with all requirements set out in this Specification. The high sulfate content according water analysis shall be considered for concrete in contact with sea water.

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Contractor.

All aggregate and sand used in the production of concrete shall be thoroughly tested for silica alkaline reaction, flakiness, aggregate crushing value, ten percent fine value etc.

The design and execution of the Works shall consider a minimum development, corrosion risks and durability of the concrete and based on the latest applicable approved codes and standards.

4.4.6.2 MATERIALS FOR CONCRETE

Cement

The cement used for concrete, reinforced concrete, mortar, grout and plaster (acid or sea water resistant) works shall be Ordinary Portland Cement, if no special quality is requested by the soil investigation reports. The cement shall comply with EN 197-1. The manufacturer's test certificate will normally be accepted as proof of compliance with Specifications but the Employer may order further tests as specified in the relevant standards. The Contractor shall bear all expenses required for the preparation, dispatch, and tests of the samples.

All accepted cement shall be delivered to the site in strong, sealed, waterproof containers unless written approval to the contrary is given. All cement delivered shall be marked in accordance with standards, stating the following particulars: type of cement, strength category, manufacturer, weight, quality control marking, date and transport data.

The cement shall be protected against all impurities and dampness during transportation and storage on the site. Sufficient cement shall be stored on site to ensure continuity of the works and to allow testing of any consignment before it is required for use. All cement shall be fresh when delivered. Cements of different types shall not be mixed one with another. Consignments shall be used in order for delivery.

Cement shall be stored in bags or in unopened containers on a dry, raised platform in a well-ventilated but watertight building.

Cement shall be kept in the store until actually required for use on the works and any cement temporarily placed near the mixer shall be adequately protected. Cement stored on site for a period longer than two months shall be laboratory tested before use.

Water

The water for cocrete production shall be potable.

The water shall be clean and free of salt, oil or acid, organic material or other matter harmful to the finished product and shall be from a source approved by the Employer. The Contractor shall undertake tests to determine the sulfate content and acidity of the water and make adequate arrangements to deliver and store sufficient water at the work site for use in mixing and curing the concrete. Water shall comply with the requirements of BS EN 1008 or equivalent.

Aggregates

Materials used as aggregate shall be obtained from a source known to produce aggregate satisfactory for concrete and shall be chemically inert, strong, hard, durable, of limited porosity and free from adhering coats, clay lumps or organic impurities that may impair the strength or durability of the concrete. Aggregate shall comply with and be tested in accordance with the requirements of BS 812, BS 882, BS 1199 and BS 1200 or equivalent.

Each size of aggregate shall be separately stored in a manner that will prevent contamination, intermixing and/or segregation. The equipment and methods of handling aggregates shall be such as to prevent deterioration and contamination of the stockpiles.

Frequency of testing the aggregates shall be at least as follows:

Frequency of testing		
Test Type	**Coarse Aggregate**	**Fine Aggregate**
Grading of each	Daily	Daily
Grading of combined aggregates	Daily	Daily
Specific gravity	7 days	7 days
Magnesium sulphate soundness	30 days	-
Clay silt and dust content	Daily	Daily
Shape (elongation and flakiness)	Twice a week	-
Los Angeles abrasion, ACV,TPF	Initially only	-
Moisture content	2 days	Daily
Drying shrinkage	Initially only	Initially only
Organic impurities	30 days	30 days

Fine aggregate shall be clean natural sand or sand derived by crushing stone and shall consist of hard, dense, durable uncoated particles. Sand derived from stone unsuitable for coarse aggregate shall not be used as fine aggregate.

The grading of the aggregates shall be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. Grading shall be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

Washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Contractor. Washing is required if the content of salt and other impurities adhering to the aggregates exceed the level given in the standards.

Coarse aggregate shall be crushed or crushed stone and shall be free of decomposed stone, clay, earth or other deleterious substances. The specific gravity of the coarse aggregate shall be not less than 2.5t/m^3. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000kg/cm^2 when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of BS 882 or equivalent. Samples of aggregates shall be submitted to the Employer, together with a sieve analysis showing the proportion by weight passing sieves. Should it become necessary to change the source or characteristics of the material supplied, this shall only be done after additional tests.

Concrete additives

If necessary, concrete additives approved by the Employer could be used to improve consistency, workability, quality and strength of the concrete. Waterproof concrete and mortar shall be used where necessary. Waterproofing shall be achieved by an approved brand of additive, which shall be used in accordance with the manufacturer's instructions.

Accelerating and retarding additives shall only be used in case of necessity and after obtaining the written approval of the Employer.

Plasticizers and air entraining additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Employer and in accordance with the manufacturer's instructions.

4.4.6.3 CONCRETE MIXES

The mix proportions shall be determined by proper mix design based on the requirements for strength, workability and the particular site in which the concrete shall be placed. The design of mixes shall be based on the principles of BS 5328 or equivalent (e.g. DIN 1045, ACI) and the British Building Research Station Publication.

Before concreting commences, the Contractor shall make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing transporting and compacting of the concrete. Only materials which the Contractor intends to use for concreting shall be used in the trial mixes.

Test cubes/cylinder from trial mixes shall be made and tested in accordance with BS 1881 or equivalent (e.g. DIN 1048 Part 2).

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests and shall not exceed the values given by BS 5328 and BS 1881 or equivalent.

The cement and aggregate shall be thoroughly mixed in a batch-type pug mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter. Partly set or excessively wet concrete shall not be used.

The Contractor shall establish and maintain a field laboratory on the site and this laboratory shall be available at all times to the Employer. The laboratory shall be adequately equipped to ensure that all necessary testing work can be carried out in compliance with the standards.

4.4.6.4 STRENGTH OF CONCRETE

All test cubes shall be made and tested for compressive strength in accordance with BS 1881 or equivalent.

The minimum required strength for different classes of concrete is as follows:

Grade	Characteristic strength N/mm^2	Lowest grade for compliance with appropriate use
7	7.0	lean concrete
10	10.0	plain mass concrete
15	15.0	reinforced concrete with dense aggregate
25	25.0	reinforced concrete with dense aggregate
30	30.0	reinforced concrete with dense aggregate (in contact with seawater, waste water and below ground level)
35	35.0	reinforced concrete with dense aggregate (Turbine Foundation, Boiler feed Pump Foundation)
30	30.0	pre-stressed concrete with post-tensioned tendons
40	40.0	pre-stressed concrete with pre-tensioned tendons
50	50.0	precast concrete members

The characteristic strength shall be determined from test cylinders of 300 mm heigh and *150mm dia at an age of 28 days.

4.4.6.5 TRANSPORT OF CONCRETE

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 30 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The concrete shall be transported by mixture truck or in clean metal buckets, barrows, dumpers. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Employer.Use of boom concrete pumps is preferable

4.4.6.6 CONCRETING OPERATIONS

All concreting methods shall be subject to the approval of the Employer.

Concrete placing shall not be started until the Employer has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Concrete shall be placed in the form as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5m height in a single pour in walls, columns and similar members.

The Contractor shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than six hours' time shall be subject to the same treatment as the construction joints.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

As concrete is being placed it shall be compacted by mechanical vibrators, to obtain a dense material free from honeycombing and without water or air holes.

The Contractor shall ensure that the vibrators are used in such reinforcement is not displaced, the formwork not damaged and no segregation caused, but complete compaction of the concrete is achieved.

The concrete face shall have the finishes indicated on the drawings or in the present Specifications. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

Construction, expansion and contraction joints

The number of construction joints shall be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting shall be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration shall be given to their exact location, which shall be indicated on the drawings. Alternatively, the location of joints shall be subject to agreement between the Employer and the Contractor before any work commences.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast shall be free from laitance and be roughened to the extent that the largest aggregate is exposed but not disturbed. Care shall be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Expansion joints, contraction joints and otherwise permanent structure joints shall be provided at positions shown in the drawings. Joints shall be straight and vertical, except where otherwise specified and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stops of a type approved by the Employer shall be embedded in the concrete. To ensure a good tightness with or without movement of the joints, the water stop shall be provided with anchor parts.

Concreting at night

When approval is given to carry out concreting operations at night or in places where daylight is excluded, the Contractor shall provide adequate lighting at all points of mixing, transportation and placing of concrete.

Concreting in high ambient temperature

For concreting in high ambient temperature, “Concreting in Hot Weather” shall apply.

The Contractor shall take special measures in the mixing, placing and curing of concrete; alternatively all pouring and finishing works shall be done at night. These measures shall include the shading of aggregates, spraying of aggregates with water, cooling of the mix constituents (introduction of ice to the mixing water) and reduction of transportation time to the minimum.

During pouring suitable measures shall be provided to prevent setting of concrete placed in contact with hot surfaces. All concreting areas, formwork and reinforcement shall be shielded from the direct sun rays and sprayed with water when necessary.

Concrete subject to chemical attack

Concrete with increased resistance to chemical attack shall meet the provisions of DIN 1045 or equivalent. Liquids, soils and vapours aggressive to concrete should be judged in accordance with DIN 4030 and be classified according to 'mild', 'severe' and 'very severe' attacks.

The resistance of concrete to chemical attack depends on its imperviousness. The concrete must be at least sufficiently dense to ensure that the maximum depth of water penetration tested according to DIN 1048, does not exceed 6 mm in the case of mild attack nor 3mm when exposed to severe attack.

Concrete, which is likely to be exposed to severe chemical attack for a prolonged period shall be suitably protected by an adequate coating system, and this shall be subject to the Employer’s approval.

All vertical concrete surfaces in contact with soil shall receive two coats of bituminous coating. Soffit and side of foundations shall be protected by means of suitable membrane installation. For basements of buildings and water tight basins protection of concrete surfaces below ground level shall consist of an approved self-adhesive pressure sensitive membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane. The membranes shall be installed strictly to the manufacturer instructions. The membranes shall extend 150mm above ground level.

All exposed concrete surfaces above ground (foundations, superstructures, etc.) shall be protected by epoxy coating with a compatible primer penetrating into the concrete. The epoxy coating must be able to bridge the maximum allowable crack width. The minimum thickness of this coating shall be 300 microns.

Alternatively, where appropriate the concrete surfaces shall be protected with approved tiles. In case any structural parts of concrete are likely to be exposed to chemical attack, crack width for such structural parts shall be designed not to exceed the dimension prescribed by the coating manufacturer.

Concreting under water

Underwater placing of concrete may be allowed for un-reinforced components, or as approved by the Employer. The placing being performed exclusively with stationary tremies and shall be in accordance with the requirements of relevant standards.

The min. cement content shall be increased by 50 kg/m3 for underwater concrete.

Underwater concrete is to be placed continuously without interruption.

The concrete is to be placed in such a way that is does not fall freely through the water. The tremies must at all times dip sufficiently far into the freshly placed concrete to ensure that the concrete emerging from the tremie does not come into contact with the water. All work connected with the placing of concrete under water shall be designed, directed and inspected with due regard to local circumstances and purposes. Work shall not proceed until all phases and methods to be used in the placing operations have been approved by the Employer.

Protective measures for concrete

In general, the cover of rebars shall be as per BS EN 1992-1-1 or equivalent taking into account the site conditions (high temperature, humidity).

Immediately after the compaction of the concrete has been finished, the Contractor shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays or a layer of sand kept constantly moist for at least 14 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Employer.

Where large sections of concrete are poured, special precautions subject to the approval of the Employer shall be taken to reduce and dissipate the heat generated by setting and hardening of the concrete.

Repair of damaged or defective concrete
Concrete which has completed its final setting shall be inspected by the Employer and any cracks, honeycomb areas, segregations, etc. shall be marked. No repairs shall be carried out until so directed by the Employer.

Dimensional tolerances
The permissible tolerances shall comply with the BS 5606 and BS EN 1992-1-1 or equivalent.

4.4.6.7 FINISHING OF CONCRETE SURFACES

The concrete surface shall have the finish indicated on the drawings or in the specifications.

All surfaces, which may come into contact with oil or oily water, will have to be adequately protected (paint, etc.). The finished surface of all concrete work shall be sound and free of defects. No plastering, cement wash or mortar shall be applied to cover defective concrete faces.

The fair faced concrete placed against shuttering shall be rubbed down with a carborundum stone immediately upon removal of the shuttering to remove fins or other irregularities. The face of the concrete for which shuttering is not provided, other than slabs, shall be smoothed with a wooden flat to give a finish equal to that of the rubbed down face where shuttering is provided. The cavities left by formwork fixing devices shall be made good closing the hole with plastic plugs and epoxy mortar. In watertight concrete structures the formwork fixing devices shall be of such a design as not to leave any holes after removing the shuttering.

All exterior corners of reinforced concrete shall be chamfered at least 25mm x 25mm, at stair treads 10mm x 10mm.

The top or final surface of all concrete works shall be finished by screeding, or floating, or trowelling or grinding, or tooling as approved by the Employer.

Dry cement or cement and sand shall not be used to dry excess water on the concrete surface.

Floors and slabs, which are required to be finished smooth, shall be trowelled just before the setting of the concrete.

Screeding:	This shall be executed by moving a straight edge or template by hand or by mechanical means immediately after compaction of the concrete.
Floating:	This shall follow screeding, but shall not be started until some

	stiffening of the concrete has taken place.
Trowelling:	Where specified as necessary, floating shall be followed by finishing until a smooth surface free from defects is obtained.
Grinding and tooling:	Where specified, the methods to produce the desired surface shall be approved by the Employer. Grinding and/or tooling shall not start until the concrete has hardened sufficiently to prevent dislodgment of the aggregate.
Chiseling:	Wherever possible all chiseling works shall be carried out with mechanical devices. Manual chiseling may be required at difficult points.

Exposed concrete surface treatment

Exposed concrete surface of a structure shall be coated with an approved clear silicone water repellent suitable for application on the concrete.

4.4.6.8 FORMWORK

Design and construction

For the proof of stability and for the type of formwork and support framing used, BS 3809 or equivalent shall be used.

The formwork and the supporting structure shall be so dimensioned as to be able to withstand all vertical and horizontal forces safely shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances as specified in sub-clause 4.4.6.6.

The Contractor shall submit for the approval of the Employer the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Forms shall be constructed from steel or from sound timber well-seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin bonded and water repellent. Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout.

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free of sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged as large as possible concreting height of one floor level in a single pour. Where necessary, panel openings shall be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc. shall be fixed to the formwork carefully.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on drawings as "Fair-faced Formwork".

Internal spacers and ties, if any, shall be arranged after removing of the forms and no holes shall extend through the concrete, in the case of watertight concrete or be closed by plastic plugs and epoxy mortar in all other cases. All formwork will be inspected and approved by the Employer before concrete placing commences but this shall not relieve the Contractor of any of his responsibilities under the Contract.

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or design loads which it is likely to be subjected to it with a normal factor of safety. It shall be removed in such a manner that no shock or damage shall result to the concrete.

Before removal of the formwork the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

The minimum period for striking the formwork (cast-in-situ concrete made with Ordinary Portland Cement) under specified conditions may be taken as follows:

a. Vertical sides excepting beams: 2 days
b. Vertical sides of beams : 7 days
c. Soffits for span 6 m or less: 18 days
d. Soffits for span over 6 m : 21 days

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

4.4.6.9 REINFORCING STEEL

Reinforcing steel used in reinforced concrete shall comply with 488-2, 488-4, ASTM A-615, BNBC or equivalent.

All reinforcement shall be hammered free of scale, scraped and wire brushed free of all loose rust and after such treatment shall be within the margins allowed by the Standards. The reinforcing steel shall be free of oil, grease or preservative coatings.

The Contractor shall supply the Employer with the manufacturer's certificate stating the process of manufacture and a test sheet giving the results of each of the materials purchased and, when required, the chemical analysis and all tests as specified in the relevant standards.

In particular it shall be possible to derive the following data from the stress-deformation curves:

- ultimate tensile strength
- guaranteed yield stress
- permissible stress
- elongation.

Reinforcing bars shall be transported and stored so that they remain clean, straight, undamaged and free of corrosion, rust or scale.

Reinforcement shall be cut and/or bent in accordance with BS 8666 or equivalent standards.

Reinforcement shall be accurately fixed and secured against displacement in the position shown in the drawings by means of spacers, chairs or other supports in order to maintain the reinforcement in its correct position, within a tolerance of 3mm. For the distance between the bars (horizontal and vertical distances), the requirements according applicable standards shall be observed.

Jointing of reinforcement bars by welding on site shall be avoided if possible, but where necessary the requirements of BS EN 1992-1-1 or equivalent standards have to be observed.

Where reinforcement is to remain exposed to the weather for a prolonged period, a thick cement grout shall be applied to the bars.

Grounding of reinforcement
Reinforcement shall be grounded according to the requirements laid down in other parts of this specification.

4.4.6.10 DURABILITY OF CONCRETE

All measures necessary in the design and selection of materials including the following shall be taken to ensure the required durability of concrete for the various concrete elements:

- Maximum crack width in the design of all reinforced concrete for structures in contact with water or chemicals and for major structures shall be kept below 0.20mm. This value might have to be varied depending of the required coating system (e.g. stack)
- Maximum crack width in the design of all reinforced concrete for all normal structures shall be kept below 0.30mm

- In general, reinforcement for cast-in-place concrete shall have a minimum cover of 40mm. For concrete in contact with the ground or sea water, the minimum cover shall be 75mm
- Specify clearly location of expansion and construction joints and their surface preparation
- Specify foundation surface coating and of concrete surfaces above ground
- Specify type of cement appropriate for the ground water, the soil conditions and ambient temperatures
- Use smaller size reinforcing bars well distributed in the tensile zone
- Limit the tensile stress in reinforcement
- Ensure adequate slope for concrete surfaces likely to receive rainwater or chemicals
- Provide chamfers at all concrete edges
- Provide strict measures for concrete curing to prevent plastic shrinkage and thermal gradients resulting from early age heat of hydration of the fresh concrete.

4.4.7 STRUCTURAL STEEL WORKS

4.4.7.1 MATERIAL

All ferrous materials, the dimensions, forms, weights, tolerances, chemical and mechanical properties shall be the best of it kind complying with relevant international Standards.

All structural steel material shall be minimum S235 for rolled steel shapes, angles, tees, plates, etc. having a minimum yield stress of 235 N/mm².

In the case of structural steel work, care shall be taken that all parts in the assembly fit accurately together and corresponding parts shall preferably be interchangeable.

The Contractor shall submit to the Employer for approval the country of origin and manufacturer of the steel he proposes to supply.

The structural steelwork and testing shall comply with the relevant clauses of BS 4, BS EN 10162, BS 4360 and BS 6323 or equivalent standards.

Each steel part shall be marked with the manufacturer's name or trademark.

The steelwork shall be manufactured by a specialist firm approved beforehand by the Employer. As much of the work of manufacturing of the steelwork as is reasonably and technically practicable shall be executed in the manufacturer's works, and facilities for inspection by the Employer shall be provided.

All steelwork before and after manufacturing shall be smooth, undeformed, straight and free of cracks, twist and burrs. All steelwork shall be cut and fabricated to a tolerance of ± 1.5mm in its length. All plates shall be truly at right angles to the longitudinal axis of the section. No work shall be painted, packed or dispatched from the manufacturer's works until it has been inspected and complies with or has been certified to comply with all the tests and requirements of the standard applicable to the material specified and until it has been inspected and approved.

Tests

The manufacturer's test certificate for all steelwork shall be supplied to the Employer. The certificates shall state the manufacturing process and shall include a test sheet giving the results of the mechanical tests and the chemical composition. The Contractor shall provide free of charge any supplementary tests reasonably required by the Employer. Steel which do not conform to the specified standards shall be rejected at the expense of the Contractor. No steelwork shall be delivered from the manufacturer's works until it has been tested and the results comply with the requirements of the relevant standards.

4.4.7.2 WORKMANSHIP

Tolerances

Care shall be taken to ensure that the tolerances specified on the drawings or the relevant standards are worked to. The erection tolerance for cleated ends of members connecting steel shall be not greater than 2mm at each end. No work shall be painted, packed or dispatched from the manufacturer's works until it has been tested and complies with all requirements of the standards.

Cutting

Cutting may be by shearing, cropping, sawing or machine flame cutting. Hand flame cutting shall be avoided. If rolled products for steel structures under predominantly static loading are cut by flame-cutting or shearing there will generally be no need for a finishing operation if the cut surface is free of defects.

Bolting

The threaded portion of each bolt shall project through the nut by at least one thread. Approved high strength friction grip bolts, preferably the type with indicated load, shall be used where specified and shall be tightened strictly in accordance with the manufacturer's instructions and the relevant regulations. The surfaces in contact shall not be painted and shall be free of oil, dirt, loose rust, burrs and other defects, which would prevent proper seating of the parts or interfere with the development of friction between them.

When connections are made using high strength friction grip bolts the relevant standards shall be observed.

Welding

The execution and testing of welding shall be in accordance with BS EN 1011-1, BS EN 1011-2 or equivalent standards.

All welds, unless otherwise stated shall be continuous minimum 6mm fillet weld and shall be dressed smooth, free of porosity, cracks, holes and finished to match adjacent surfaces. When welding operations are completed, all welding flux shall be removed without delay. Cooling of welds shall not be accelerated by any special measures.

Site welding shall be restricted to the absolute minimum. Site welding is subject to approval by Employer. The examination of welded work and the inspection of welds during and after manufacture shall be carried out by responsible specialist welding engineers. Welding shall be carried out by expert trades men and in strict accordance with the current code of practice.

Painting

Surface treatment and painting before and after delivery to site shall be in accordance with Attachment B2 of Section 5.

Parts to be encased in concrete shall not be painted or oiled. Surfaces inaccessible after shop assembly shall receive the full-specified protective treatment before assembly.

Erection

The Contractor shall supply all suitable plant, hoisting gears and tackles for the erection of the steelwork and shall provide all temporary baulks, struts, shores, etc.

Steelwork damaged due to inadequate precautions being taken during the storage, transport and erection of the steelwork shall be made good to the satisfaction of the Employer at the Contractor's expense.

All shop connections shall be made by electric welding. All site connections shall be bolted unless otherwise specified in drawings or directed by the Employer.

Encased steelwork and steel in foundations shall be solidly encased in concrete with a minimum cover of 100mm. Anchors of the required structural strength shall be used as holding down anchors in concrete foundations for columns. Sole plate of the column shall be grouted with low shrinkage grout of 50mm nominal thickness.

The grout shall be shaped with an inclination of 45° from the lower edge of the sole plate to avoid stagnant water.

Rejection

Any steelwork, which in the opinion of the Employer is not in accordance with the requirements of the standards or with the specifications, shall be mandatory rejected and removed from the site at the Contractor's expense.

4.4.7.3 SMALL NON-STRUCTURAL STEEL PARTS

General

This sub-clause covers the provision of all materials and labor in relation to supply and manufacture on site of articles made of steel or cast iron.

All steel structures and parts specified under this clause shall be hot dip galvanized and painted according to Attachment B2 of Section 5.

The list of small items to be furnished shall contain but not be limited to the following:

- steel sections, bent plate sections and square bars for construction of:
  - metallic stairs, platforms and walkways
  - railing for stairs, platforms, walkways and protective around floor openings
  - corner and edge protection for concrete steps and concrete
  - structural parts such as columns, beams, removable cover slabs, etc.
  - support of any equipment foundation
  - joint covers
  - anchors, ties, hangers, inserts, slots, embedded steel parts, etc.
- steel pipes and plain round bars for making guardrails and ladders
- steel plates, chequered and/or flat, for fabrication of removable covers
- open steel grating for metal steps, platforms, and walkways.

Materials

The requirements for materials of structural steel specified herein are applicable to all steel sections, bars, plates, pipes and any sections as far as their quality, source, dimensions, mechanical characteristics and their delivery, handling, storage and tests on site are concerned.

4.4.8 ROOF AND WALL CLADDING

Metal cladding

The insulated sandwich roof and wall construction shall consist of a double skin construction, rear ventilated and comprising the following:

Internal liner profile:	trapezoidal profile min. 0.75mm thick.
Insulation core:	60mm (minimum) thick non-combustible material like glass wool or similar of density not less than 16 kg/m3.
External weathering profile:	trapezoidal profile min. 0.75mm thick

The sheeting unit shall be a multilayer, protected metal system consisting of a trapezoidal galvanized steel substrate, heavy epoxy base coat and a high build weather coat of polyurethane as follows:

Substrate

Hot-dipped galvanized steel substrate, with a minimum zinc coating weight of 275 g/m2 total both sides. The steel substrate shall be min. 0.75mm thick.

Pre-treatment

After cleaning, of the chemical zinc coating to non-metallic convers surface with corrosion inhibiting and adhesion additives shall be applied.

Primer

Nominal 8-micron thick anti-corrosive pigmented epoxy primer applied to both sides of the sheet.

Epoxy barrier coat
Nominal 70-micron thick TF Epoxy Barrier coat with special flexibilizer compounds applied to both sides of the sheet and baked to a hard corrosion resistant finish.

External weather coat
Nominal 40 micron thick urethane exterior coating pigmented in one of the standard colors of the manufacturer's color range.

Internal decorative coat of the interior profiled liner
Nominal 20 micron stoving polyester decorative finish.

Requirements for walls
These requirements apply to all walls (not only for wall cladding). External walls are to be constructed taking into account the climatic conditions and any air conditioning plant installed in the rooms as well as the manner of use of the rooms, no damp will penetrate the walls. All external walls must have a minimum sound-absorbing index of 20 dB (A) and a heat transmission coefficient of 0.75 W/m2 K. Appropriate insulation materials will have to be used to achieve the above mentioned figures.

The walls shall not allow the passage of rain or moisture into the building. The walls shall be provided with all necessary horizontal and vertical damp-proof courses and flashings.

Requirements for roofs
These requirements apply to all roofs (not only for roof cladding).

The roof construction is to be such that, with due allowance for the climatic conditions and any air conditioning plant installed in the rooms, and with the intended use of the rooms taken into account, no damp will penetrate into the materials used.

All roofs must have a minimum sound absorbing index of 20 dB (A) and a maximum heat transmission coefficient of 0.45 W/m2K. Appropriate insulation materials will have to be used to achieve the a.m. figures.

Roof surfaces are to be designed with a min. slope of 3% for concrete roofs and 5% for metal roofing.

All roofs shall be suitable constructed to serve for PV-Modules. The roofs shall be able to mount the supporting structure and provide sufficient arrangements for operation and maintenance.

4.4.9 FINISHING WORKS

Floor and wall finishes
The finishing works to be applied for the buildings and structures of the plant are listed below. Buildings or rooms not included, or special items, must be agreed with the Employer.

Floor finishes (typical)

Room	Floor Finishes
Switchgear and rooms	Epoxy screed (trowel applied minimum 5 mm thick) and epoxy seal coat
Rest room, toilets, kitchen mess room	Glazed non-slip fully vitrified ceramic tiles.
Offices	ceramic tiles
Corridors, stairs, landings	Vitrified ceramic tiles (floor tiles with epoxy grout)
Battery rooms	Acid resistant ceramic tiles
Control room, relay rooms, electrical equipment	Heavy duty PVC sheeting on false floor
Instrument/electrical workrooms	Heavy duty PVC / rubber backed tiles
Stores workshop, mechanical work room and store room	3 mm self-leveling oil resistant epoxy screed with non-slip granule finish; see also the specification of buildings.
Transformer pits	Oil-proof hard-wearing epoxy coating

Internal wall finishes (typical)
Plaster (or similar approved) and paint:

Control rooms, MV/LV switchgear rooms, LVAC rooms, computer rooms, restroom, administration areas, offices and similar rooms, corridors, instrument and electrical workrooms, mechanical workroom and storeroom.

Skirting shall be provided in same material as floor finish.

Fair faced block work, cement wash, paint
Switchgear rooms, HVAC mechanical plant rooms, stores and workshop.

Glazed ceramic tiles, plaster and paint above
Glazed ceramic tiles up to a level of 2.3m and plaster and paint above this level shall be applied in toilets, washrooms, locker rooms, kitchen, etc.

Acid/Alkali resistant tiles, plaster and acid/alkali resistant paint
Acid/Alkali resistant tiles, (plaster and acid/alkali resistant paint) up to a level of 1.2m shall be applied in battery room, waste treatment plant, laboratory, rooms where any chemicals and stored, handled or prepared. Plaster and acid/alkali resistant paint to remaining walls and ceilings. Suitably approved skirting shall be provided at the base of all tiled or plaster finished walls.

4.4.10 SANITARY INSTALLATIONS

The Western WCs closet seats and covers are to be of plastic of a color to match the tiles. The WCs shall be provided with hand spray with angle valve and hand trigger, 100cm long hose, toilet roll holders made of chromium-plated brass to be fitted within convenient reach.

The Asian Squatting WCs are to be white ceramic plates (500 x 400mm approx.) with raised treads for flush installation at floor level. The WCs shall be provided with hand spray with angle valve and hand trigger, 100cm long hose, toilet roll holders made of chromium-plated brass to be fitted within convenient reach.

Washbasins, minimum size 58 x 45cm, are to be provided with a mixing tap. Above each washbasin is to be provided one mirror, minimum size 70 x 50cm and one soap dispenser for fluid soap.

Bowl urinals are to be fitted with flushing devices.

Each toilet is to be equipped with one push button operated hot air hand dryer provided with overheating protection.

All rooms where leakages of liquids may occur (pump rooms, wash rooms, toilets, shower rooms, battery rooms, etc.) are to be provided with adequate floor drains, even if this does not result from the relevant civil drawings and/or from the written part of the specification.

4.4.11 DOORS

Metal doors
All internal and exterior and safety doors shall be made of double steel sheet walls, insulated with glazing. Minimum nominal dimensions of doors shall be as follows:

- Single leaf doors: width 1.01m x height 2.135m
- double doors to rooms housing valves pumps and similar equipment: width 2.20m x height 2.135m
- double doors to rooms housing electrical equipment: width 2.20m x height 2.50m.

Steel parts of the doors shall be protected in accordance with the relevant section of the specification for coating of steel surfaces. All doors shall be fitted with approved locks and self-closing mechanism.

Fire rated doors shall be all in accordance with the applicable regulations and standards and shall have glazing panel of the same fire resistance as that of the door: G30 or G90 to match T30 or T90.

All doors and gates shall be installed such that rain water penetration is avoided.

Roller-shutter doors
Large openings to buildings shall be fitted with electrically operated rolling shutters as appropriate. An escape door shall be provided next to each rolling shutter. The shutters shall be of double walled hollow sections of galvanized steel protected with coating in accordance with the Attachment B2 of Section 5.

Hand crank with continuous chain reel shall be fitted to operate the door by hand in case of emergency.

4.4.12 WINDOWS

All windows shall be aluminum with double glazing which meet the requirements of the applicable standards. Each window shall have side and bottom sash fitting and shall safely absorb an impact force of at least 7.5kN. Scissor type stay shall be designed to prevent the sash from dropping in case of malfunctioning.

The windows shall be resistant to pelting rain. Approved sunshade system shall be provided for windows facing east, west and south.

Window sill shall be of aluminum matching in color with that of the window on the outside and with the color of the room on the inside.

Fastening devices for safety harness shall be provided on the exterior of the building for windows which cannot be cleaned from inside the building or from the floor outside.

4.4.13 AVIATION WARNING LIGHTS

Aviation warning lights shall be provided for the stack and on all tall buildings and structures in accordance with the local aviation safety requirements.

4.4.14 EARTHING AND LIGHTNING PROTECTION

All buildings and structures shall be provided with adequate earthing and lightning protection system.

4.4.15 ROADS AND SURFACING

General
The actual thickness of road-courses shall be calculated based on the results of the soil investigation, loads, intensity of traffic, design life, etc. the thickness of road-courses shall be in no case less than those of the existing roads in the zone of the plant.

The design of all pavements shall conform to the requirements of the American Association of State Highway and Transportation Officials (AASHTO), and Local Highway Requirements (RHD) or local standards whichever is more stringent.

Foundation bed
The requirements for the particular road type and the recommendations of the soil investigation report have to be observed.

Wearing course
The requirements for the particular road type have to be observed as per the local standards and codes.

Compaction of sub-grade
The area for the roads shall be cleared of any material or obstructions, which in the opinion of the Employer might adversely affect the stability of the fill or pavement, and the top layer removed to a depth of 300mm (or more if the design so required).

Any ruts or soft areas caused by improper drainage conditions, hauling or any other cause shall be corrected and rolled to the required compaction before sub-base is placed thereon.

The formation shall be compacted to a dry density of at least 95% of the maximum dry density (modified proctor).

Tests for sub-grade
The sub-grade compaction test and in-situ dry density tests on each layer of compacted material shall be carried out at an average of not less than 2 per 100m length of carriageway.

Sub-base
Sub-base material shall be crushed rock or other approved local material having suitable properties and confirming to the following grading:

Sieve [mm]	Percentage by Weight Passing
75	100
37.5	85-100
10	45-100
5	25-85
0.6	8-45
0.075	0-10

The material shall be spread evenly on the preceding material in layers not exceeding 150 mm compacted thickness.

The sub-base shall be compacted by approved plant to a dry density, which shall not be less than 98% relative compaction (modified proctor) until movement of the surface ceases and the surface is closed. The CBR value shall be at least 80% at the optimum moisture content.

Wet mix road base
Wet Mix road base material shall consist of crushed gravel or crushed rock and shall be suitably proportioned to confirm to the following grading as approved by the Employer:

BS Sieve Size [mm]	Percentage by Weight Passing
50	100

37.5	90 - 100
20	60 - 80
10	40 - 60
5.00	25 - 40
2.36	15 - 30
0.600	8 - 22
0.075	0 - 8

The final surface shall be shaped and finished true to line and level within a tolerance of ±10mm to the levels shown on the drawings.

Placing of road base

The compaction procedure and plant shall be proved by trials at the commencement of the Works.

Road base material shall be placed and spread evenly, without delay, using a paving machine or spreader box, operated with a mechanism which level off the material at an even depth and it shall be spread in layers not exceeding 150mm compacted thickness. Segregation shall be avoided during transport and placing and any segregation evident after compaction shall be corrected by vibrating in non-plastic fines or made good by removing and replacing with properly graded material.

The road base shall achieve a minimum dry density of 98 % of the maximum laboratory dry density (modified proctor). The CBR value shall be at least 80% at the optimum moisture content.

Before placing the next construction layer or applying prime coat, the road base shall be mechanically swept, then cleaned with compressed air to remove loose material. As soon as possible after cleaning of the surface, the road base shall be sealed by the application of a prime coat as specified.

Chlorides and sulphates

The level of chlorides and sulphates in the sub-base and wet mix road base shall be within the following limits:

	Maximum by weight	
	Sub-base	**wet-mix road base**
Acid soluble chloride (NaCl)	3.5%	0.5%
Acid soluble sulphate (SO_3)	2.0%	0.5%

Hard shoulders

The material used for any hard shoulders shall comply with the specification for wet-mix road base.

Segmental Concrete Paving Block Surface

For the stipulated requirements of the laying of the segmented concrete paving block surface, it is assumed that the sub-grade or sub-base has been properly constructed, that there are no soft or unstable areas and that the sub-grade or sub-base has been trimmed to within ±10mm of the specified level.

Laying Pattern

Unless otherwise approved, all blocks shall be laid in herringbone pattern. The blocks shall be laid against the edge restraint shown on the plans in order to prevent the outward migration of blocks. Areas against kerbs, manholes, etc. requiring infilling and which exceed 25% of a full block unit shall be filled with units cut to size using a mechanical or hydraulic guillotine, bolster or angle grinder. Infill areas constituting less than 25% of a full block area and of 25 mm minimum dimension shall be filled with 25 MPa concrete. Smaller areas shall be filled with cement mortar having proportions of 1 sack cement to 130 litre of good quality mortar sand.

Bedding Sand

Except for mine sand, sand for the bedding layer shall comply with the following grading limits:

SIEVE SIZE (mm)	% PASSING
9,52	100
4,75	95 -100
2,36	80 - 100
1,18	50 - 85
0,600	25 - 60
0,300	10 - 30
0,150	5 - 15
0,075	0 - 10

Mine sand may be used where experience has shown it to be satisfactory. The moisture content of the sand shall be 5 - 8%. Bedding sand shall be maintained in a loose condition and protected against pre-compaction. Any pre-compacted areas shall be removed and replaced. The loose sand-bedding layer shall be evenly laid and shall not be used to fill hollows in an uneven subgrade or subbase surface. The compacted sand layer shall have a thickness of not less than 15mm and not more than 35mm.

Block Laying

All blocks shall be laid true to line and level. Full blocks shall be laid first, care being taken that joint lines are straight and square. Disturbance of laid blocks shall be prevented and any areas distorted or damaged shall be lifted and re-laid by the Contractor. The maximum joint width shall be limited to 5mm.

Compaction of Blocks

After laying the blocks, a mechanical flat plate vibrator shall be applied to the surface of the blocks to bed them. For block thicknesses up to and including 80mm the vibrator shall be capable of producing centrifugal force of approximately 7 to 16kN at a frequency of approximately 75 – 100Hz, the plate area being between 0,2m² and 0,4m². For greater thicknesses the required centrifugal force shall be 16 - 20kN at a frequency of approximately 75 - 100Hz, the plate are being between 0,35 and 0,5m². Compaction of blocks shall follow block laying as closely as possible, but shall not be attempted within 1m of the laying face. At the end of each day, compaction must be completed up to within 1m of the working face. All blocks damaged during the compaction process shall be removed and replaced. Sufficient passes shall be made to compact the block pavement fully and to produce an even surface. The number of passes shall, however, not be less than two.

Jointing Sand

Joints between blocks shall be filled with a 50-50 sand-cement mixture. The jointing sand shall pass a 1.18mm sieve and contain 10 - 50% material passing the 75µm sieve. The sand shall be free of soluble salts or contaminants likely to cause efflorescence or staining. After initial vibration, joint filling sand shall be uniformly distributed over the surface of the pavement and brushed into the joints. Further passes of the plate vibrator shall be made to fill the joints, more sand being spread over the surface if required.

Excess sand shall be removed before the pavement is opened to traffic.

Surface Tolerances

Surface tolerances on the finished paving are based on the layer directly below the bedding sand complying with:

a) maximum deviation in surface level from the true surface level to be ±10mm;
b) maximum deviation from a 3m straight edge placed on the surface to be 10mm, except where vertical curves necessitate a greater deviation;
c) the finished paving shall be so laid as to create a regular and smooth appearance.
d) Surface tolerances shall be as follows:
    - maximum deviation in surface level from the true surface level to be ±10mm, except immediately adjacent to gullies, where the tolerance shall be +3mm and 0mm
    - maximum deviation from a 3m straight edge placed on the surface to be 10mm, except where vertical curves necessitate a greater deviation
    - levels of adjacent blocks shall not differ by more than 3mm
    - the line of the pattern shall not deviate more than 15mm from a 3m straightedge.

Site Clearance

Before the pavement is opened to traffic the area shall be cleared of all debris and other waste and left in a tidy condition.

Weed/Ant Poison

Weed and ant poison approved by the Employer, shall be applied to the sand layer strictly in compliance w to block laying.

Gravel Wearing Course Surface
For this type of road surface, the road base shall be of an approved Gypsum gravel with a grading complying with a G4 quality natural gravel, the finished surface of which acts as the wearing course surface.

New and existing pavement joints
Where new bituminous pavement is required to join into existing road construction, each layer of existing bituminous course shall be cut back to a clean vertical face and coated with hot bitumen of a grade suitable for the purpose immediately before laying the new bituminous material.

The existing pavement layers shall be cut back to form a stepped pattern. The lower layers of bituminous courses shall be prepared to receive the new covering coats by removal of dust and deleterious materials by air jetting or other approved means, and shall be coated with bituminous tack coat.

Exposed existing road base surfaces shall be scarified then re-compacted and sealed with bituminous prime coat in accordance with road base specification.

Bitumen macadam
Aggregate shall be hard, clean, durable crushed rock, sand and shall be obtained from approved source which shall not include quarries containing significant proportions of weather bed, decomposed or extensively fractured materials.

Coarse aggregate is defined as that fraction retained on a 3.5mm sieve. It shall have physical properties, which do not exceed the following test values:

	Wearing course	Base course
Aggregate crushing value	20%	25%
Flakiness index	25%	30%
Elongation index	25%	30%
Water absorption	2%	2%

Separate coarse and fine aggregate fractions shall be tested for soundness.

Wearing course shall be of min. 40mm finished thickness; the aggregate grading shall be as follows:

Test Sieve [mm]	Grading (20mm nominal size) % by weight passing
28	100
20	95 -100
14	70 -90

10	55 -75
6.3	40 -60
3.35	25 -40
1.18	15 -30
0.075	2 -6

Composition of bitumen macadam
Mixes shall be submitted for approval and proved by means of laboratory, plant and field trials.

The designed mixes shall comply with the following:

	Binder Course	Wearing Course
Voids in mix [%]	7 - 10	5 - 8
Voids in mixed aggregate [%]	14 - 20	14 - 20
Minimum stability [kg]	750	1000
Flow (mm)	2 - 4	2 - 4
Minimum stability flow ratio [kg/niTn]	270	320
Bitumen content [% of total mix]	4.0 - 5.0	4.5 – 5.5
Voids filled with Bitumen [%]	48 - 60	48 - 60

Mixing and laying
The aggregate and bitumen shall be mixed in an approved plant of the batch type. Constituents shall be proportioned by weight; the bitumen may be proportioned by a metering pump.

Bitumen and aggregates shall not be heated to above 150°C and 170°C, respectively, and the temperature difference between them at the time of mixing shall not exceed 15°C. The mixing temperature shall be established from the bitumen viscosity/temperature graph. Approved facilities for continuous measurement of temperatures shall be provided.

Bitumen macadam shall be transported in clean vehicles. Dust, coated dust, oil or water may be used on vehicle bodies to facilitate discharge, but the amounts shall be kept to a minimum and any excess shall be removed by tipping or brushing.

Immediately after arrival at the site, the macadam shall be supplied continuously to the paver and placed without delay.

Joints in wearing course shall be offset by at least 300mm from parallel joints in the layer beneath.

A priming coat of petroleum/bitumen shall be applied to the road base at the rate of 0.9 to 1.2 l/m², before placing macadam. The binder course shall not be laid until the priming coat has been cured. Curing time normally is 24 hours

The binder course shall be prepared to receive the wearing course by removal of dust and deleterious materials by air jetting or other approved means and application of tac coats.

Interlocking paving blocks

Footpaths and areas to be paved with interlocking concrete blocks shall be excavated and placed with 300mm depth of compacted material at the exact levels and falls required for the finished work.

If parts of the base are found to be unstable, the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving, irregularities shall not be compensated by varying the depth of sand bedding.

Compaction of formation and base for interlocking concrete slabs shall be as sub-clauses (Compaction of Sub-Grade), (Road Base), (Tests on Sub-Base and Road Base).

A stable edge shall be provided to retain the paving units and sand bedding by means of pre-cast concrete edging unit or kerbs set in-situ concrete. The sand bedding shall be a fine, well graded sand in a dry to moist condition and laid to an uncompacted thickness of 50mm.

The mix for paving blocks shall contain a water-repelling additive.

The paving blocks shall be laid in accordance with the manufacturer’s instructions and shall be compacted at completion of each work. The interlocking block shall be a minimum of 80mm thick and the concrete quality must be approved by the Employer.

Kerbs

All roads shall be provided with kerbs.

Kerbs, channels, edgings and quadrants shall be cast generally to BS EN 1343 or equivalent. They shall be cast to the required radius for all curves not less than 10m.

Raised kerbs shall be laid with a 6mm gap and pointed with 1 to 3 polymer modified cement mortar above road level only. Concrete bedding and backing to kerbs shall be cast in-situ to the dimensions shown on the drawings.

Flush kerbs shall be similarly laid and jointed or may be cast in-situ. The outside comer of the kerbs shall be chambered.

Marginal strips and kerbs shall be protected against covering or splashing with bitumen or cement. Kerbs and manhole frames shall be primed before bituminous macadam is laid.

All raised kerbs shall be alternately painted black and white in the plant area and at junctions.

Traffic signs
Traffic signs shall be reflectorized and shall comply with the latest revision of the latest Bangladesh standard.

Number, type and position of the signs have to be as agreed with the Employer.

Mounting posts shall be of circular hollow steel section structural steel. Single post signs will generally be cast directly into a concrete base.

Guardrails
Guardrails shall be provided where the occupants of a vehicle or passers-by can be endangered by a vehicle leaving the road.

Guardrails are to be used also to protect pipes and structures located at traffic areas and are to be designed to withstand impact forces in accordance to the traffic type and speed.

Railings shall be of galvanized steel, which shall be epoxy-painted in addition. Plastic guideposts with glass reflector elements shall be used where required.

Road drainage system
The drainage system of the roads shall comply with the respective standards.

The arrangement of the drain lines discharge collectors shall suit the traffic requirements, simplicity and reliability, having maintenance facilities to make sure that the system is working properly.

4.4.16 FENCES AND GATES

The following fences shall be provided:

- internal fences around different plant components (open storage area, switch yard, etc.).

Internal fences
Chain link fences shall be constructed of plastic coated galvanized steel wire and shall be of such manufacture that when any one segment is cut remaining segments within the pattern retain their rigidity.

Overall height of the fencing shall be 1.8m above ground level. All mesh shall be of plastic coated galvanized steel wire. Line wires shall be of plastic coated galvanized steel wire of the same gauge to adequately support the mesh rigidly. Line wires shall be provided at the top and bottom of the mesh and at two evenly spaced intermediate levels. The line wires shall be attached to the supporting posts. The top wire shall be doubled, making five line wires in all. Mesh and line wires shall comply with BS 4102 or equivalent standards.

Supporting posts and struts shall be of reinforced concrete to the same approved standard as above, unless otherwise approved by the Employer. The posts shall be set in concrete in the ground. The posts shall have cranked tops set at 45° outward to the posts, to which shall be attached three strands of galvanized barbed wire. Droppers shall be fitted at the center of each bay of fencing, to prevent the wires bunched together. Intermediate posts shall be provided at centers not exceeding 3m. Corner posts and struts shall be provided at all changes in direction.

The fences shall be connected to the earthing system.

Gates

Along the internal fences mentioned above an adequate number of single-leaf pedestrian gates and double-leaf hinged gates shall be provided.

The height of these gates shall correspond to the height of the adjacent perimeter fences.

Gates shall comply with BS 1722 or equivalent standards and shall be constructed of plastic coated galvanized chain link mesh on a plastic coated galvanized RHS or tubular steel frame, with three strands of barbed wire across the top on cranked galvanized extension arms.

Gateposts shall be made of plastic coated galvanized RHS section and set in concrete in the ground. Gate hinges (pivots) shall be heavily galvanized and plastic coated.

All gates shall be provided with locks.

Also the gates shall be connected to the earthing system.

4.4.17 COOLING TOWER

Refer Chapter 36 of Section 5.

4.4.18 OUTDOOR FACILITIES

4.4.18.1 POTABLE WATER SYSTEM

Drinking water pipelines shall be constructed to BS 8558, BS EN 806 or equivalent.

For water piping the material listed in the following may be used.

For the water storage tank reinforced concrete, galvanized steel or glass-fibre reinforced polyethylene may be used providing the materials satisfy the requirements of the appropriate standards. Any material used shall meet the requirements of the World Health Authority with regard to harmful influences on the drinking water. They shall not promote the formation of algae or the growth of bacteria in water.

The materials used shall be UV-resistant and withstand any climatic conditions to which they are exposed.

Glass-fibre reinforced material shall meet the requirements laid down in the "Voluntary Product Standard" of the National Bureau of Standards (US Department of Commerce) or other relevant internationally recognized standards.

4.4.18.2 STORM WATER DRAINAGE

Storm water drainage shall be supplied for all buildings, roads, paved areas etc. in accordance with the local rainfall conditions. If possible by gravity only, lifting or pumping stations shall be avoided.

4.4.18.3 OILY WATER DRAINAGE/SEPARATORS

The tank farm, the transformer enclosures and the workshop have to have provisions to collect oily water and to treat it in one or more oil separators.

4.4.18.4 CHEMICAL DRAINAGE

The drainage from battery rooms and similar shall not be connected to the storm water systems, but to the chemical drainage system, connected to the neutralization tank or to the waste water tanks.

4.4.18.5 MANHOLES

Manholes shall be provided for the above-described drainage systems, at each change in gradient or direction, and at maximum intervals of 50m. The diameter of manhole shall be chosen as a function of the pipe cross section. Either prefabricated or cast-in-situ concrete manholes may be used.

Shaft and manhole covers shall be made from cast iron and reinforced concrete, of watertight construction, to suit local requirements. Shaft and pit covers shall have a test load suited to the traffic conditions. Trash gratings shall be of cast steel.

4.4.18.6 PIPING MATERIAL FOR OUTDOOR SYSTEMS

General

- Tubes and fittings of other materials shall be used only if they are in conformity with local regulations and with the approval of the Employer.
- All materials shall comply with the regulations regarding quality and dimensions and shall be adequate for the required work.
- Materials and structural parts not standardized shall be subject to the approval of the Employer’s Engineer prior to use
- All pipes and joints shall be marked indelibly immediately after taking from the moulds.
- The marking shall include:
    - name of manufacturer
    - date of manufacturing and serial number

- nominal diameter and pipe class.

Unplasticized Polyvinyl Chloride (UPVC) pipes
UPVC pipes can be used for water supply, storm water and sewerage purposes. Pipes couplings and pipe fittings of UPVC shall have a uniform dark gray color throughout.

Vitrified clay pipes
Vitrified clay pipes can be used for domestic sewerage, oily water system and chemical contaminated water drains.

Galvanized steel pipes
May be used for water supply

Cast iron pipes
May be used for water supply

Glass-fibre reinforced pipes
May be used for main pressure lines and fittings for water supply and all kind of drainage systems and shall be in accordance with BS EN 1976, BS EN 14364 or equivalent

Copper tubes
Conforming to BS EN 1057 or equivalent may be used for water supply inside buildings.

4.4.19 PIPE AND CABLE DUCTS

The ducts are to be constructed of reinforced concrete and must be watertight. Particular attention must be paid to satisfactory expansion and settling joints. The walls and covers of the ducts must be designed and reinforced to withstand the soil pressure and the relevant traffic loads. The ducts are to be provided internally with hot dip galvanized anchor rails every 1.5m for the easy attachment of clips and cable racks. All ducts covered by removable covers will have to be provided with metal protection angles.

Pipe ducts shall be big enough for maintenance. Trench and cover shall be designed for the relevant traffic loads.

For drainage purposes the cable and pipe ducts shall be provided with slopes (min. slope 0.3%) towards accessible pump sumps. The pump sumps in which will be frequently water will have to be provided with permanently installed automatic pumps.

4.4.20 PIPE BRIDGES

Structure of pipe bridges shall be of galvanized steel and shall consider reasonable heights for under passing and impact loads due to traffic. Floors and stairs shall be galvanized steel grating. Along the pipe bridge, around the various openings and for the stairs tubular steel railings of galvanized steel shall be provided.

Access shall be made by steel stairs and/or from the various plant items. For escape purposes a clear width of min. 1.00m and minimum headroom of 2.20m shall be provided along the pipe bridge. All fittings, apparatus and parts requiring maintenance must be easily accessible via stairs (only in exception cases via ladders) and must be secured by platforms and railings. Minimum headroom of 2.20m and a clear width of min. 1.00m must be assured everywhere and no dangerous objects must protrude into the accessible areas. When are crossed, care must be taken to ensure a clear headroom of min. 8.00m for the main access roads, 6.00m for any other road and a clear width not less than the road width.

The structure must be sturdy and well founded to enable it to support both, the pipe loads as well as the horizontal and vertical pressures and tensile stresses at the fixed points. Sliding bearings must ensure an adequately long travel without jamming. The settlements of pipe bridges must be kept to a minimum in order to avoid unacceptable stresses in the pipes.

4.4.21 SYNTHETIC FILTER FABRICS

Where filter membranes or geo-textiles are required, only non-woven needle-punched fabrics shall be used. In this process discrete long fibre is mechanically interlocked by a barbed needle-punching operation. The filter fabrics shall be installed permanently as required.

4.4.21.1 GENERAL REQUIREMENTS

Resistance to chemical attack
The material shall experience no significant change in its physical, chemical or engineering properties under the influence of oil, sulphates, chlorides, acids and alkalis in the forms and concentrations, which are present in soils, brackish water and groundwater to be found at the site.

Resistance to biological attack
The material shall be resistant to bacterial attack, fungus, insects and vermin etc.

Stability under ultraviolet light
The material shall incorporate sufficient resistance to ultraviolet light that its physical properties shall satisfy the specification after exposure for a period of up to 30 days of full sunlight in summer at the site.

The Contractor shall propose for review methods of storage and laying of the material which will ensure that exposure is not more than half of the manufacturer's recommended maximum exposure period for conditions at site.

Drinking water suitability
The material shall be of such quality that drinking water is not affected.

Supply

Filter fabrics shall be supplied in rolls of at least 3.5m width and shall be jointed in accordance with the manufacturer's recommendation. Each fabric shall be such as to lay one strip complete in one operation, without jointing, each of the various separate sloping and horizontal lengths involved (e.g. for the shoreline protection, placing direction vertical to the coastline). Rolls of adequate standard lengths shall be supplied for this purpose.

Material approval

The Contractor shall demonstrate before use that the proposed materials, from all the proposed sources of supply, meet the specification. Such demonstrations (laboratory tests) shall be performed or stated by an approved official laboratory for materials testing. The results shall be summarized and interpreted in a report and presented to the Employer for approval.

Filtration properties and pore size distribution

Filter fabrics shall be permeable and have a mean pore size not greater than 0.3mm and a pore size for a fraction of 90% not greater than 1.0mm, retaining at least 50% of material with a particle size in the range of 0.06mm to 0.2mm. The pore size distribution shall be determined by appropriate methods in accordance with good engineering practice.

Permeability

The transverse filter fabric permeability range shall be k = 5 x 10 - 4 m/s and 5 x 10 - 3 m/s at a loading of 0.5 bar (50 kN/m^2).

Mechanical and hydraulic filter stability

3 samples shall be taken from the filter fabrics used for every kind of soil to be tested. The fabric shall be fastened as the bottom of at least 15cm diameter and 10cm high PVC-cylinders where these tools are filled with 1500g of dry soil to be tested each. These cylinders shall be submerged 40cm into water and lifted up reciprocally every 30 seconds for 34 hours. The sand penetrated through the fabric shall be measured after 4, 9, 24, 29 and 34 hours where the penetrated sand shall be not more than 2.5g in the last 10 hours. The water volume passing the above sample shall also be measured at above intervals. After the end of the test, two fabric samples shall be taken from each cylinder and their reduced permeability shall be measured which might be caused by soil particles penetrated into the fabric. This permeability still shall be more than of the natural soil.

Weight

In respect of hydrodynamic reversing flow conditions the fabric weight shall be equal or greater than l000g/m^2 (at 20° C and 65 percent humidity) for shoreline protection and scour protection.

4.4.21.2 TENSILE PROPERTIES OF FILTER FABRICS

The tensile strength of the filter fabric shall be verified in any direction (longitudinal and cross) under a uniformly applied load. The following laboratory tests shall be performed on wet samples, which have been fully submerged in water for a period of 48 hours before testing.

Plain strain test

This test shall be carried out according to ISO 13934 but with a 20cm by 20cm fabric sample, restrained from reduction in width by laths on the two tensioned sides of fabric with steel pins penetrating fabric. The tensile strength of the material shall not be less than 1.2/1.6 KN over a 200 mm width and the breaking strain shall exceed 50/70%.

“Grab” tensile test

The 25mm '“grab” tensile strength be carried out in accordance with ISO 13934.

4.4.21.3 TESTING FREQUENCY

The thickness, weight, permeability and tensile properties (plain strain test) shall be carried out once at start of works and then on every 5000m^2 of each material used. The samples shall be taken from the material at the site and tested by a specialized official institution to be approved by the Employer. More tests may be required if above tests fail or there are doubts about fabric quality.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 5 – MECHANICAL

CONTENTS

5 MECHANICAL ENGINEERING DESIGN CRITERIA

This section covers the design criteria which shall be used for all mechanical work related to the Project.

All equipment shall be furnished with individual name tags to identify the equipment name and tag number. All supplied equipment shall be tagged according to the Project's designated tagging system.

5.1 DESIGN CODES AND STANDARDS

The design and specification of all work shall comply with all applicable International Laws and codes. A summary of the major codes and industry standards to be used in design and construction is provided below. In case of conflict between them, Bangladesh legislation, regulations, and codes are mandatory and represent the required minimum; compliance with more stringent standards is acceptable. Contractor may adopt alternative standards not covered by the list presented below, provided the Contractor has requested and demonstrated, to the Employer's satisfaction, and Employer has accepted each such alternative standard as being equivalent to the listed standard.

1. Air Moving and Control Association (AMCA).
2. Antifriction Bearing Manufacturers Association (AFBMA).
3. American Gear Manufacturers Association (AGMA).
4. American National Standards Institute (ANSI).
5. American Petroleum Institute (API).
6. American Society of Mechanical Engineers (ASME) (ASME Boiler and Pressure Vessel Code Sections I, II, V, VIII, IX and X, ASME PTC and other ASME codes and standards).
7. Piping and piping supports shall be designed in accordance with ASME B31.1, Power Piping.
8. American Society for Testing and Materials (ASTM).
9. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
10. American Welding Society (AWS).
11. American Water Works Association (AWWA).
12. Factories and Machinery and Regulations including all amendments.
13. Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations.
14. Fire Services & Regulations
15. Heat Exchange Institute (HEI).
16. Hydraulic Institute (HI).
17. International Plumbing Code (IPC)
18. Instrument Society of America (ISA).
19. International Standards Organization (ISO).
20. Airports Standard Directives (ASD).
21. Department of Occupational Safety and Health (DOSH)

22. Manufacturers Standardization Society of Valve and Fitting Industry (MSS).
23. National Fire Protection Association (NFPA).
24. National Sanitation Foundation International (NSF)
25. The Society for Protective Coatings - (SSPC).
26. Tubular Exchanger Manufacturers Association (TEMA).
27. Underwriters' Laboratories (UL) or Factory Mutual (FM).
28. Expansion Joint Manufacturers Association (EJMA).
29. Street, Drainage and Building including all amendments
30. Uniform Building By-Laws 1984.
31. Air Compressors, vacuum pump, Air Receivers, Air Drying Plants
32. Acceptance test for positive displacement compressors and exhausters
33. Guide for selection, installation and maintenance of air compressors, plants with operating pressures up to 10 bars
34. Code PTC-9 Displacement compressors, vacuum pumps and blowers
35. Glossary of terms relating to compressor and exhausters.
36. Code of practice for testing of positive displacement type air compressors and exhausters.
37. Compressor performance test.
38. Silica Gel
39. Displacement Compressors-Acceptance tests
40. Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
41. Steel Pipes for Water and Sewage (168.3 to 2 540 mm Outside Diameter) – Specification
42. MS tubes and tubular for sizes up to 150 NB
43. Horizontal centrifugal pumps for clear, cold fresh water.
44. Technical requirements for roto-dynamic special purpose pumps
45. Pumps handling chemicals & corrosive liquids
46. Pumps for process water.
47. Pumps for handling volatile liquids.
48. Centrifugal pumps for general refinery service.
49. Standards of Hydraulic Institute of U.S.A.

Other recognized standards shall be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

5.2 PIPING

Design loads and load combinations for buildings, structures, structural elements and All piping shall be furnished with labels to identify the KKS number assigned to the pipe and identify the service. All carbon steel piping shall be painted with a colour scheme approved by the Employer.

Piping systems shall be sized and arranged so that the maximum design flow through the piping will not produce cavitation, erosion, water hammer, excessive noise, or vibration.

Piping sizes shall be based on limiting the pressure drop to an acceptable value and shall generally be large enough to keep fluid velocities below the maximum velocities indicated in Table 4.3.2-1 (Maximum Velocities in Pipes) below.

Table 4.3.2-1
Maximum Velocities in Pipes

	Nominal Pipe Size or Smaller				
Service or Type of Fluid	**50 mm**	**200 mm**	**350 mm**	**500 mm**	**600 mm**
Superheated Steam Supercritical, Continuous service	1830	2740	3350	3660	3660
Superheated Steam Subcritical, Continuous service	2740	4570	5490	6700	6860
Sub-Atmospheric Steam	6100	6100	7620	9140	9140
Saturated Steam	910	1830	2130	2740	3050
All Gases	910	1220	1520	1520	1520
Boiler Feed water Pump suction Pump discharge	 1.5 3.0	 2.4 6.1	 3.7 7.6	 4.3 9.1	 5.5 9.1
Circulating water Pump suction Pump discharge	 0.6 1.2	 1.2 2.4	 1.8 3.0	 1.8 3.7	 1.8 3.7
Condensate Pump suction Pump discharge	 0.6 1.5	 1.2 3.0	 1.2 3.7	 1.2 4.6	 1.2 4.6
General service water Pump suction Pump discharge	 0.6 1.5	 1.5 3.0	 1.8 3.7	 2.4 4.6	3.0 4.6
Auxiliary Cooling Water	1.2	1.8	2.4	3.7	3.7
Gravity Drains	0.9	1.2	1.5	2.4	3.7

Notes:
1. All steam and gas velocities are specified in meters per minute. All water velocities are specified in meters per second.
2. For pipe sizes between tabulated values, the velocity associated with the larger pipe size shall be used.
3. Deviations from the above criteria shall not affect 30 year equipment life.

The piping shall be arranged and designed to facilitate the erection, operation, dismantling, and maintenance of the pipe, equipment, and other components. Piping arrangements shall allow safe access to components and equipment and not limit egress in the event of an emergency.

5.2.1 PIPE CLEANLINESS CONTROL

Pipe internal cleanliness shall be controlled as set forth in Table 4.3.2-2 (Pipe Cleanliness Control). The purpose is to establish fabrication cleaning, preservative treatment, and post installation cleaning criteria for each system.

Pipe routings and plant equipment arrangements shall avoid dead legs, non-valved bypasses, and inaccessible or non-flushable piping sections where contaminants can collect and reside.

Equipment internal pipe bracing and other support members should be designed or provided with drain holes to preclude stagnant non-flow areas and water accumulation, corrosion products, grit blasting materials, and other contaminants that could impair cycle cleanliness. Such supports can be found in condensers, deaerators, and similar equipment.

Piping stored prior to erection shall be maintained in the same type of packaging as it was received if not the original packaging materials. This packaging includes pipe and valve caps and covers, nitrogen blanketing, desiccants, and similar requirements. Piping shall not be stored in direct contact with the ground.

Temporary caps, covers, or similar methods of protection shall be in place during suspended work periods including, but not limited to shift changes and weekends. Cleanliness practices shall be part of the Site’s QC procedures, and routine inspections and corrective actions shall be established in advance of erection activities. Nitrogen blanketing and other corrosion control measures will need to be temporarily suspended during the erection phase, but these measures shall be reinstated as soon as practical following erection.

Demineralized water is required for all hydrostatic testing of the boiler or steam and feed water piping. Demineralized water shall be defined as high purity water with less than five (5) parts per million (ppm) total dissolved solids and free of suspended solids. Treatment shall consist of 200 ppm of an oxygen scavenger that does not contain organic materials, and enough Ammonia (NH_3) to give a final pH of 10.0. Hydrazine (N_2H_4) shall not be used as an oxygen scavenging agent.

Demineralized water is preferred, though not required, for hydrostatic testing of all other piping systems. In the event that demineralized water is not available, clean service water may be substituted. Service water shall be of potable water quality (less than 500 mg/l total dissolved solids, less than 1 mg/l total suspended solids, less than 250 mg/l chlorides, less than 250 mg/l sulfates, and pH 6 to 9). The hydrostatic test water shall be treated as specified for demineralized water.

Table 5.2.1-1
Pipe Cleanliness Control

		Refer to Note 1.	Refer to Note 2.	Refer to Notes 3 and 4.	
Bottom Ash	Low	NO	NO	Not Applicable	
Fly Ash	Low	NO	NO	Not Applicable	
Boiler Hopper / Economizer Ash	Low	NO	NO	Not Applicable	
Pulverizer Rejects	Low	NO	NO	Not Applicable	
Scrubber Solids	Low	NO	NO	Service Water Flush	
Auxiliary Steam Supply	High	Sa2	P50	Chemical Cleaning or Steam Blow	Post-installation cleaning may not be needed for all services.
Auxiliary Boiler Fuel	Low	NO	NO	Service Water Flush	Air dry immediately following flush.
Auxiliary Boiler Chemical Feed	High	NO	CP	Demineralized Water Flush	
Station Air	Low	NO	NO	Air Blow	
Control Air	High	NO	NO	Air Blow	Cleaning and coating for stainless steel piping. If piping is carbon steel use Sa2 and P50.
Hydrogen Storage	Low	NO	NO	Air Blow	
Carbon Dioxide Storage	Low	NO	NO	Air Blow	
Chlorine Storage	Low	NO	NO	Air Blow	
Nitrogen Storage	Low	NO	NO	Air Blow	
Ammonia Storage	Low	NO	NO	Air Blow	
Construction Water	Low	NO	NO	Service Water Flush	
Construction Fire Protection	Low	NO	NO	Service Water Flush	
Condenser Air Extraction	Low	NO	NO	Service Water Flush	
Circulating Water	Low	NO	NO	Not Applicable	
Condenser Cleaning	Low	NO	NO	Water Flush	
Vacuum Priming	Low	NO	NO	Service Water Flush	
Building Drains and Plumbing	Low	NO	NO	Service Water Flush	
Auxiliary Cooling Water	Low	NO	NO	Service Water Flush	
Closed Cycle Cooling Water	Medium	St2	NO	Service Water Flush	
Boiler Feed	High	Sa2	P50	Chemical Cleaning	
Boiler Feed Pump Injection	High	Sa2	P50	Demineralized Water Flush	
Condensate	High	Sa2	P50	Chemical Cleaning	
Condensate Polishing	High	Sa2	P50	Chemical Cleaning	
Cycle Chemical Feed	High	NO	CP	Demineralized Water Flush	
Cycle Makeup and Storage	High	NO	CP	Demineralized Water Flush	
Building Fire Protection	Low	NO	NO	Service Water Flush	
Fuel Oil Receiving and Storage	Low	St2	NO	Service Water or Oil Flush	
Fuel Oil Supply, including supply to Auxiliary Boiler	Medium	St2	NO	Service Water or Oil Flush	
Chemical Cleaning	Low	NO	NO	Service Water Flush	
Shutdown Corrosion Protection	Low	NO	NO	Air Blow	
Vacuum Cleaning	Low	NO	NO	Not Applicable	
Scrubber Liquids Sampling and Analysis	Low	NO	NO	Service Water Flush	
Steam Cycle Sampling and Analysis	High	NO	CP	Demineralized Water Flush	
Water Supply Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Waste Water Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Site Fire Protection	Low	NO	NO	Fire Water Flush	
Steam Generator	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Ignitor Fuel	Medium	SP3	NO	Air Blow	
First Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Second Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Boiler Vents and Drains	Low	NO	NO	Not Applicable	
Main Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Soot Blowing Steam	Medium	St2	NO	Air Blow	
Hot and Cold Reheat Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Bypass Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Temporary Blowout	Low	NO	NO	Not Applicable	
High-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Low-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Extraction Drains	High	Sa2	P50	Demineralized Water Flush	
High-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Low-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Heater Vents and Miscellaneous Drains	High	Sa2	P50	Demineralized Water Flush	
Steam Turbine	High				In Accordance with Manufacturer's Recommendations
Turbine Seals and Drains	High				In Accordance with Manufacturer's Recommendations
Turbine Lube Oil (Carbon Steel)	High	P	P51	Fluid Flush	No Preservative for EHC
Steam Turbine EHC and Lube Oil (Stainless Steel)	High	NO	CP	Fluid Flush	
Generator Cooling and Purge	Low	NO	NO	Air Blow	
Chemical Waste Drainage and Treatment	Low	NO	NO	Service Water Flush	
Sanitary Drainage and Treatment	Low	NO	NO	Service Water Flush	
Wastewater Collection and Treatment	Low	NO	NO	Service Water Flush	
Surface Water Supply	Medium	St2	NO	Raw Water Flush	
Service Water	Medium	St2	NO	Service Water Flush	
Potable Water	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Fire Protection Water Supply and Storage	Low	NO	NO	Fire Water Flush	
Scrubber Makeup Water	Low	NO	NO	Service Water Flush	
Service Water Treatment	Medium	St2	NO	Service Water Flush	
Potable Water Treatment	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Cycle Makeup Treatment	High	NO	CP	Demineralized Water Flush	

		Refer to Note 1.	Refer to Note 2.	Refer to Notes 3 and 4.	
Bottom Ash	Low	NO	NO	Not Applicable	
Fly Ash	Low	NO	NO	Not Applicable	
Boiler Hopper / Economizer Ash	Low	NO	NO	Not Applicable	
Pulverizer Rejects	Low	NO	NO	Not Applicable	
Scrubber Solids	Low	NO	NO	Service Water Flush	
Auxiliary Steam Supply	High	Sa2	P50	Chemical Cleaning or Steam Blow	Post-installation cleaning may not be needed for all services.
Auxiliary Boiler Fuel	Low	NO	NO	Service Water Flush	Air dry immediately following flush.
Auxiliary Boiler Chemical Feed	High	NO	CP	Demineralized Water Flush	
Station Air	Low	NO	NO	Air Blow	
Control Air	High	NO	NO	Air Blow	Cleaning and coating for stainless steel piping. If piping is carbon steel use Sa2 and P50.
Hydrogen Storage	Low	NO	NO	Air Blow	
Carbon Dioxide Storage	Low	NO	NO	Air Blow	
Chlorine Storage	Low	NO	NO	Air Blow	
Nitrogen Storage	Low	NO	NO	Air Blow	
Ammonia Storage	Low	NO	NO	Air Blow	
Construction Water	Low	NO	NO	Service Water Flush	
Construction Fire Protection	Low	NO	NO	Service Water Flush	
Condenser Air Extraction	Low	NO	NO	Service Water Flush	
Circulating Water	Low	NO	NO	Not Applicable	
Condenser Cleaning	Low	NO	NO	Water Flush	
Vacuum Priming	Low	NO	NO	Service Water Flush	
Building Drains and Plumbing	Low	NO	NO	Service Water Flush	
Auxiliary Cooling Water	Low	NO	NO	Service Water Flush	
Closed Cycle Cooling Water	Medium	St2	NO	Service Water Flush	
Boiler Feed	High	Sa2	P50	Chemical Cleaning	
Boiler Feed Pump Injection	High	Sa2	P50	Demineralized Water Flush	
Condensate	High	Sa2	P50	Chemical Cleaning	
Condensate Polishing	High	Sa2	P50	Chemical Cleaning	
Cycle Chemical Feed	High	NO	CP	Demineralized Water Flush	
Cycle Makeup and Storage	High	NO	CP	Demineralized Water Flush	
Building Fire Protection	Low	NO	NO	Service Water Flush	
Fuel Oil Receiving and Storage	Low	St2	NO	Service Water or Oil Flush	
Fuel Oil Supply, including supply to Auxiliary Boiler	Medium	St2	NO	Service Water or Oil Flush	
Chemical Cleaning	Low	NO	NO	Service Water Flush	
Shutdown Corrosion Protection	Low	NO	NO	Air Blow	
Vacuum Cleaning	Low	NO	NO	Not Applicable	
Scrubber Liquids Sampling and Analysis	Low	NO	NO	Service Water Flush	
Steam Cycle Sampling and Analysis	High	NO	CP	Demineralized Water Flush	
Water Supply Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Waste Water Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Site Fire Protection	Low	NO	NO	Fire Water Flush	
Steam Generator	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Ignitor Fuel	Medium	SP3	NO	Air Blow	
First Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Second Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Boiler Vents and Drains	Low	NO	NO	Not Applicable	
Main Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Soot Blowing Steam	Medium	St2	NO	Air Blow	
Hot and Cold Reheat Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Bypass Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Temporary Blowout	Low	NO	NO	Not Applicable	
High-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Low-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Extraction Drains	High	Sa2	P50	Demineralized Water Flush	
High-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Low-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Heater Vents and Miscellaneous Drains	High	Sa2	P50	Demineralized Water Flush	
Steam Turbine	High				In Accordance with Manufacturer's Recommendations
Turbine Seals and Drains	High				In Accordance with Manufacturer's Recommendations
Turbine Lube Oil (Carbon Steel)	High	P	P51	Fluid Flush	No Preservative for EHC
Steam Turbine EHC and Lube Oil (Stainless Steel)	High	NO	CP	Fluid Flush	
Generator Cooling and Purge	Low	NO	NO	Air Blow	
Chemical Waste Drainage and Treatment	Low	NO	NO	Service Water Flush	
Sanitary Drainage and Treatment	Low	NO	NO	Service Water Flush	
Wastewater Collection and Treatment	Low	NO	NO	Service Water Flush	
Surface Water Supply	Medium	St2	NO	Raw Water Flush	
Service Water	Medium	St2	NO	Service Water Flush	
Potable Water	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Fire Protection Water Supply and Storage	Low	NO	NO	Fire Water Flush	
Scrubber Makeup Water	Low	NO	NO	Service Water Flush	
Service Water Treatment	Medium	St2	NO	Service Water Flush	
Potable Water Treatment	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Cycle Makeup Treatment	High	NO	CP	Demineralized Water Flush	

		Refer to Note 1.	Refer to Note 2.	Refer to Notes 3 and 4.	
Bottom Ash	Low	NO	NO	Not Applicable	
Fly Ash	Low	NO	NO	Not Applicable	
Boiler Hopper / Economizer Ash	Low	NO	NO	Not Applicable	
Pulverizer Rejects	Low	NO	NO	Not Applicable	
Scrubber Solids	Low	NO	NO	Service Water Flush	
Auxiliary Steam Supply	High	Sa2	P50	Chemical Cleaning or Steam Blow	Post-installation cleaning may not be needed for all services.
Auxiliary Boiler Fuel	Low	NO	NO	Service Water Flush	Air dry immediately following flush.
Auxiliary Boiler Chemical Feed	High	NO	CP	Demineralized Water Flush	
Station Air	Low	NO	NO	Air Blow	
Control Air	High	NO	NO	Air Blow	Cleaning and coating for stainless steel piping. If piping is carbon steel use Sa2 and P50.
Hydrogen Storage	Low	NO	NO	Air Blow	
Carbon Dioxide Storage	Low	NO	NO	Air Blow	
Chlorine Storage	Low	NO	NO	Air Blow	
Nitrogen Storage	Low	NO	NO	Air Blow	
Ammonia Storage	Low	NO	NO	Air Blow	
Construction Water	Low	NO	NO	Service Water Flush	
Construction Fire Protection	Low	NO	NO	Service Water Flush	
Condenser Air Extraction	Low	NO	NO	Service Water Flush	
Circulating Water	Low	NO	NO	Not Applicable	
Condenser Cleaning	Low	NO	NO	Water Flush	
Vacuum Priming	Low	NO	NO	Service Water Flush	
Building Drains and Plumbing	Low	NO	NO	Service Water Flush	
Auxiliary Cooling Water	Low	NO	NO	Service Water Flush	
Closed Cycle Cooling Water	Medium	St2	NO	Service Water Flush	
Boiler Feed	High	Sa2	P50	Chemical Cleaning	
Boiler Feed Pump Injection	High	Sa2	P50	Demineralized Water Flush	
Condensate	High	Sa2	P50	Chemical Cleaning	
Condensate Polishing	High	Sa2	P50	Chemical Cleaning	
Cycle Chemical Feed	High	NO	CP	Demineralized Water Flush	
Cycle Makeup and Storage	High	NO	CP	Demineralized Water Flush	
Building Fire Protection	Low	NO	NO	Service Water Flush	
Fuel Oil Receiving and Storage	Low	St2	NO	Service Water or Oil Flush	
Fuel Oil Supply, including supply to Auxiliary Boiler	Medium	St2	NO	Service Water or Oil Flush	
Chemical Cleaning	Low	NO	NO	Service Water Flush	
Shutdown Corrosion Protection	Low	NO	NO	Air Blow	
Vacuum Cleaning	Low	NO	NO	Not Applicable	
Scrubber Liquids Sampling and Analysis	Low	NO	NO	Service Water Flush	
Steam Cycle Sampling and Analysis	High	NO	CP	Demineralized Water Flush	
Water Supply Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Waste Water Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Site Fire Protection	Low	NO	NO	Fire Water Flush	
Steam Generator	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Ignitor Fuel	Medium	SP3	NO	Air Blow	
First Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Second Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Boiler Vents and Drains	Low	NO	NO	Not Applicable	
Main Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Soot Blowing Steam	Medium	St2	NO	Air Blow	
Hot and Cold Reheat Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Bypass Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Temporary Blowout	Low	NO	NO	Not Applicable	
High-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Low-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Extraction Drains	High	Sa2	P50	Demineralized Water Flush	
High-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Low-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Heater Vents and Miscellaneous Drains	High	Sa2	P50	Demineralized Water Flush	
Steam Turbine	High				In Accordance with Manufacturer's Recommendations
Turbine Seals and Drains	High				In Accordance with Manufacturer's Recommendations
Turbine Lube Oil (Carbon Steel)	High	P	P51	Fluid Flush	No Preservative for EHC
Steam Turbine EHC and Lube Oil (Stainless Steel)	High	NO	CP	Fluid Flush	
Generator Cooling and Purge	Low	NO	NO	Air Blow	
Chemical Waste Drainage and Treatment	Low	NO	NO	Service Water Flush	
Sanitary Drainage and Treatment	Low	NO	NO	Service Water Flush	
Wastewater Collection and Treatment	Low	NO	NO	Service Water Flush	
Surface Water Supply	Medium	St2	NO	Raw Water Flush	
Service Water	Medium	St2	NO	Service Water Flush	
Potable Water	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Fire Protection Water Supply and Storage	Low	NO	NO	Fire Water Flush	
Scrubber Makeup Water	Low	NO	NO	Service Water Flush	
Service Water Treatment	Medium	St2	NO	Service Water Flush	
Potable Water Treatment	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Cycle Makeup Treatment	High	NO	CP	Demineralized Water Flush	

		Refer to Note 1.	Refer to Note 2.	Refer to Notes 3 and 4.	
Bottom Ash	Low	NO	NO	Not Applicable	
Fly Ash	Low	NO	NO	Not Applicable	
Boiler Hopper / Economizer Ash	Low	NO	NO	Not Applicable	
Pulverizer Rejects	Low	NO	NO	Not Applicable	
Scrubber Solids	Low	NO	NO	Service Water Flush	
Auxiliary Steam Supply	High	Sa2	P50	Chemical Cleaning or Steam Blow	Post-installation cleaning may not be needed for all services.
Auxiliary Boiler Fuel	Low	NO	NO	Service Water Flush	Air dry immediately following flush.
Auxiliary Boiler Chemical Feed	High	NO	CP	Demineralized Water Flush	
Station Air	Low	NO	NO	Air Blow	
Control Air	High	NO	NO	Air Blow	Cleaning and coating for stainless steel piping. If piping is carbon steel use Sa2 and P50.
Hydrogen Storage	Low	NO	NO	Air Blow	
Carbon Dioxide Storage	Low	NO	NO	Air Blow	
Chlorine Storage	Low	NO	NO	Air Blow	
Nitrogen Storage	Low	NO	NO	Air Blow	
Ammonia Storage	Low	NO	NO	Air Blow	
Construction Water	Low	NO	NO	Service Water Flush	
Construction Fire Protection	Low	NO	NO	Service Water Flush	
Condenser Air Extraction	Low	NO	NO	Service Water Flush	
Circulating Water	Low	NO	NO	Not Applicable	
Condenser Cleaning	Low	NO	NO	Water Flush	
Vacuum Priming	Low	NO	NO	Service Water Flush	
Building Drains and Plumbing	Low	NO	NO	Service Water Flush	
Auxiliary Cooling Water	Low	NO	NO	Service Water Flush	
Closed Cycle Cooling Water	Medium	St2	NO	Service Water Flush	
Boiler Feed	High	Sa2	P50	Chemical Cleaning	
Boiler Feed Pump Injection	High	Sa2	P50	Demineralized Water Flush	
Condensate	High	Sa2	P50	Chemical Cleaning	
Condensate Polishing	High	Sa2	P50	Chemical Cleaning	
Cycle Chemical Feed	High	NO	CP	Demineralized Water Flush	
Cycle Makeup and Storage	High	NO	CP	Demineralized Water Flush	
Building Fire Protection	Low	NO	NO	Service Water Flush	
Fuel Oil Receiving and Storage	Low	St2	NO	Service Water or Oil Flush	
Fuel Oil Supply, including supply to Auxiliary Boiler	Medium	St2	NO	Service Water or Oil Flush	
Chemical Cleaning	Low	NO	NO	Service Water Flush	
Shutdown Corrosion Protection	Low	NO	NO	Air Blow	
Vacuum Cleaning	Low	NO	NO	Not Applicable	
Scrubber Liquids Sampling and Analysis	Low	NO	NO	Service Water Flush	
Steam Cycle Sampling and Analysis	High	NO	CP	Demineralized Water Flush	
Water Supply Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Waste Water Sampling and Analysis	Medium	St2	NO	Service Water Flush	
Site Fire Protection	Low	NO	NO	Fire Water Flush	
Steam Generator	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Ignitor Fuel	Medium	SP3	NO	Air Blow	
First Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Second Stage Air Preheat	High	Sa2	P50	Demineralized Water Flush	
Boiler Vents and Drains	Low	NO	NO	Not Applicable	
Main Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Soot Blowing Steam	Medium	St2	NO	Air Blow	
Hot and Cold Reheat Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Bypass Steam	High	Sa2	P50	Chemical Cleaning and Steam Blow	
Temporary Blowout	Low	NO	NO	Not Applicable	
High-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Low-Pressure Extraction	High	Sa2	P50	Chemical Cleaning or Steam Blow	
Extraction Drains	High	Sa2	P50	Demineralized Water Flush	
High-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Low-Pressure Heater Drains	High	Sa2	P50	Demineralized Water Flush	
Heater Vents and Miscellaneous Drains	High	Sa2	P50	Demineralized Water Flush	
Steam Turbine	High				In Accordance with Manufacturer's Recommendations
Turbine Seals and Drains	High				In Accordance with Manufacturer's Recommendations
Turbine Lube Oil (Carbon Steel)	High	P	P51	Fluid Flush	No Preservative for EHC
Steam Turbine EHC and Lube Oil (Stainless Steel)	High	NO	CP	Fluid Flush	
Generator Cooling and Purge	Low	NO	NO	Air Blow	
Chemical Waste Drainage and Treatment	Low	NO	NO	Service Water Flush	
Sanitary Drainage and Treatment	Low	NO	NO	Service Water Flush	
Wastewater Collection and Treatment	Low	NO	NO	Service Water Flush	
Surface Water Supply	Medium	St2	NO	Raw Water Flush	
Service Water	Medium	St2	NO	Service Water Flush	
Potable Water	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Fire Protection Water Supply and Storage	Low	NO	NO	Fire Water Flush	
Scrubber Makeup Water	Low	NO	NO	Service Water Flush	
Service Water Treatment	Medium	St2	NO	Service Water Flush	
Potable Water Treatment	Medium	St2	NO	Service Water Flush	Disinfect per SANS
Cycle Makeup Treatment	High	NO	CP	Demineralized Water Flush	

Notes:

1. Piping Fabrication Cleaning Codes:
   NO - No special cleaning required.
   St2 - Power tool cleaning
   Sa2 - Commercial blast cleaning
   P – Pickled
2. Post-Fabrication Piping Preservative Codes:
   NO - Manufacturer's standard coating system (this could be no coating at all).
   P50 - Water soluble preservative.
   P51 - Oil soluble rust preventive.
   CP - Coating prohibited.
3. Service water and demineralized water flushes shall be performed with treated water.
4. Hydroblasting may be an appropriate alternative to chemical cleaning and steam blowing for certain applications, depending on piping length and accessibility.

5.2.2 DESIGN PRESSURE AND TEMPERATURE

The design pressure and temperature for piping shall be consistent with conditions established for the design of the associated system and in accordance with ASME B31.1, Power Piping. High pressure piping may be designed according to EN codes.

5.2.3 GENERAL DESIGN AND SELECTION CRITERIA FOR PIPE/TUBING

The general criteria for pipe/tubing are shown in Table 5.2.3-2 (General Pipe and Tubing Selection Criteria) below.

Other materials may be used depending on the service, media, and conditions. Fire water systems shall use Factory Mutual (FM) certified materials and installation methods where required by NFPA and/or local codes. HDPE pipe shall meet NSF International and relevant local code requirements and be certified when used for potable water service.

Schedule/nominal wall thickness pipe shall be used unless the service conditions exceed heaviest schedule pipe limitations. Threaded pipe shall be Schedule 80 at the minimum. Corrosion/additional allowance on pipe wall thickness shall be 1.625 mm except where service conditions require a greater allowance. Condensate, feed water, and steam lines shall use 0.5 mm minimum corrosion allowance.

NDE / NDT shall be in accordance with ASME. If no volumetric NDE /NDT is required by the ASME Codes, then sampling and progressive evaluation shall be per Table 5.2.3-1, Note 1. Boiler tube butt welds shall be 100% RT examined, where the configuration is permitted by the Code(s). However, due to configuration, where RT can not be performed, then MT shall be used.

Unless approved by Employer, for boiler tubes, no dissimilar metal welds shall be made in the field, safe ends shall be used.

Grade 91 and Grade 92 materials shall comply with the specification “Procurement, Fabrication, Inspection, Testing and Documentation Requirements for Grade 91 (9Cr-1Mo-V) and Grade 92 (9Cr-2W) Materials” provided in **Attachment B1** of these Employer’s Requirements and the following Non-destructive testing of Grade 91 (9Cr-1Mo-V) and Grade 92 (9Cr-2W) Materials piping shall be performed in accordance with the applicable Laws and codes, and shall comply with the requirements provided below in Table 5.2.3-2 (Grade 91 (9Cr-1Mo-V) and Grade 92 (9Cr-2W) Material Pressure Part Service Conditions).

Table 5.2.3-1
Grade 91 (9Cr-1Mo-V) and Grade 92 (9Cr-2W) Material
Pressure Part Service Conditions

Weld Type	
1. Longitudinal butt welds	Radiography Technique (RT) all sizes and thicknesses and Ultrasonic Technique(UT) if thicknesses > 19 mm
2. Circumferential butt welds in drums and shells and separator(s).	RT > NPS 10 (DN 250) or > 1 ⅛ in. (29 mm) thick and Magnetic Particle Inspection (MPI) 100% and UT if thicknesses > 19 mm.
3. Circumferential butt welds in pipes, tubes, and headers > NPS 4 (DN 100),	RT > NPS 10 (DN 250) or > 1 ⅛ in. (29 mm) thick and MPI 100% and UT if thicknesses > 19 mm.
4. Circumferential butt welds in pipes and tubes < NPS 4 (DN 100), (including economizer, super heater and re-heater)	Progressive sampling (See Note 1) 10 % RT for all thicknesses.
5. Nozzles, nipples and stubs welds to headers, drums, separators and vessels.	MPI 100 %
6. Inspection openings	MPI 100%

Other requirements	All non-destructive testing (NDT) shall be done after PWHT.

Note:

1. Sampling shall be 10% minimum. When any of the 10% sampling examination reveals a defect.

10% additional samples of the same kind (if welded or bonded joints, by the same welder, WPS, joint configuration and component shall be given the same type of examination; and

(a) if the items examined as required by (a) above are acceptable, the defective item shall be repaired or replaced and re-examined, and all items represented by these two additional samples shall be accepted; but

(b) if any of the items examined as required by (a) above reveals a defect, 10% additional samples of the same kind shall be examined for each defective item found by that sampling; and

(c) if all the items examined as required by (c) above are acceptable, the defective item(s) shall be repaired or replaced and re-examined, and all items represented by the additional sampling shall be accepted; but

(d) if any of the items examined as required by (c) above reveals a defect, all items represented by the progressive sampling shall be either:

  (1) Fully examined and repaired as necessary.

  (2) The welds shall be completely removed, re-welded, or replaced and examined in accordance with the original requirements of 10% evaluation.

Table 5.2.3-2
General Pipe and Tubing Selection Criteria

Material	Typical Standard	Typical Temp. Range	Minimum Pipe Wall Thickness		Notes
			Diameter, less than or equal to 50mm	Diameter, greater than 50mm	
Carbon Steel	A53, A106, A134, A672	-29°C to 413°C	Sch XS	Std wt	Lined pipe may use other criteria.
CrMo Alloy	A335, or such other as may be agreed by the Employer.	413°C to 594°C	Sch XS	Std wt	--
Stainless Steel	A312	-29°C to 649°C	Sch 10S	Sch 10S	Minimum carbon 0.04 percent over 538°C
SS Tubing	A213 TP 304 or TP 316	-29°C to 649°C	Refer to Table 4.3.2-6	--	EAW and U not allowed; minimum carbon 0.04 percent over 1,000° F;(538°) Rockwell hardness less than B90 (B80 or less preferred).
Concrete Cylinder Pipe	AWWA	0°C to 66°C	--	Varies	Specific type of pipe varies.
HDPE	ASTM D3350	-18°C to 49°C	SDR 11	SDR17	Air, slurry, ash, or water service (PE100 resin or heavier wall required for compressed air service).
PVC/CPVC	D1785 F441	4°C to 82°C	Sch 40	Sch 40	--
FRP	Varies	4°C to 99°C	Varies	Varies	--
Ductile/Cast Iron	C151 A123	4°C to 102°C	--	Class 50	--
Alloy 20	B464 N08020	29°C to 427°C	Sch 40	Sch 10	--

5.2.4 PIPE AND TUBING SIZE SELECTION

The pipe sizes shown in Table 5.2.4-1 (Carbon/Low Alloy Pipe) below shall be used for carbon steel and low/intermediate alloy steel pipes. Other sizes or schedules shall not be used.

Table 5.2.4-1
Carbon/Low Alloy Pipe

Nominal Pipe Size (NPS)	Service	Schedules	Connection
25mm	All	XS, XXS	SW or flanged
50mm	All	XS, 160, XXS	SW or flanged
65mm and up	All	Std wt min	BW or flanged

The pipe sizes shown in Table 5.2.4-2 (Stainless Steel Pipe) below shall be used for stainless steel pipes. Other sizes or schedules shall not be used, unless approved by the Employer.

Table 5.2.4-2
Stainless Steel Pipe

Nominal Pipe Size (NPS)	Service	Schedules	Connection
25mm	All	5S, 10S, 40S	SW, flanged, or grip type
50mm	All	5S, 10S, 40S	SW, flanged, or grip type
65mm and up	All	10S and up	BW or flanged

The tubing specifications shown in Table 5.2.4-3 (Tubing Requirements) below shall be used for chemical feed, instrument primary piping, compressed air, plumbing, and sample line systems. Other tubing sizes may be used as part of a vendor equipment package.

Tubing material shall be stainless steel tubing using butt-weld, grip type, or socket-welded fittings as described in Table 5.2.4-3 (Tubing Requirements).

Table 5.2.4-3
Tubing Requirements

Tubing Design Parameter	Project Design Basis
Tubing Fittings (wall thickness 2 mm) and less)	316 SS grip type fittings butt-weld or socket-weld fittings.* For 2 mm wall tubing, all joints shall be checked using manufacturer's gap inspection gauge.
Tubing Fittings (wall thickness greater than 2 mm)	316 SS butt-weld or socket-weld fittings.
Tubing Direction Changes	Tubing fitting or bending (bending will affect pressure and temperature rating).
Tubing Supports	In accordance with ASME B31.1 to allow thermal expansion or as required to protect tube from damage.
Tubing Design Pressure and Temperature	In accordance with mechanical design criteria for process pipe connected to and ASME B31.1.
Tubing Sizing	
Pressure measurement tubing, sample lines, chemical lines, compressed air	12 mm OD with minimum wall thickness (average wall thickness not acceptable) of 1.25 mm, 1.65 mm, or 2 mm) depending on process design pressures and temperatures, and ASME B31.1.
Sample lines, compressed air	9.5 mm OD with minimum wall thickness (average wall thickness not acceptable) of 1.25 mm, 1.65 mm, or 2 mm depending on process design pressures and temperatures, and ASME B31.1.
Flow and level measurement by differential pressure	Use pressure tubing criteria.
Using separate instrument manifolds (not direct mounted) Note: Direct manifold mounting to the instrument is preferred.	6 mm OD with minimum wall thickness of 1 mm as flex lines (less than 900 mm length).

* Minimum carbon content of 0.04 percent (0.04%) required when temperatures are greater than 538 °C.

5.2.5 MISCELLANEOUS BRANCH AND INSTRUMENT CONNECTIONS

The branch, pipe tap, and instrument connection sizes listed in Table 5.2.5-1 (Branch and Instrument Connections) shall be used on the main line and through the root/isolation valve for all systems.

Table 5.2.5-1
Branch and Instrument Connections

System	Service	Tap Size/Type
All Systems (except as below)	Vents, drains, test connections	25 mm NPS, socket weld
	Pressure connections	25 mm NPS, socket weld
	Temperature connections	25 mm NPS, threadolets
	Level switch connections	25 mm NPS, socket weld
	Level transmitter connections	50 mm NPS, socket weld, varies
	Sample connections	25 mm NPS, socket weld
	Orifice flange connections	12 mm NPS, threaded
	Flow nozzle connections	25 mm NPS, socket weld
	Chemical injection	25 mm NPS, socket weld
All Steam Systems and Feedwater	Temperature connections	40 mm inch NPS
	All others	Refer to above
Circulating Water	Drain connections (water box drains)	100 mm NPS, FF flanged*
	All others	50 mm NPS, FF flanged*
Air and Flue Ducting	All connections	50 mm NPS, threaded half couplings**

* 75 mm NPS or larger required for rubber lined piping greater than or equal to 900 mm.
** For coal fired plants, the arrangement shall include plugged cleanout port for all pressure connections.

5.2.6 SEAM WELDED PIPE

Seam welded pipe may be used in the applications listed in Table 5.2.6-1 (Seam Welded Pipe), or where seamless pipe is not available.

Table 5.2.6-1
Seam Welded Pipe

System /Application	Limitations
Stainless Steel, Steam, and Water Applications	No limitations where design complies with ASME B31.1.
Carbon Steel, Steam, and Water Applications with Low Corrosion Potential	Class 300 systems and lower (no alloy). No slurry or wastewater applications.

5.2.7 VENT AND DRAIN PIPING DESIGN CRITERIA

Vent and drain piping shall generally be in accordance with the following criteria:

1) Vent and drain piping size and schedule through the isolation valve to the vent or drain line termination shall be as described for miscellaneous piping.
2) Vent connections shall be provided at all high points in water piping, and all high points in other piping including steam lines, which shall be hydrostatically tested.
3) Drain connections shall be provided at all non-drainable points in major steam and water, piping, and all other piping which shall be hydrostatically tested.
4) Drain connections shall be provided at control valve stations between the inlet isolation valve and the control valve, especially in high-pressure or high temperature service.
5) All vent and drain connections for liquid filled systems shall be provided with isolation valves. All vents and drains with CL 600 isolation valves shall use gate valves. All vents and drains utilizing CL 1500 and above isolation valves shall use Y-pattern globes.
6) Plug valves or diaphragm valves shall be used for all slurry vent and drain applications.
7) Vent and drain connections that require frequent operation or which may discharge significant quantities of fluid shall be piped to a suitable drain. Vent or drain connections that shall normally require operation at a time when hot fluids shall be discharged shall be piped to a safe termination point (drain funnel or floor area discharge).
8) All HP/IP vent and drain systems shall be provided with double isolating valves.

5.2.8 FITTING MATERIALS

Fittings shall be constructed of materials equivalent to the pipe with which they are used, except for polypropylene lined cast iron or ductile iron fittings which shall be used with polypropylene lined steel pipe, and rubber lined cast iron or ductile iron fittings which shall be used with rubber lined steel pipe:

Steel Fittings: Steel fittings 65 mm and larger shall be of the butt welding type and steel fittings 50 mm and smaller shall be of the socket welding type.

Butt Welding Fittings: The wall thicknesses of butt welding fittings shall be equal to the pipe wall thickness with which they are used. The fittings shall be manufactured in accordance with ANSI B16.9, ANSI B16.28, and ASTM A234 or ASTM A403.

Forged Steel Fittings: Forged steel fittings shall be used for socket-weld and steel threaded connections and shall conform to ANSI B16.11. The metal thicknesses in the fittings shall be adequate to provide actual bursting strengths equal to or greater than those of the pipe with which they are used.

Forged steel socket-weld and threaded fittings shall have the minimum class rating described in Table 5.2.8-1 (Forged Steel Fittings Minimum Class Ratings) below. All welded fittings shall be of the same material as the pipe.

Table 5.2.8-1
Forged Steel Fittings Minimum Class Ratings

	Fitting Type	
Pipe Wall Thickness	**Threaded**	**Socket Welded**
Schedule 80 or less	3,000	3,000
Over Schedule 80 to Schedule 160	3,000	6,000
Over Schedule 160 to Schedule XXS	6,000	9,000
Over Schedule XXS (Minimum Wall Pipe)	Engineered fittings only.	Engineered fittings only.

Integrally reinforced branch fittings (such as o-lets and pipettes) shall have the minimum class rating described in Table 5.2.8-2 (Integrally Reinforced Branch Fittings Minimum Class Ratings) below. All welded fittings shall be of the same material as the header pipe. Fittings between dissimilar branch/header materials shall be considered on a case-by-case basis. The Contractor shall provide the fabricator’s calculations to verify suitability.

Table 5.2.8-2
Integrally Reinforced Branch Fittings Minimum Class Ratings

	Fitting Type	
Pipe Wall Thickness	**Threaded**	**Socket Welded**
Schedule 80 or Less	3,000	3,000
Over Schedule 80 to Schedule 160	6,000	6,000
Over Schedule 160 to Schedule XXS	9,000*	9,000
Over Schedule XXS (Minimum Wall Pipe)	Engineered fittings only.	Engineered fittings only.
*The Contractor must verify with the fitting supplier that the class is suitable for the application.		

Cast Steel Flanged Fittings: Cast carbon steel flanged fittings shall conform to ANSI B16.5 and shall be of materials conforming to ASTM A216 WCB.

Adapters: Reducing outlet tees should be used in lieu of specially designed adapters for branch piping 65 mm and larger whenever possible. Specially designed adapters may be used in lieu of reducing outlet tees if standard reducing outlet tees are not available for the run and branch sizes specified. Specially designed adapters must be post weld heat treated as specified in ASME B31.1.

Branch connections 50 mm and smaller shall be made with special reinforced welding adapters or shall be special welded and drilled pads.

Ductile Iron Fittings: Mechanical joint or push-on joint ductile iron fittings shall conform to ANSI/AWWA C110/A21.10 and ANSI/AWWA C111/A21.11. Flanged ductile iron fittings shall conform to ANSI/AWWA C110/A21.10.

Cast Iron Fittings: Cast iron fittings shall conform to ASTM A126, Class B.

Lined Pipe Fittings: Fittings used with lined pipe shall be lined with the same material as the pipe with which they are used.

Brass and Bronze Fittings: Screwed brass and bronze pipe fittings shall conform to ANSI B16.15.

Flanged brass and bronze pipe fittings shall conform to ANSI B16.24.

Fiberglass Reinforced Plastic (FRP) Fittings: Fittings for use with FRP pipe shall be manufactured from material of the same type as the pipe. Joints shall be as required by the application. Filament wound or molded fittings shall be used as required by the application.

Polyvinyl Chloride (PVC) Fittings: PVC pipe fittings shall be manufactured from PVC material of the same type as the pipe with which they are used. The fittings shall have socket ends with internal shoulders designed for solvent cementing.

Chlorinated Polyvinyl Chloride (CPVC) Fittings: CPVC pipe fittings shall be manufactured from CPVC material of the same type as the pipe with which they are used. The fittings shall have socket ends with internal shoulders designed for solvent cementing.

High Density Polyethylene (HDPE) Fittings: HDPE pipe fittings shall be manufactured from HDPE material of the same type as the pipe with which they are used. Joints shall be as required by the application.

Tubing Fittings: Brass fittings shall be used with ASTM B75 copper tubing, and shall be of the flareless "bite" type. Braze joint fittings shall be used with ASTM B88 Type K copper tubing and shall be wrought copper, bronze, or brass, conforming to ANSI B16.22.

Stainless steel fittings shall be used with stainless steel tubing. Fittings for use with stainless steel tubing in sizes smaller than 20 mm shall be of the flareless "bite" type. Fittings for use with tubing in sizes 20 mm and larger shall be socket-weld type conforming in general design to ANSI B16.11. Fitting material and bursting strength shall be equivalent to the tubing with which they are used.

5.2.9 FLANGES, GASKETS, AND UNIONS

Flanges mating with flanges on piping, valves, and equipment shall be of sizes, drillings, and facings which match the connecting flanges of the piping, valves, and equipment.

Flange class ratings shall be adequate to meet the design pressure and temperature values specified for the piping with which they are used.

Flanges shall be constructed of materials equivalent to the pipe with which they are used.

Flanges for orifices shall be of the orifice flange type.

Flanges shall be as described in Table 5.2.9-1 (Flanges) below.

Table 5.2.9-1
Flanges

System /Application	Limitations
Flanges, nonmetallic with metallic backing ring	Flat faced slip-on or socket weld for thermal or solvent welding.
Flanges, cast iron or steel, to mate with nonmetallic flange	Flat faced slip-on type or threaded, in accordance with ANSI B16.5.
Flanges 150 class	Raised face weld neck, socket weld (50 mm and smaller) or slip-on type, in accordance with B16.5.
Flanges 300 class and higher	Raised face weld neck type only in accordance with B16.5.
Grooved pipe joints	Rolled or cut grooved joints in accordance with AWWA C-606 (rolled grooves preferred).
Crimp type joints	Pressfit system only.

Gaskets containing asbestos shall not be used. Gaskets shall be suitable for the design pressures and temperatures.

Gaskets shall be as described in Table 5.2.9-2 (Gaskets) below. Some chemical and glycol systems may require the use of different gasket materials.

Table 5.2.9-2
Gaskets

Joint	Gasket	Gasket Limitations
Class 150 SW Flanges and RFSO Flanges	2 mm compressed fiber type. Non-asbestos.	Class 150 systems or lower. (Within temperature limits of gasket material.)
FF Flanges, Nonmetallic Flanges, and Cast Iron Flanges	3 mm red rubber type (EPDM for hot service)	With backing rings as needed. (Up to 65 °C only; above 65 °C to 102 °C use EPDM.)
RF Flanges (except as above)	Spiral wound type. Non-asbestos.	--
“Press-Fit” Joints	EPDM (water) or nitrile (air) O-ring	Cold air and water systems (less than or equal to 102 °C and less than or equal to 2 MPa).
Grooved Pipe Joints	EPDM (water) or nitrile (air) rubber	Cold air and water systems (less than or equal to 102 °C and less than or equal to 2 MPa).
Bell and Spigot CI and DI	EPDM rubber	Gravity drains less than or equal to 102 °C and roof conduits.
Mechanical Joints and Bell and Spigot CI and DI with restrained joints.	EPDM rubber	Cold water systems (less than or equal to 102 °C and less than or equal to 2 MPa).

Piping unions shall be of the ground joint type constructed of materials equivalent in alloy composition and strength to other fittings in the piping systems in which they are installed. Union class ratings and end connections shall be the same as the fittings in the piping systems in which they are installed.

5.2.10 STUDS, NUTS, AND BOLTS

Flange studs, nuts, and bolts shall be as described in Table 5.2.10-1 (Stud, Nuts, Bolts) below. Stainless steel bolting shall not be used.

Table 5.2.10-1
Studs, Nuts, Bolts

Application	Studs/Nuts/Bolts
Alloy bolting for pipe design temperature greater than or equal to 413°C, Class 150 flanges or higher (except SO flanges), including SS	ASTM A193/A193M Grade B16 studs, electroplated cadmium; ASTM A194/A194M Grade 3 nuts, electroplated cadmium
Alloy bolting for pipe design temperature less than 413 °C including SS	ASTM A193/A193M Grade B7 studs, electroplated cadmium; ASTM A194/A194M Grade 2H nuts, electroplated cadmium
Carbon steel bolting for slip-on flanges, cast iron flanges, non-metallic flanges, and flanges less than Class 150	ASTM A307 Grade B bolts or studs, mechanically deposited zinc coated ASTM A563 Grade A heavy hex nuts, mechanically deposited zinc coated

5.2.11 CATHODIC PROTECTION

Underground metallic piping (except ductile iron) condenser, tanks and other applicable areas shall be cathodically protected and electrically isolated. Typical methods include coatings, galvanic anodes, impressed current systems, sacrificial anode system, isolation flanges, and combinations thereof. A cathodic protection plan shall be established for underground pipe. Ductile iron pipe will not be protected, because of its inherent corrosion resistant characteristics, unless water migration is probable. In this case, polyethylene bags shall be installed over the ductile iron pipe.

5.2.12 INSPECTION AND TESTING

Inspection and testing of piping shall be performed in accordance with the requirements of the applicable Laws and codes, and in accordance with the following criteria.

Pressure testing of piping assemblies, including hydrostatic, pneumatic, and in-service leak testing, shall be performed on the system assemblies upon the completion of erection. Shop leak testing of piping shall not be required. All underground piping shall be tested before the line is covered, except for large circulating water systems, which may use internal visual test methods or testable joints and may be buried before such verification. Testing shall be performed in accordance with the following methods:

a. Hydrostatic testing of all piping, except as otherwise discussed herein or for which a pneumatic leak test shall be provided, shall be performed with cold water at 1.5 times the design pressure of the piping. This shall generally include the following piping:

   i. Boiler external piping hydrostatically tested with the boiler, including main steam, boiler vents and drains, instrument piping to the second root valve, and economizer feedwater inlet piping.
   ii. Auxiliary steam.
   iii. Boiler feed pump discharge to economizer inlet, including superheat and reheat desuperheater piping.
   iv. All underground piping except fuel oil or air piping.

b. Temporary piping for use only during construction (including temporary blowout piping) shall not be hydrostatically tested.
c. Piping that shall be hydrostatically tested, but which would be adversely affected by rust, shall be tested with chemically treated water. After the completion of testing and acceptance, the piping shall be completely dewatered and dried. This shall generally include high-pressure (design pressure above 1.03 MPa) systems requiring a high degree of cleanliness.
d. Circulating Water: Testable joints: low-pressure pneumatic verification; welded joints: internal visual inspection only; other joints: hydrostatic test at 1.3 times design pressure; above grade: initial service test.
e. Pneumatic testing shall be provided for all pressure piping that should not be subject to water filling. This shall generally include the following piping:
   i. Lube oil piping.
   ii. Fuel oil piping.
   iii. Low-pressure (design pressure less than or equal to 1.03 MPa compressed gas piping conveying natural gas, hydrogen, carbon dioxide, nitrogen, welding (MAPP) gas, anhydrous Ammonia, SO_2, and Cl.
   iv. Station air and control air piping.
f. Leak tolerances in instrument primary piping shall be determined in conformance with ISA Tentative Recommended Practice RP-7.1.
g. Instruments shall be carefully protected against overpressure during testing of piping.
h. In-service leak testing shall be performed for all pressure piping that is not hydrostatically or pneumatically tested by tests that are in full accordance with the applicable code.

Non-destructive testing of piping shall be performed in accordance with the applicable Laws and codes.

5.3 PIPE SUPPORTS AND HANGERS

The term "pipe supports" includes all assemblies such as hangers, floorstands, anchors, guides, brackets, sway braces, vibration dampeners, positioners, and any supplementary steel required to attach pipe supports.

Structure attachment components shall be fastened by welding or bolting. Pipe supports shall be attached to concrete by cast-in-place anchor bolts, studs, or plates. Where it is not practical to cast bolts, studs, or plates into the concrete, post-installed mechanical anchor bolts shall be used. Post-installed mechanical bolts shall in accordance with Federal Specification A-A-1923A Type 4, and Appendix A of the American Concrete Institute (ACI). The minimum thickness of cast-in-place steel plate bearing against concrete shall be as follows:

Supported Nominal Pipe Size, mm	Plate Thickness, mm
100 and smaller	6
150	10
200	12
250 through 450	19
500 and larger	25

Supplementary support beams, required for attachment of supports to building structure, shall be attached by means of clip angles. Clip angles shall be designed for welding to the building structure beams or columns. Clip angles shall conform to "Framed Beam Connections" as shown in the latest American Institute of Steel Construction, Inc. (AISC) Manual of Steel Construction. Clip angles shall be sized to match support beam strength. Clip angles may be securely attached by bolting to the beam for installation ease. Bolting shall be through elongated holes in the beam web. Permanent attachment of clip angles shall be by field welding.

Pipe attachments shall generally be pipe clamps or lugs. Pipe attachments shall be rigid relative to the piping and insulation and shall extend sufficiently outside insulation, if any, to permit free installation and operation of other support components. Insulation saddles, securely attached by welding or bolted clamps, shall be used where required to prevent damage to insulation. For piping other than steel or iron, the piping manufacturer's recommendations shall be followed.

Material for clamps, lugs, bolts, studs, and nuts shall be carbon steel for piping 400 °C or less, and shall be alloy steel for piping more than 400 °C. Alloy clamps shall be hot-forged and stress-relieved after forming.

Piping attachments for non-metallic pipe shall meet the following minimum requirements:

1. The minimum recommendations of the piping manufacturer shall be met or exceeded.
2. Piping attachments shall not bear load by a point. Their width shall equal or exceed the square root of the outside diameter of the piping, and they shall bear around 120 degrees or more of the circumference.
3. In general, clamps shall not be clamped tight and hard on the piping. Where piping attachment must grip the piping by clamping, a soft, Shore 50-60 rubber pad shall be provided between the clamp and the piping, and the clamp shall be formed to fit the padding.

Riser clamps that attach to rigid rods shall be designed such that all of the applicable load can be transferred to one side of the riser clamp. Likewise, spring supported riser clamps that are to be pinned during testing shall be designed such that all of the test load can be transferred to one side of the clamp.

The top surface of riser clamps shall be flat and normal to the pipe.

Riser lugs shall be sized in accordance with Welding Research Council Bulletin No. 198 and the requirements of ANSI/ASME B31.1.

Trapezes shall be constructed from structural tubing channel, angle, wide flange beams, or from double channels positioned back-to-back with space between for the hanger rods and with washer plates welded to channel tops and bottoms. Washer plates shall be used at all hanger rod attachment points.

Hanger rods shall be constructed of solid round steel bars or continuously threaded rod. Maximum allowable stress in a rod shall be 62.1 MPa average at the thread root cross-sectional area, or 82.8 MPa in non-threaded rods. Pipe, strap, chain, or other similar materials shall not be permitted in place of rods. Eye rods shall have fully and neatly welded eyes. Cross-sectional area and strength of the eye weld must be equal to, or greater than, the cross-sectional area and strength of the rod.

Screw threads shall be in conformance with ANSI/ASME B1.1. Stress areas for threaded rods shall be equal to, or larger than, the following American National Standard Unified Inch Screw Thread Series:

Nominal Rod Diameter, mm	Thread Series
9.5 through 101.6	UNC
108 and larger	4 UN

When an eye rod with a rod diameter in excess of 65 mm is required, a forged eye or welded plate eye may be substituted for a welded eye. The forged or welded plate eye, and the weld attaching the plate eye, shall be equal to, or greater than, the cross-sectional area and strength of the rod.

Where piping moves significantly or operates at 148.9 °C or more, swivel connections shall be provided at both ends of rods. Swivel connections minimize rod bending and allow, without binding, at least 5 degrees sway in all directions from the vertical position. Special arrangements, such as rockers, shall be provided as required to keep total combined stress in the rod from exceeding 18,000 psi when swinging.

Forged steel turnbuckles or welded steel turnbuckles shall be provided near the center of rod assemblies unless the arrangement provides other means of vertical adjustment under load. Steel turnbuckles shall be used to couple long rods. Turnbuckles and other threaded adjustment components shall be provided with locknuts.

Spring assemblies shall be enclosed and shall have a load and position indicator scale. Counterweight supports shall not be used. All spring assemblies shall be stamped with "H" at hot (operating) position and "C" at cold (ambient) position on the load and position indicator. Spring assemblies which support the pipe by use of an intermediate rod shall incorporate an adjustable rod coupling or turnbuckle with locknut. Spring assemblies shall be suitable for inside or outside installation. A field adjustment feature for varying support effort shall be provided on spring assemblies.

Variable support spring supporting effort at cold position shall be within 25 percent (25%) of design operating pipe load.
Constant support springs shall have a total travel range of at least 20 percent (20%) greater, but not less than 25 mm greater, than design travel. Supporting effort shall not vary more than plus or minus 6 percent (6%) throughout the travel range. This tolerance shall also apply after any field adjustment of supporting effort.

Bearing surfaces are grouped into two general categories: (1) high friction bearing surfaces, and (2) low friction bearing surfaces. High friction bearing surfaces typically consist of flat, sliding bases. Low friction bearing surfaces typically consist of roller bearings, ball bearings, graphite plates, lubricating metals such as "Oilite," or plastics such as Teflon.

High friction bearing surfaces shall have a maximum dry static coefficient of friction of 0.333. Rubbing surfaces shall be hard and smooth, of either steel or cast iron. The surfaces shall be free of burrs or other projections. A coat of lubricating grease shall be either shop or field applied to the surfaces. Where lubricant is field applied, lubricating material shall be shipped in separate container to the construction facility. Lubricating grease shall be a water insoluble type, suitable for the pressures and temperatures involved. Grease shall be synthetic silicone, barium, or lithium base, with fillers or additives such as natural graphite or molybdenum-disulfide.

Low friction bearing surfaces shall have a maximum static coefficient of friction of 0.100.

Bolting shall consist of either studs and nuts or bolts and nuts. Threaded ends of studs or bolts shall not extend more than one diameter beyond the nut. The minimum thread engagement shall be 100 percent (100%) of the nut thread. Nuts for each stud shall be installed equidistant from the ends of the stud. Middle portions of studs and shank portions of bolts shall not be threaded. Bolt heads and nuts shall be hexagonal type, conforming to ANSI B18.2. Where no axial load is to be carried, pins with washers and cotter pin retainers shall be permitted in place of bolts.

Restraints, struts, and anchors shall have the following features:

1. Restraints fabricated of structural steel shall have a clearance of 3 mm, with respect to the restrained component, in the directions of the restrained movement.
2. All restraints shall be designed to withstand the static and kinematic friction due to relative movement of the pipe with respect to the restraints.
3. All restraints and anchors shall withstand the design loading indicated without buckling.
4. The strut design shall provide for easy field adjustment of at least plus or minus 65 mm after erection and while supporting the load.
5. Spherical ball joints, permitting a minimum of 10 degrees of angular rotation in any plane, shall be provided at the ends of struts unless specified otherwise.
6. All struts shall be provided with means for locking the length adjustment. The length adjustment lock shall be on the right-hand thread end, if both right- and left-hand threads are used.

Shock and sway suppressers used in absorbing thrust loads associated with relief valve discharge, water hammer, turbine trip, seismic or other causes shall be as specified herein.
Hydraulic shock and sway suppressors specified to resist the single direction thrust of safety relief valves shall be designed by the manufacturer for a bleed rate necessary to limit displacements to 6 mm during the complete load duration.

Selected components of major load carrying supports shall be shop inspected for cracks and other defects. Inspections shall be in the form of magnetic particle. Inspection shall be made after parts have been formed, cut, or welded to final shape. Any part showing a defect by this test shall be either rejected or shall be repaired by welding. Repaired alloy parts shall be stress relieved after welding. Any repaired parts shall be retested.

Parts to be tested shall include, but are not necessarily limited to, the following:

1. Riser clamps or sleeves.
2. Bolts and studs under tensile loads.
3. Rods, including the eye if any.
4. Rod clevises.
5. Pins.
6. Welding lugs.
7. Portions of beams that shall be stressed to one third (1/3) or more of the maximum allowable bending stress.
8. Structural attachment clip angles.

Exposed components of shop fabricated pipe supports shall be shop painted before shipment to the jobsite. Each individual pipe support component shall be painted using the coating system that is applicable for the maximum temperature of that component. Before painting, surfaces shall be suitably cleaned and prepared in accordance with the paint manufacturer's instructions. Bearing surfaces and nameplates shall not be painted. These surfaces shall be coated with an easily removable rust-preventive compound. Sliding surfaces and threads shall not be painted, but shall be properly lubricated.

5.3.1 PIPE SUPPORT AND HANGER MATERIALS

Support component materials shall be suitable for service at the operating temperature of the pipe to which they are attached. Where support component temperature is below 399 °C, component material shall be carbon steel or of an ASTM type having minimum yield strength of 241 MPa, and a minimum ultimate strength of 400 MPa. Where support component temperature exceeds 399 °C, they shall be fabricated from materials having physical properties equal to or better than the following. These material requirements apply to parts that are wholly, or partially, within 230 mm of the outside of the pipe, including further extension of the part until it is completed:

Material nominally 2.25 percent chromium, 1 percent molybdenum	
Plate	ASTM A387 Grade 22, Class 1
Pipe	ASTM A335 Grade P22

Material nominally 1 percent chromium, 0.25 percent molybdenum	
Bolts, studs, and rod	ASTM A193 Grade B7
Nuts	ASTM A194 Grade 7

On copper piping or tubing, the pipe clamp shall be of copper or copper-plated steel.

Supports shall be of fireproof construction; no combustible materials shall be used. Malleable iron materials shall not be allowed.

Miscellaneous support beams required for attaching supports to the building structure shall conform to ASTM A36.

5.4 VALVES

Valve pressure classes, sizes, types, body materials, and end preparations shall generally be as described herein. Special features and special application valves shall be utilized where required.

All valves shall be furnished with individual name tags to identify the valve tag name and service description. All supplied valves shall be tagged according to the Project's designated tagging system.

Valves specified to have flanged, socket-welded, or screwed connections shall have ends prepared in accordance with the applicable ANSI/ASME standards. Steel flanges shall be raised face type unless otherwise required. Cast iron and bronze flanges shall be flat faced type. Butt welding ends shall be prepared in accordance with ANSI/ASME B16.25 and ANSI/ASME B31.1.

Steel body gate, globe, angle, and check valves shall be designed and constructed in accordance with ANSI/ASME B16.34 as applicable. Valve bodies and bonnets shall be designed to support the valve operators (handwheel, gear, or motor) with the valve in any position, without external support.

5.4.1 STEEL BODY VALVES 50 MM AND SMALLER

Steel body valves 50 mm and smaller shall have forged steel bodies. Forged steel valves complying with the standards and specifications listed in Table 126.1 of ANSI/ASME B31.1 shall be used within the manufacturer's specified pressure temperature ratings and shall be limited in accordance with the pressure temperature ratings specified in ANSI/ASME B16.34:

1. Class 1500, 2500 and 4500 globe valves shall be of the Y-pattern type, unless specific design conditions dictate otherwise.
2. Valve ends shall be socket-weld type unless otherwise required.

Except as otherwise required, check valves shall be of the guided piston or swing disk type. All check valves shall be designed for installation in either horizontal piping or vertical piping with upward flow.

5.4.2 STEEL BODY VALVES 65 MM AND LARGER

Steel body valves 65 mm and larger shall have cast or forged steel bodies. The face-to-face and end-to-end dimensions shall conform to ANSI/ASME B16.10. The use of these valves shall be in accordance with the pressure temperature ratings specified in ANSI/ASME B16.34 as applicable:

Body ends shall be butt weld type unless otherwise required.

Check valves used on pump discharge installations, and on other applications in which the valves may be subjected to significant reverse flow water hammer or fluid surges, shall be of the nonslam tilting disk type. All other check valves shall be of the guided piston, swing disk, or double disk spring check type. The use of double disk spring check valves shall be limited to cold water services. All check valves shall be designed for installation in either horizontal or vertical piping with upward flow. Stop check valves, where specified, shall be Y-pattern globe type.

5.4.3 IRON BODY VALVES

Iron body gate, globe, and check valves shall have iron bodies. The face-to-face dimensions shall be in accordance with ANSI/ASME B16.10. These valves shall have flanged bonnet joints. Gate and globe valves shall be of the outside screw and yoke construction. Gate valves 100 mm and larger shall be of the wedge disk type. Lined cast iron body diaphragm and check valves used with lined piping shall be flanged body with liner and diaphragm material suitable for the service.

5.4.4 BUTTERFLY VALVES

Rubber-seated butterfly valves shall be generally constructed in accordance with AWWA C504 Standard for Rubber-Seated Butterfly Valves. The valves shall also generally conform to the requirements of MSS Standard Practice SP-67, Butterfly Valves. Valves of the wafer or lug-wafer type shall be designed for installation between two ANSI flanges. Valves with flanged ends shall be faced and drilled in accordance with ANSI/ASME B16.1. The selected use of butterfly valves shall be in accordance with the pressure temperature ratings specified in AWWA C504, the pressure temperature ratings specified by the manufacturer, and as specified in the following criteria:

1. Butterfly valves shall generally be used for 100 mm and larger cold water services only.
2. Butterfly valves for buried service shall be of cast iron body material and shall be equipped with flanged ends.
3. Cast iron butterfly valves shall have pressure classes selected based on the piping design pressure as follows:

Piping Design Pressure	Valve Class
172 kPa and below	Class 25

Above 172 kPa to 517 kPa	Class 75
Above 517kPa to 1.03 MPa	Class 150

1. Cast iron butterfly valves shall be limited to use with piping systems having a design temperature of 52°C or less.
2. Butterfly valves for other than buried service shall be of carbon steel or cast iron body material depending on the service application. Valves 600 mm and larger in size shall be equipped with flanged ends. Valves 500 mm and smaller in size shall be of the wafer type, or lugwafer type, if used with steel or alloy steel piping, and shall be flanged if used with other piping materials including, but not limited to cast iron, ductile iron, FRP, PVC.
3. Carbon steel butterfly valves shall be limited to use with piping systems having a design temperature of 65.6°C or less. Carbon steel butterfly valves shall have pressure classes selected in accordance with the pressure temperature ratings specified in ANSI/ASME B16.34 for 600 mm and smaller valves. Valves 750 mm and larger in size shall be selected and specified based on the piping design pressure and temperature, without reference to a specific pressure class.
4. Metal seated or teflon seal ring seated butterfly valves for special service applications shall be of the wafer or lug-wafer type and shall be designed for installation between ANSI flanges. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer.

The table below indicates where radiographic examination shall be performed on castings in accordance with the requirements in ANSI/ ASME B16.34, Paragraph 8.3.1.1(a)(1). In addition, any components which contain a hazardous or flammable/combustible fluid shall also be inspected in accordance with these requirements. Any defects found in these examinations shall be documented in a non-conformance report and submitted to the Employer prior to repair or acceptance of the affected casting part.

Size - NPT	**Press. Class**	**Design Temp**	**NDE Sample**	**Acceptance Criteria**
>50 mm	All	>=750F	100%	B16.34, Para 8.
>50 mm	>300#	>=350F	100%	B16.34, Para 8.

5.4.5 BRONZE BODY VALVES

Bronze valves shall have braze joint or compression fitting type end connections when used in copper sipping or copper tubing systems, and shall have threaded end connections when used in steel piping systems. Gate valves shall be inside screw, rising stem type with solid wedge disks. Globe valves shall have renewable seats and disks.

Bronze check valves 50 mm and smaller shall be Y-pattern swing disk type or guided piston type designed for satisfactory operation in both horizontal piping and vertical piping with upward flow.

The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer and in accordance with the criteria established in MSS SP-80. Bronze valves shall generally be Class 200, and shall be limited to service with piping systems having design pressures of 29 kPaG or less, and design temperatures of 65.6 °C or less.

Bronze valves shall generally be limited to a size of 75 mm or less.

5.4.6 PLUG VALVES

Plug valves shall be of the lubricated type, shall have short pattern bodies, and unless otherwise specified, shall have flanged ends. Plug valve bodies shall conform to the requirements of ANSI for dimensions, material thicknesses, and material specifications. Bonnets shall be of the bolted flange type. Body ends shall be flanged, faced, and drilled for installation between ANSI flanges. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer.

Worm geared operators with handwheels shall be provided on all valves 150 mm and larger. The gearing shall be enclosed in a suitable housing. Each valve smaller than 150 mm shall be provided with an operating wrench. All lubricant fittings and injectors required for introduction of plug lubricant shall be supplied with each valve.

5.4.7 BALL VALVES

All ball valves shall have full area ports, teflon seats and seals, and chrome plated carbon steel or stainless steel balls. Ball valve bodies 50 mm and smaller shall have threaded end or socket-weld connections. Ball valves 65 mm and larger shall have flanged ends. The valves shall not require lubrication. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer. Ball valves for use with copper piping shall have brazed or screwed ends.

All ball vales in fuel handling service shall be of fire safe design and use secondary metal seating surfaces to ensure shutoff if the Teflon seats are destroyed by fire.

5.4.8 DIAPHRAGM VALVES

Diaphragm valves shall be weir bodies with flanged ends faced and drilled for installation between ANSI flanges. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer.

5.4.9 POLYVINYL CHLORIDE (PVC) AND CHLORINATED POLYVINYL CHLORIDE (CPVC) VALVES

PVC and CPVC valves shall be constructed entirely from Polyvinyl Chloride, Chlorinated Polyvinyl Chloride, and teflon. Valve bodies shall be double entry flanged or true union screwed type. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer of such valves.

5.4.10 VALVE MATERIALS

Valve bodies shall generally be constructed of materials equivalent to the pipe with which they are used. Valve body and trim materials of construction shall be in accordance with applicable Laws and codes in particular ASTM and AISI standards.

The main cycle system valves shall be free of copper materials to allow the cycle to be treated at the optimum pH for corrosion protection of carbon steel components.

Valve body materials shall generally be as follows:

Material Name	Description	
	Forged	**Cast**
Cast Iron	ASTM A126 Class B	
Bronze	ASTM B61 or ASTM B62	
Carbon Steel	ASTM A105	ASTM A216 Grade WCB
1.25 Percent Chromium Alloy Steel	ASTM A182 Grade F11	ASTM A217 Grade WC6
2.25 Percent Chromium or 9 Percent Chromium Alloy Steel	ASTM A182 Grade F22	ASTM A217 Grade WC9
5 Percent Chromium Alloy Steel	ASTM A182 Grade F5	ASTM A217 Grade C5
Stainless Steel	ASTM A182 Grade F316	ASTM A351 Grade CF8M
Alloy 20		

5.4.11 VALVE OPERATORS

Valves shall be provided with manual or automatic operators as required for the service application and system control philosophy. Automatic operators shall be motor, piston, or diaphragm type. All manual valve operators (including chain wheel operators) requiring frequent operation and control valves shall be accessible from grade or from a platform. Please refer to sub-clause 6.7 of Chapter 6 (Electric Motors) for further details on motor operators.

Manual operators shall be lever, handwheel, or gear type, with the use of lever operators to be limited to valves requiring a maximum of 90-degree stem rotation from full open to full closed position on valve sizes 150 mm and smaller. All operators shall be sized to operate the valve with the valve exposed to maximum differential pressure.

The use of gearing for manually operated valves will generally be as follows.

Valve Class	Valve Size
Up to 300	300 mm and larger
400 and 600	150 mm and larger
900 and larger	100 mm and larger

5.4.12 BRANCH LINE ISOLATION VALVES

Double isolation valves shall be provided in 50 mm and smaller branch lines from main piping headers and equipment in accordance with the relevant code requirements.

Valves shall be installed as follows:

1. The portion of the branch line containing the two (2) valves shall be installed parallel to the main line.
2. Except for drains, the connection on the main line should not be on the bottom of the main line.
3. A support shall be furnished from the main line to the branch line located so that the two valves are supported between the main line connection and the support. The support shall be flexible in design to permit differential expansion.

Branch lines not requiring double isolation valves shall be provided with single isolation valves.

5.4.13 VALVE SPECIAL FEATURES

Valves shall be provided with locking devices, handwheel extensions, vacuum service packings, limit switches, and other special features as required. Locking devices, when furnished, shall allow the valve to be locked either open or closed with a standard padlock. Limit switches, when furnished, shall be provided for the open and closed position of the valve.

All valve bonnets for valves potentially exposed to high temperatures shall be provided with bonnet relief valves. The relief valves shall prevent the bonnets from being exposed to excessive pressure when the bonnet is full of water and the valve is exposed to elevated temperatures.

Valves shall not be equipped with bypasses unless specifically required.

5.4.14 SAFETY VALVES

The total discharge capacity of safety valves arranged on the superheater shall be larger than the maximum continuous evaporation capacity of the boiler, and the total discharge capacity of safety valves arranged at inlet and outlet of the reheater shall be larger than the maximum design flow of the re-heater.

Sufficient safety valves shall be arranged in accordance with the requirements set out in the Supervision Code for Boiler and Pressure Vessel of the Power Industry.

Compressed air storage tank should be provided with a safety valve and arranged in the shade outdoor.

In the hydrogen supply station, hydrogen tank shall be provided with a pressure meter and a safety-relief device (safety valve). A nitrogen flushing and replacinginterface should also be arranged.

5.5 PRESSURE VESSELS

Performance and design requirements shall be as required by the system design, in accordance with other applicable specification sections or standards, and as required by the Contractor’s design.

5.5.1 SHOP FABRICATED TANKS

The tank design and fabrication shall be in accordance with ASME Boiler and Pressure Vessel Code Section VIII Division 1, American Petroleum Institute Standard 12F, American Petroleum Institute Standard 650, Special Normal and Emergency Vents - Underwriters Laboratories Inc. Standard UL 142, Underwriters Laboratories Inc. Standard UL 58, and Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations 1970.

5.5.2 TEST REQUIREMENTS

Tanks shall be hydrostatically tested and radiographic examination performed in accordance with ASME Boiler and Pressure Vessel Code Section VIII.

Pressure or leak test reports shall be provided for each tank. All testing shall be conducted by the Contractor.

5.5.3 MATERIALS

The selection of materials for construction of pressure containing parts and their integral attachments shall take into account the suitability of the material with regard to fabrication and to the conditions under which it will operate.

5.5.4 CONSTRUCTION

All tanks shall be of the all-welded construction and shall all have lifting lugs.

The metal thickness of tank dished heads shall not be less than the shell thickness. The flat heads, shell, and partition plates of all tanks with flat surfaces shall be stiffened. Internal stiffeners shall be of the smooth, formed, structural shape type, continuously welded to the flat surfaces. Internal stiffeners shall be of the same material as the tank shell.

Stiffening shall be sufficient to prevent waves and bellying of flat surfaces with the tank full to capacity. Skirt supported tanks shall have all skirt access openings reinforced and pipe penetrations sleeved. Tank supports for horizontal tanks shall be rigid box frame saddle type supports. All welds shall be continuous; stitch welding shall not be used. All welds and cut edges shall be ground smooth to facilitate external coating requirements.

Tanks with incoming flashing drains shall have replaceable impact plates made from a suitable erosion resistant stainless steel.

Manholes and handholes for pressurized tanks shall be of the internal pressure seal, boiler drum type, utilizing yokes and internal hinges. All manhole and handhole covers shall be machine faced.

Atmospheric tanks shall be provided with the manufacturer's standard hinged manholes. Eyebolts, wing nuts, cover stops, and all other metal parts of the manhole cover assembly shall be carbon steel.

Two (2) sets of permanent gaskets for all manholes, handholes, and blind flanges shall be furnished.

Access ladders, walkways, and platforms shall be provided as needed for adequate access to tank instruments, connections, and manholes.

Tanks furnished with partition plates shall be designed so that the partition and tank are capable of withstanding the forces which result when one (1) section of the tank is full while the other section is empty.

Each flanged nozzle and fitting shall be supplied complete with one set of bolts and nuts and one insertion piece (gasket) of the appropriate diameter and made of a material that is suitable for the bolts and nuts.

5.5.5 GROUNDING PADS

A minimum of two (2) grounding pads shall be provided, equally spaced around the exterior of the tank and welded to the tank shell 150 mm above the bottom. Flat and smooth contact surfaces shall be provided and protected during handling to maintain contact surface quality.

5.5.6 TRANSPORT AND STORAGE

On delivery the equipment shall be dry internally and externally and ready for installation. The equipment shall be protected against any damage during transportation.

Each flanged nozzle shall be protected with a wooden blank using the appropriate jointing material for protection prior to transportation.

The equipment shall be stored indoors or under ventilated covers. The storage area shall be clean, dry and dust free.

5.5.7 FIELD ERECTED TANKS

The Employer's preference is for shop fabricated tanks wherever possible. When this is not possible due to size limitations then field erected tanks may be provided.

Performance and design requirements for the field erected tanks shall be as required by the system design, in accordance with other applicable specification sections in these Employer's Requirements, and as required by the Contractor's design.

5.5.8 TEST REQUIREMENTS

Welded joints shall be radiographically inspected in the shell of the tank as required by applicable Laws and codes.

All tank floor joints shall be tested by vacuum box method. Wall joints may also be tested by vacuum box method.

After completion of welding, but before beginning surface preparation for painting or coating, and before any external piping has been connected, the tank shall be filled with water and all submerged joints shall be inspected. Any leaking joints shall be repaired after the water level has been dropped to at least 600 mm below the point being repaired. The test shall be repeated until all joints are completely leak tight (zero leakage and seepage).

5.5.9 CONSTRUCTION

Each water storage tank shall be a vertical, cylindrical, crowned bottom sloped 1 to 120 (1/120), aboveground tank. Each tank shall be designed for field erection by welding.

A self-supporting roof shall be provided. Shell plate joints shall be double-welded butt joint type welds with complete penetration. Roof joints shall be complete penetration welds or lap welds welded continuously on both edges. Bottom plates shall be complete penetration welds or lap welded on top side.

All clips and lugs used for erection shall be cut off. Any remaining clip and lug attachment weld material, and any welds used for fit-up, shall be ground smooth and flush with the parent metal. All welds shall be ground to remove any roughness or irregularity. All weld spatter shall be removed.

On the interior of the tank, all butt welds shall be ground smooth. All sharp metal edges existing at fillet welds shall be ground to a minimum 3 mm radius. All surfaces shall be cleaned of lubricants.

5.5.10 TANK APPURTENANCES

One (1) roof manhole shall be provided on each tank, each with a minimum inside diameter of 600 mm. Each manhole shall have a hinged, rainproof cover with locking device.

Two (2) shell manholes shall be provided on each tank. Shell manholes shall be 600 mm diameter hinged closures. Manholes shall be located on opposite sides of the tank.

Two (2) sets of permanent gaskets shall be furnished for all manhole covers. The permanent gaskets shall be furnished in wooden boxes identified by tank name.

5.5.11 PIPING CONNECTIONS

Each tank outlet that is routed to a pump suction shall be provided with an anti-vortexing device.

An external overflow assembly shall be provided. The assembly shall consist of an overflow loop seal. Overflow piping shall be rigidly supported and braced from the tank wall at intervals not exceeding 1,800 mm. The piping shall be adequately supported and braced for weight, expansion or contraction, wind, and hydraulic forces. U-bolts for support members shall not be used. If required, spreading pads shall be provided on the shell where pipe supports are attached.

Four (4) grounding pads shall be provided, equally spaced around the exterior of the tank and welded to the tank shell 150 mm above the bottom. Flat and smooth contact surfaces shall be provided and protected during handling to maintain contact surface quality.

5.5.12 ACCESS PROVISIONS

Where required, an interior ladder shall be provided with a fall prevention ladder climbing system.

Where required, exterior stairs shall be provided with a top landing platform. The stairs shall extend from the bottom to the top of the tank and shall be spiral type.

Each stair landing platform shall incorporate the best access and most economical use of space in platform design.

A 900 mm wide walkway shall be provided on each tank roof. The walkway shall extend from the upper ladder termination or stair landing platform to the manholes and other roof mounted appurtenances. The walkway shall be completely enclosed with handrails and kick plates except at the ladder or landing platform access opening.

The Contractor is responsible for provision of permanent safe and easy access for operation and maintenance of all valves, fittings, instrument tapping points, variable spring and constant load hangers and snubbers.

5.5.13 HANDLING

Shop fabricated tank sections and structural components shall be handled during shipping, storage, and erection in a manner that will prevent warping, bending, distortion, or physical damage of any kind.

5.5.14 CLEANING AND DISINFECTING OF WATER TANKS

After erection, testing, and painting have been completed, the interior of the tank shall be thoroughly cleaned and all debris shall be removed.

If required, the interior of the tank shall be disinfected in accordance with the referenced standard and state and local laws and ordinances, whichever requirements are the most stringent. Prior to starting any cleaning and disinfecting work, the Contractor shall submit to the Employer the detailed procedures proposed, including the coordination and sequence of operations and safety concerns. All procedures shall be acceptable to the Employer.

The Contractor shall provide all cleaning and disinfecting materials and all equipment and labour necessary for the cleaning and disinfecting operations. All wastewater used in disinfecting the tank shall be disposed of in a manner acceptable to the Employer and the appropriate Laws relevant to pollution control.

5.6 PUMPS

5.6.1 CENTRIFUGAL PUMPS

The details of the requirements for Condensate Pumps and Boiler Feed Pumps are covered in other sections of these Employer’s Requirements. This section applies to other miscellaneous centrifugal pumps to be provided by the Contractor under these Employer’s Requirements.

All the centrifugal pumps shall be designed in accordance with ANSI/HI 1.1-1.4, American National Standard, or ISO equivalent, for Centrifugal Pumps standards. The maximum head generated by the pumps shall be developed at zero flow and the characteristics of the pumps being of the progressively drooping head type. The duty of the pumps shall be attained as close as possible to the best efficiency point (BEP) of the pumps selected. Similar pumps installed to perform similar duties shall be capable of parallel operation.

Impellers shall not be the minimum or maximum size for the pump casing furnished.

Mechanical seals are preferred.

Pumps shall be type tested in accordance with ANSI/HI 1.6 – Centrifugal Pump Tests, ASME PTC 8.2 - Centrifugal Pumps and ANSI/HI 1.6 - Centrifugal Pump Tests, or international equivalent.

5.6.2 MATERIALS AND CONSTRUCTION

Pumps shall be designed and constructed for ease of maintenance and the following materials (or equivalents acceptable to the Employer) delivered by the Contractor shall comply with international standards and shall meet the minimum standards for materials and details of construction as established in the following table:

Component	Material
Casing	
Cast iron	ASTM A48
Ductile iron	ASTM A395 or ASTM A536, Grade 60-45-12
Carbon steel	ASTM A216, Grade WCB
12 percent chromium alloy	ASTM A743, Grade CA-15 or ASTM A743, Grade CA6NM
Stainless steel	ASTM A744, Grade CF-8M
Iron-chrome-nickel	ASTM A744, Grade CD-4MCu, 250 BHN
Abrasion resistant	ASTM A532 Class 3 Type A, 550 BHN
Impeller	
Bronze	ASTM B584
12 percent chromium alloy	ASTM A743, Grade CA-15 or ASTM A743, Grade CA6NM
Stainless steel	ASTM A744, Grade CF-8M
Iron-chrome-nickel	ASTM A744, Grade CD-4MCu, 250 BHN
Abrasion resistant	ASTM A532 Class 3 Type A, 550 BHN
Shaft	
Carbon steel	ASTM A576, Grade 1045; ASTM A321 or ASTM A322, Grade 4140
12 percent chromium alloy	ASTM A276, Type 410 Condition T
Stainless steel	ASTM A276, Type 316
Shaft sleeves	
12 percent chromium alloy	ASTM A276, Type 410
Stainless steel	ASTM A276, Type 316
Iron-chrome-nickel	ASTM A744, Grade CD-4MCu, 250 BHN
Wearing rings	
Bronze	ASTM B584

Component	Material
12 percent chromium alloy	ASTM A276, Type 410
Stainless steel	ASTM A276, Type 316
Iron-chrome-nickel	ASTM A744, Grade CD-4Mcu
Minimum flow orifices	
Stainless steel	ASTM A276, Type 316
Mechanical seals	
Metals	Type 316 stainless steel
Faces	One carbon, the other silicon carbide or tungsten carbide
Elastomers	Viton
Seal water heat exchanger tube materials	Type 304 stainless steel
Seal water flush piping	Type 316 stainless steel

The pumps shall be designed so that the efficiency may be readily maintained by means of renewable wearing rings fixed to the casing. Spare wearing rings shall be supplied undersize in the bore to enable them to be bored out on-Site to suit any reduction in impeller neck diameter which may occur due to wear.

Baseplates shall be cast iron or fabricated steel and shall support the unit and its drive assembly. Each baseplate shall have pads for anchoring the units. Grout holes shall be provided to allow proper installation of flowable non-shrink grout. Baseplates for equipment subject to water or oil leakage shall be provided with a raised lip perimeter suitable for collecting all leakages and shall have a drain connection.

Pumps shall include features for the adequate control of gland and other spills.

The couplings shall be of the flexible membrane type and shall be fitted with guards.

Each pump shall be fitted with an air cock, drain cock, priming cock, lubricators and all necessary fittings.

The pumps shall be fitted with ball or thrust bearings of ample size instead of balance discs.

5.6.3 SUBMERSIBLE SUMP PUMPS

Submersible sump pumps provided by the Contractor shall be complete with a waterproof junction box, discharge piping, controls, and all accessories required for proper operation.

5.6.4 MATERIALS

The materials selection in the construction of the equipment and accessories shall be the responsibility of the Contractor and shall be suitable for the service. As a minimum the following materials of construction shall be adhered to:

Motor enclosure	Cast iron
Pump chamber	Cast iron
Impeller "A"	Bronze
Shaft	Stainless steel

5.6.5 TEST REQUIREMENTS

Performance, hydrostatic, NPSH, motor integrity, and vibration testing shall be conducted in accordance with the Manufacturer’s standards and are the responsibility of the Contractor.

5.6.6 CONTROLS

Each sump pump shall be automatically controlled with an integral micropressure switch, factory set liquid level control.

5.6.7 MOTOR

Motor rating shall be not less than 370 W with 1.25 service factor. Motors shall be suitable for full voltage starting, frequent starting duty if required, and continuous duty in a 40 °C ambient temperature.

Sump pump motors shall be arranged for vertical mounting integral with the driven equipment. Sump pump motor enclosures shall be waterproof submersible type. External surfaces shall be coated with moisture corrosion-resistant alkyd enamel or with polyester or epoxy paint or coating. Motor parts exposed to sewage shall be of stainless steel or bronze of equivalent corrosion resistance. Metal-to-metal fits shall be coated with corrosion-resistant compound. Shaft and hardware shall be of corrosion-resistant material. The shaft shall be threaded for attaching the impeller.

Prelubricated sealed antifriction bearings with provisions for relubrication shall be furnished.

Rotors shall be dynamically balanced and coated with a corrosion-resistant polyester paint.

Motors shall be furnished with provisions for ground connection in accordance with NEMA MG 2-2.06. Size of grounding cable shall be 8 AWG copper.

Routine tests shall be performed on each motor at the manufacturer's factory to confirm that there are no electrical or mechanical defects.

5.7 HEAT EXCHANGERS

Details of the requirements for feedwater heaters are covered in other sections of these Employer's Requirements. This section covers other miscellaneous heat exchangers to be provided by the Contractor under these Employer's Requirements. The heat exchangers shall be structurally and hydraulically designed to operate satisfactorily at the maximum flow conditions; however, maximum flow conditions shall not be used as a design point for guaranteed thermal performance.

The heat exchangers shall be designed to operate reliably in continuous service under the design conditions.

Design and fabrication of heat exchangers shall be in accordance with one of the following codes (whichever is applicable):

Heat Exchange Institute (HEI);
ASME Boiler and Pressure Vessel Code, Section VIII, Division 1;
ASME Code for Power Piping, ANSI/ASME B31.1 - Power Piping;
DOSH; applicable Laws;
Standards of Tubular Exchanger Manufacturers Association (TEMA), Class C.

Connections shall be located to allow the heat exchanger to be opened for inspection or cleaning without disturbing the piping.

5.8 PIPING COMPONENTS

5.8.1 STRAINERS

Twin compartment strainers (if applicable) shall be so designed so that each compartment has a passage area of not less than twice that of the pipe cross sectional area. The strainer valves shall be so arranged that either section can be isolated and removed for cleaning at any time whilst in operation. The valves shall be fitted with conspicuous indicators and instruction labels to prevent incorrect operation. Vent and drain valves shall be fitted to each strainer.

5.8.2 TRAPS

Steam traps shall be of the thermodynamic, inverted bucket, or float and thermostatic type, complete with an integral strainer when indicated. The traps shall discharge condensate and non-condensable gases at steam temperature. Trap operation shall not promote backup of condensate in lines or equipment ahead of the trap.

The installation of the steam trap shall incorporate the following features:

1. An isolating valve close to the pipe being drained;
2. Isolating valves at the inlet and outlet of the steam trap;

3. A bypass line fitted with a globe valve;
4. A witness valve between the steam trap and its downstream isolating valve for checking the operation of the steam trap unless discharge is to an open tundish;
5. A strainer at the inlet to the steam trap;
6. The trap and all valves shall be easily accessible for operation and maintenance;
7. All valves shall be adequately supported.

Consideration may be given to the use of orifices instead of steam traps, where a small continuous flow is acceptable, or if removal of water is not required after the main system is hot.

Air traps shall be of the snap-acting liquid drain type.

5.8.3 BACKFLOW PREVENTERS

The backflow preventers shall be AWWA approved.

Backflow preventers shall be of the reduced pressure type and shall be a complete assembly consisting of two independently acting spring-loaded check valves with an automatically operating pressure relief valve located between the two check valves. The first check valve shall reduce the supply pressure a predetermined amount so that during normal flow and cessation of normal flow the pressure between the check valves is less than the inlet pressure. In case of leakage of either check valve, the differential relief valve shall act to maintain the pressure between the check valves at a pressure less than the inlet pressure.

The unit shall include tight closing shutoff valves at each end of the preventer and shall be fitted with properly located test cocks. Test cocks shall facilitate testing of upstream check valve, relief valve, and downstream check valve.

Operation of the backflow preventer shall be completely automatic. The design shall be such that each major component, such as a shutoff or check valve, may be removed or replaced individually. Major components, as well as internal parts of the different components shall be accessible for inspection, repair, or replacement without removing the entire device from the line.

5.8.4 SILENCERS

The acoustical performance of each silencer shall be such that the equivalent “A” weighted sound pressure level expressed in decibels to a reference of 20 micropascals shall not exceed the decibel limit specified in Section 2.6 (Performance Guarantees).

The internal components of each silencer shall be designed and constructed to withstand the dynamic forces of the entering steam flow at the specified conditions. Internal components shall be designed and constructed to allow for thermal growth and cyclic operation without buildup of excessive stress.

Silencers shall be of all welded construction.

Shell joints shall be welded butt joints with complete penetration for their full length, and shall be free of undercuts, overlaps, or abrupt ridges. Carefully fit components to form joints free of voids. Filling weld joint voids with weld metal is not acceptable.

Weld spatter shall be removed by grinding or wire brushing before coating. Flame cut edges shall be ground smooth.

All metallic surfaces subject to harmful corrosion shall be protected by suitable coatings applied in the shop. Surfaces which will be inaccessible after assembly shall be protected for the life of the equipment. The surfaces shall be cleaned and prepared in the shop prior to application of the coatings. Coatings shall conform to the manufacturer’s standard.

Ferrous surfaces which should not be painted and are subject to corrosion shall be protected with preservative coatings.

Steam vent stack silencers shall be single unit modular type blowdown mutes of welded carbon steel construction, prefabricated, and completely assembled. Fabricate the silencers with the following minimum shell thicknesses:

Silencer Shell Diameter	**Minimum Shell Thickness**
300 to 600 mm	3.2 mm
650 to 1,650 mm	4.8 mm
1,800 to 2,550 mm	6.4 mm
2,700 to 3,600 mm	7.9 mm

Silencer shell head thickness shall be compatible with the above shell wall thicknesses as a minimum.

Silencers shall be constructed using inlet diffusers, with an acoustically lined plenum of long strand fiberglass. Unless otherwise specified, provide steel flanges for inlet and outlet connections. Furnish the silencers with required drain connections and lifting lugs.

The silencer inlet nozzle and diffuser shall match the connecting piping size and wall thickness. Unless specified otherwise, the diffuser exit area shall be not less than 1.3 times the cross-sectional area of the connecting pipe. The diffuser cap material and thickness shall be equivalent to that of the pressure reducing diffuser.

The pressure drop across the silencer on an open stack cannot be greater than ¼ psi more than the pressure drop across the stack exit without the silencer.

Unless otherwise specified, the temporary steam blowout silencers shall be of the self-supporting type suitable for outdoor location at grade level on a graded surface, concrete pad, or shoring.

The silencers shall be designed for minimum pressure drop when operating at the specified design conditions.

Temporary steam blowout silencers shall be single unit modular type blowdown mutes of welded carbon steel construction, prefabricated, and completely assembled. The silencers shall be fabricated with a minimum 7.9 mm shell thickness.

Silencers shall be either cylindrical or rectangular shaped using inlet diffusers. Unless otherwise specified, steel flanges shall be provided for all connections. Silencers shall be furnished with required plugged drain connections and lifting lugs.

Each silencer shall be furnished with a flanged side inlet connection, top outlet, and bottom support. Each silencer shall be provided with a flanged cleanout leg opposite the inlet connection to collect debris suspended in the steam flow and to protect the silencer internal components from damage due to missile impact.

Measures for preventing and controlling noise:

Use equipment of low noise or with noise control measures, and propose noise limit requirements when ordering equipment (installing anti-noise casing or noise silencer if necessary) so as to guarantee that the noise of main equipment is no higher than the level set out in the table above.

Steam/water pipes and flue gas/coal powder pipes are reasonably designed and arranged, and supporting and hanging frames are reasonably chosen, so as to avoid vibration and noise.

Such equipment of relatively loud noise as blower and pump are arranged in closed buildings so as to insulate sound by buildings.

Noise at the border of the plant is reduced by means of reasonable planning, arrangement and based on such conditions as distance, terrain and surface features.

Use silencers to control air power noise from boiler steam venting and emergency door steam venting, so as to ensure noise is <100dB(A).

Require construction and installation units to take such control measures as deadening against blowpipe noise.

Noise Source Name	Location	Sound Level [dB(A)]	Spectral Characteristics
Suction blower	Outside boiler house	85 (3m in front of air inlet)	High, low and medium frequency
Ventilating blower	Outside boiler house	90 (1m in front of suction outlet)	High, low and medium frequency

Coal mill	Bunker bay	95	Low and medium frequency
Turbine	Turbine house	90(with casing)	Low and medium frequency
Generator and exciter	Turbine house	90	Low and medium frequency
Feed water pump	Turbine house	101	Low and medium frequency
Slurry circulating pump	Desulfurization area	90	Low and medium frequency
Coal crusher	Coal crusher room	90	Low and medium frequency
Circulating water pump	Water pump house	85	Low and medium frequency
Boiler steam venting	Boiler house	120-150 occasional	High frequency
Emergency door steam venting	Boiler house	100-110 occasional	High frequency

5.9 INSULATION AND LAGGING

The insulation and lagging to be applied to piping, equipment, and ductwork for the purposes of reducing heat loss, reducing sweating, and personnel protection shall be in accordance with the criteria set out in the following paragraphs.

5.9.1 INSULATION MATERIALS AND INSTALLATION

Insulation materials shall be inhibited and of a low halogen content so that the insulation meets the requirements of ASTM C795 regarding stress-corrosion cracking of austenitic stainless steel. Insulation materials shall contain no asbestos.

Equipment pipe and ductwork operating at elevated temperatures shall be insulated with calcium silicate block or mineral fiber block insulation.

Mineral fiber block insulation for use on equipment surfaces shall be in accordance with ASTM C612, Class 3.

Mineral fiber blanket insulation shall be used where practical.

Insulating cements shall be mineral fiber thermal insulating cements and shall conform with ASTM C195.

Antisweat insulation shall be flexible elastomeric cellular thermal insulation. Outdoor antisweat insulation shall be protected with paint or lagging in accordance with the manufacturer's recommendations.

Studs used for attachment of insulation shall be Nelson stainless steel studs in lengths suitable for the insulation thickness. Studs shall be spaced on centers not exceeding 300 mm. Washers for attachment of lacing wire shall be spaced on centers not exceeding 460 mm. All block insulation shall have joints broken and pointed up with plastic insulation.

Ducts with external stiffeners shall have insulation installed between the stiffeners, and a second layer of insulation installed thereon, so that stiffeners are insulated and a level surface achieved.

In order to reduce dust arising from repair and disassembly of the thermal insulation layer of piping, use finished thermal insulation materials which are not easy to produce dust.

Roofing insulation measures are strengthened and selecting thermal insulation materials with lower density and higher coefficients of thermal conduction avoids the great roofing weight and thickness and facilitates heat preservation and energy conservation. Heat-preservation and thermal insulation roofing is adopted in this project and extruded polystyrene foam boards are used as heat-preservation and thermal insulation materials, with the thickness defined by Code for Thermal Design of Civil Building.

5.9.2 LAGGING MATERIALS AND INSTALLATION

All insulated surfaces of equipment, ductwork, piping, and valves shall be lagged. Lagging on top of flat ductwork shall be crowned or sloped to shed rainwater.

All aluminium lagging shall be ASTM B209 Type 1100, 3003, 3105, or 5005 alloy or acceptable equal. Box rib lagging panels shall be stucco pattern embossed.

Ribbed or fluted aluminium lagging for equipment and ductwork shall be 100 mm and have 1.0 mm minimum thickness for vertical and bottom surfaces, and 0.125 mm minimum thickness for top horizontal surfaces. Piping lagging shall be stucco embossed finish sheet aluminium, 0.50 mm minimum thickness on applications up to 330 mm outside diameter, and 0.60 mm minimum thickness on all other applications.

All lagging shall be secured in place using self-tapping screws, fitted with neoprene faced stainless steel washers. Screws shall be 6061-T6 aluminium alloy, stainless steel, or anodized 2024 aluminium alloy. Spacing of screws for joints in ribbed aluminium lagging shall be not more than 300 mm. Spacing of screws for flat aluminium sheet shall be not more than 200 mm. All joints shall be placed to shed water. On outdoor piping, in addition to screws, lagging shall be secured by machine attached stainless steel bands spaced on not greater than 610 mm centers.

5.9.3 INSULATION SUPPORTS FOR PIPING

Vertical runs of piping which shall be insulated shall utilize support lugs and collars to prevent slippage of the insulation.

5.9.4 INSULATION CLASSES FOR PIPING AND EQUIPMENT

The insulation for piping accessories shall be of the same class as is indicated for the piping. Insulation materials for miscellaneous piping and equipment shall be suitable for the actual operating temperatures and shall, whenever possible, be of the same insulation class as insulated main piping and equipment operating under similar temperatures.

For piping systems operating above 60 °C where the retention of heat is not necessary for proper operation, such as feedwater heater vents and various hot drains to the condenser, the insulation thickness shall be reduced to that necessary to maintain the surface temperature of the insulation at approximately 60 °C for personnel protection.

5.9.5 ANTISWEAT INSULATION

All aboveground cold water and air piping which operates at temperatures which could cause pipe sweating located over walkways or equipment shall be provided with antisweat insulation, with the exception of piping in which fluid flow is not normally expected.

5.10 HEATING VENTILATING AND AIR CONDITIONING (HVAC)

Space conditioning, consisting of heating, ventilating, and air conditioning (HVAC) systems, shall be provided to ensure design basis environmental conditions are maintained for equipment and personnel. For environmental limitations refer Section 5, Chapter 1, sub-clause 1.11.

HVAC systems shall be designed to maintain the indoor conditions listed in the HVAC Criteria Table unless noted otherwise herein.

The design shall be based on space conditioning ambient design criteria set out in: ASHRAE STANDARD.

The design criteria table below indicates the level of redundancy for HVAC equipment in the indicated areas. Multiplicity means that more than one partial capacity device shall be used, and some capacity shall be provided in the event of a single component failure. When redundancy is indicated, only the major active components shall be provided with backup equipment. Static components including, but not limited to duct work duct mounted heaters and duct mounted variable volume boxes shall not be duplicated. Minimum ventilation rates shall be provided in areas that are normally occupied on a continuous basis in accordance with local codes. In the absence of applicable local codes, ASHRAE Standard 62 requirements shall be met.

The air conditioning for control and electrical equipment shall be designed to meet the filtration levels indicated in the HVAC design criteria table (HVAC Criteria Table) below. Tabulated filtration efficiency and MERV levels are indicated in accordance with ASHRAE Standard 52.1, Method of Testing Air-Cleaning Devices Used in General Ventilation for

Removing Particulate Matter and ASHRAE Standard 52.2, Method for Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particulate Size:

Filtration Level	Dust Spot Efficiency, %	Minimum MERV
High	80 to 90	13
Medium	20 to 60	7 to 11
Low	Less than 20	N/A

Noise criteria are indicated in the HVAC design criteria table which follow as NC levels, decibels, or as background. Noise criteria (NC) values are as indicated in the ASHRAE Handbook series for acoustic design criteria. Decibels are sound pressure levels, A-weighted to a reference of 0.0002 microbar at 1.5 m from the equipment, as measured in a free field with a single reflecting plane. Background indicates that the HVAC equipment shall be 2 dB(A) less than the room noise at 6 feet above the floor with normal plant equipment in operation.

Mechanical equipment rooms containing refrigerants shall be designed in accordance with the requirements of ASHRAE 15, Safety Code for Mechanical Refrigeration.

A minimum of 10 air changes per hour of ventilation or recirculation air shall be provided for effective mixing during heat removal ventilation or air conditioning.

Laboratory design ventilation rates shall be in accordance with local codes but in no case less than required by established, USA model codes.

Maximum design temperatures represent the average temperature; cooler temperatures are permissible near ventilation inlets, and higher temperatures are permissible at relief and exhaust points.

The plant shall be located in non-heating area and no central heating is provided in building design; for the purpose of comfortableness, heat pump air conditioner is considered as heating measure in winter.

Main power house is provided with natural air intake and ventilation system with roof ventilator and perturbation fan is installed to strengthen air circulation, prevent heat point accumulation and remove ventilation blind angle. In summer, outdoor new air naturally enters from row A external window and electric rainproof shutter and runs through the holes of radiator to absorb surplus heat and humidity in the room and finally discharged outside from the explosion proof roof ventilator. Ventilation system in summer will maintain an indoor temperature to meet requirements of specifications. Hydrogen emission device is installed on the top most part of turbine room roof.
Process rooms on operating floor are provided with all air central air conditioning system with air cooling constant temperature and humidity unit, such as central control room, engineer room, electronic equipment room, relay protection room, etc. Air conditioning system carries a set of air conditioner automatic control system.

Electrical equipment room in main power house and centralized control room normally use emergency ventilation system. When ventilation can't meet indoor temperature requirement in summer, industrial air conditioner is used to lower the temperature.

Battery room has emergency ventilation system. When ventilation can't meet indoor temperature requirement in summer, direct air conditioner is used to lower temperature and indoor air recirculation is prohibited.

All process rooms in main power house and centralized control building shall be provided with ventilation system according to specifications and process requirements.

Electric equipment room of Ash Handling Building Coal handling control building and Chemical water treatment building etc. shall be provided cooling ventilation system; cooling equipment is direct evaporation type industrial unit air conditioner.

Local control room, attendance room, test laboratory, experimental laboratory, instrument maintenance room and process unit room of other auxiliary system in plant site shall all be provided with ventilation and split-type air conditioner.

Coal transfer towers and coal crusher house, bunker bay shall have bag filter to maintain negative pressure at the transfer point feed channel opening or hopper and allow the emissions from dust suppression system to meet national standard.

Boiler house shall be provided with vacuum cleaning system, which concurrently functions to clean dust deposition of the locations in bunker bay where is not practical to use water flushing method.

The administration quarters shall be provided with split air conditioners or multi-split air conditioning system.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 6 – ELECTRICAL

CONTENTS

6 ELECTRICAL ENGINEERING DESIGN CRITERIA

This section describes the design criteria which shall be used for all electrical works related to this Project.

6.1 DESIGN CODES AND STANDARDS

Design and specification of all works shall be in accordance with the Contract. The electrical requirement and grid interface shall meet the requirements of the Grid Code and Contractor's obligations with respect to Employer's Power Purchase Agreement (PPA), as summarized into Attachment A4 [Schedule of Contractor's Obligations with Respect to the Employer's Power Purchase Agreement] of the Contract.

A summary of the major international codes and industry standards to be used in the design and construction of the Plant is provided below. In case of conflict between them, Bangladesh legislation, regulations, and codes are mandatory and represent the required minimum compliance with more stringent standards is acceptable.

The Contractor may adopt alternative standards not covered by the list presented below, provided the Contractor has requested and demonstrated to the Employer's satisfaction, and the Employer has accepted each such alternative standard as being equivalent to the listed standard.

1. Antifriction Bearing Manufacturers Association (AFBMA).
2. American National Standards Institute (ANSI).
3. American Society for Testing and Materials (ASTM).
4. Edison Electric Institute (EEI).
5. Insulated Cable Engineers Association (ICEA).
6. International Electrotechnical Commission (IEC)
7. International Organization for Standardization (ISO)
8. Institute of Electrical and Electronics Engineers (IEEE).
9. Illuminating Engineering Society (IES).
10. Bangladesh Department of Safety and Health (DOSH).
11. National Electrical Code (NEC).
12. National Electrical Manufacturers Association (NEMA).
13. National Electrical Safety Code (NESC).
14. National Fire Protection Association (NFPA).
15. Underwriters' Laboratories (UL).

Other recognized standards shall be utilized as required to serve as design, fabrication, and construction standards when not in conflict with the above listed standards.

6.2 GENERAL DESIGN REQUIREMENTS

Electrical plant auxiliary power system equipment shall be either all IEC standard equipment or all NEMA/IEEE equipment. IEC standards are preferable. This shall apply to all equipment from the main 6.6 kV switchgear down to low voltage power panel boards. Therefore, common IEC parameters shall be specified with the NEMA/IEEE parameters. Any exceptions to this requirement are stated herein.

The electrical equipment that is furnished shall have a standard ambient temperature limit of 40°C. The electrical equipment rating is based on extended exposure to the subject surrounding temperatures (related to accelerated insulation breakdown). The number of hours per year at the extreme (high) temperature is expected to be low.

Redundant loads including, but not limited to pumps, fans shall be powered from different switchgear and motor control centers in order to increase reliability and plant availability.

6.3 SWITCHGEAR

The 6.6kV Unit Auxiliary Switchboards shall be fed from two numbers of 20 / 6.6kV three-windings Unit Auxiliary Transformers and one number of 400 / 6.6kV three-windings Standby/Startup Transformer. The 6.6kV Unit Auxiliary Switchboards shall be interconnected to enhance reliability. The 6.6kV Unit Auxiliary Switchboards shall also supply to the 415V switchboards through auxiliary transformers.

The Electrical Main Wiring diagram number 10-PE-PAY-01 in Attachment B4 of Section 5 - Employer's Requirements indicates basic concept of the electrical system distribution and connection to 400kV Substation. The medium voltage system is shown on the single line diagram 10-PE-PAY-02 in Attachment B4 of Section 5 - Employer's Requirements. Exact numbers of MV and LV switchboards, feeders to motor and other MV loads shall all be determined during detailed design.

All medium voltage switchgear shall be of the metal clad internal arc proof certified type in accordance with IEC 60056, 62271-100, and 62271-200, Appendices AA – Criteria 1-5 (IEEE C37). Arc detection for selective tripping shall be provided as part of the protection scheme. The switchgear arc venting system shall be coordinated with the building systems to provide safe outlet of the arc gases out of the switchgear room and building.

Each medium voltage circuit shall be provided with a power cable earthing switch. Additionally, the switchgear bus shall be provided with earthing switch. Mechanical interlocks shall be provided to prevent closing an earth switch on a live power cable or bus bar. Electrical interlocks shall be provided between upstream and downstream switchgears which are physically apart for operational safety purpose.

Medium voltage switchgear shall utilize multifunction microprocessor based electronic protective relays for main supply feeder breakers and motor and feeder breakers.

The medium voltage switchgears powered from the unit auxiliary transformers shall be connected to the transformer via non-segregated phase bus duct or cable buss.

MV equipment interrupting rating shall be sufficient to interrupt the maximum fault current available. Ratings and settings specified shall be based upon calculations, including complete auxiliary electrical system load flow and fault current software analysis. All calculations and settings shall be reviewed and approved by the Employer prior to final equipment selections.

Overvoltages on motor feeders which may occur in the event of switching high voltage motors by vacuum circuit breakers or vacuum contactors shall be prevented by suitable measures (e.g. voltage limiters). All circuit breakers must be lockable by padlock provisions in withdrawn position.

Each switchgear lineup shall include a minimum of one spare breaker for each rating and one equipped space.

The switchgear and main equipment items shall comprise but not be limited to:

- steel-clad, bulk headed design, various functional compartments (circuit breaker/contactor, busbar, cable connection and relay compartments) are separated from one another by multiple bulk heading.

- the switchgear design shall be in accordance to IEC 62271 Part 200 and internal arc classification (IAC) = AFLR (40 kA 1s).

- short time withstand current 40 kA, 1 second single busbar system with isolated bus bars with the same cross section throughout all cubicles

- feeders with vacuum type circuit breakers or vacuum contactors

- withdrawable vacuum circuit breakers with 220V DC motor-driven energy mechanism: Provision are to be taken that when the switch is withdrawn, the insertion contacts are automatically covered with sheet metal shutters so as to prevent any danger of accidental contact. The circuit breaker module shall be interlocked in such a way that closing in the service position is not possible locally (on the switchboard)

- withdrawable vacuum contactor with 220 /110V DC operating voltage: Provision are to be taken that when the switch is withdrawn, the insertion contacts are automatically covered with sheet metal shutters so as to prevent any danger of accidental contact. The contactor module shall be interlocked in such a way that closing in the service position is not possible locally (on the switchboard)

- current and voltage transformers as required

- earthing switch in each fully equipped cubicle

- all feeders equipped with vacuum circuit breakers shall be provided with over-voltage protection devices

- quick-acting type earthing switch for each busbar section
- fuses and voltage transformers for busbar measurement
- cable connection compartment with the necessary current and voltage transformers, the earthing switch, including the necessary fixing for high voltage cables with protection covers to prevent damage due to accident contact
- cable paralleling arrangement in cable connection compartments with auxiliary busbar systems, connecting bars and support structures together with a sufficient number of earthing studs, for all feeders with more than two parallel cables per phase
- fireproof closure to the floor of the switchgear panels to seal the outgoing power cables
- control and monitoring compartment with monitoring and signaling equipment, MCB´s for protection and voltage transformers, switch position indicators, reporting and operating facilities, mimic diagram on the front of each panel, protection and monitoring relays, interface with DDCMIS, measurement transducers, miniature circuit breakers, complete terminal boards, meters etc. including the illumination with LED tubes
- mimic diagram on the front of each cubicle consisting of graphical symbol and position indication
- control voltage – 220/ 110 VDC
- control voltage supplies with double infeed and diode coupling, monitoring etc. for each switchgear section
- high speed change-over equipment
- heating units humidity controlled within the switchgear panels with over-temperature protection
- 240V AC supplies for space heaters and lighting; one (1) infeed for each section from the essential supply.
- trip and close circuit monitoring
- anti pumping device
- internal arc fault detection and quick isolation facility
- cable (between two bus sections) to have isolation facility at both ends

- multi-functional numerical relays complying with IEC 61850 shall be provided for all MV & LV Switchgears which shall be networked to a standalone Fault Monitoring System for indication purpose.

- padlocking arrangement as required by local safety requirement shall be provided

The Contractor shall provide a margin of at least 15 percent (15%) between the switchgear fault current rating and the available fault current to allow for future system growth.

An automatic “bumpless” break before make type transfer system shall be provided for the 6.6kV unit switchboards between the bus section and the incoming circuit breaker.

The internal control voltage for the MV switchgear shall be 110V DC for control supplied from the independent station battery. The breaker spring charge also used this power.

The interface between the medium voltage switchgear and the station control system shall be hardwired for control and trip/open from the DCS. The MV switchgear protection trip shall be hardwired to the breaker with trip alarm signals to DCS for monitoring.

Current and voltage transformers
The current and voltage transformers shall comply with IEC 61869.

The thermal withstand capability of the instrument transformers is to be based on a disconnection time of min. 0.5 sec in the outgoing circuits to the consumers and of min. 1.0 sec in the in feeds. All current transformers must be mounted in the fixed part of the switchgear cubicle.

The instrument transformers secondary circuits must be wired individually to the switchgear cubicle terminal strip. In case of current transformers, the necessary terminals are to be equipped with short-circuit links. Cast-resin insulated, corona-free transformers are to be employed.

Current transformers:

Accuracy for metering class	0.2
Accuracy for measurement class	0.5
Accuracy for protection class	5P20 as a minimum
Accuracy for differential protection class	5P20 as a minimum PX
Accuracy for REF protection class	P5P20 as a minimum X

The current transformers are to be designed capable to withstand the dynamic and thermal short circuit stresses. Intermediate transformers are to be avoided. For protection and measurement separate cores are to be provided.

Voltage transformers:

Accuracy for measurement class	0.5
Accuracy for metering class	0.2

In infeed and measuring cubicles, three single-phase insulated voltage transformers are to be used.

The secondary sides of voltage transformers are in general to be safeguarded by mini circuit breakers. If the same voltage transformer is used for several purposes (e.g. measurement, protection, metering) then individual separate mini circuit breakers with auxiliary contact are to be provided.

Protection relays:
Only multifunctional digital/numerical type, self-monitoring protection relays (MFR) fitted with test facilities are to be used throughout. Test facility of the relay shall be designed in such a manner that the relay initiate trip to the connected circuit while testing through inbuilt testing facility. The relays shall be programmable with display to read the operating and set point values. The relays are to be of modular plug-in type to be installed and wired in sub-racks accommodated behind the doors with plastic windows of the control recess. Indicating and resetting devices must be provided. Resetting should be possible without removing its front cover. It must be possible to see without opening the door that a relay has operated.

The numerical multifunctional relays (MFR) shall have fault/event recording functions. The MFR complying with IEC61850 shall be networked to a “Standalone SCADA System” interfaced with DDCMIS only for indication purpose. Protocol conversion shall be provided if required.

The MV switchgear will be operated from the DCS through hardwired signals for commands and feedbacks. Measuring and monitoring system will be connected to the DCS with redundant MODBUS TCP network for monitoring purposes and by hardwired signals for control and protection purpose.

Type test certificates shall be submitted as required by the Engineer. Type test certificates shall also prove that the switchgear supplied is internal arc classified IAC = AFLR according IEC 62271 Part 200.

The Contractor shall provide his plan for operator safety from arc flash for switchgear and all other electrical equipment based on the applicable Laws and codes. The method of determining incident energy shall be based on the Contractor’s short circuit study for this facility. Drawings shall indicate arc flash boundaries for electrical equipment.

6.4 ELECTRICAL AUXILIARIES SYSTEM

The 415V Auxiliary Boards shall supply electric power to the 415V essential auxiliary boards. Each unit’s essential auxiliary boards shall be supplied from its individual emergency diesel generator.

All switch boards shall be provided with an alternative supply source, where practicable, with interlocking facility for flexibility of operation and maintenance. Where connection is provided between supply that may be paralleled, check synchronizing relay shall be provided.

An automatic “bumpless” break before make type transfer system shall be provided for the 415V Auxiliary Board between the bus section and the incoming circuit breaker.

The standing load list for all electrical auxiliary system shall be provided.

The Contractor shall provide a margin of at least 15 percent (15%) between the switchgear fault current rating and the available fault current to allow for future system growth.

Each switchgear lineup shall include a minimum of one spare breaker and one equipped space.

All auxiliary transformers shall be provided with a no load tap changer.

All motor loads greater than or equal to 75 kW and less than 200 kW shall be fed from the 415/240V Secondary Unit Substation (SUS), and feeder to motor control center also shall be fed form 415/240V SUS.

6.5 MOTOR CONTROL CENTER (MCC)

MCCs shall be provided as needed to distribute power to cyclic 415/240V loads, 415/240V intermittent loads, and small 415/240V loads that require motor starters or are essential to plant operation.

MCC shall comply with the requirements of IEC 60947-4-1 and IEC 60947-2 MCC in general shall be located indoors. Exact quantity and locations shall be determined during detail design. Each MCC shall contain combination full voltage motor starters and molded case circuit breakers. Each 415/240V MCC shall include one spare for each type and size of breakers. In addition, spare starters, breakers, or spaces to allow for 20 percent (20%) future growth shall also be provided.

The Contractor shall provide a margin of at least 15 percent (15%) between the MCC fault current rating and the available fault current to allow for future.

The incoming feeders to the main distributions and outgoing feeders to sub-distributions are to be equipped with motor-driven circuit breakers equal or larger than 630A. All remaining outgoing feeders to the rectifiers and inverters etc. shall be equipped with load break switches and fuses.

The copper busbars shall be equipped with an adequate number of earthing studs.

The short time withstand current shall be minimum 50 kA, 1 second.

The MCC shall be supplied with plug-in units which shall be equipped essentially with the following units:

- circuit breaker plug-in units with motor-driven stored-energy mechanism with auxiliary relays, plug-and-socket control connections, electronic protection relays, mini circuit breaker for monitoring and protection, and possibly current transformers, etc.
- motor plug-in units either with fuses and hand-operated load-break switch or with motor protection switch, motor contactor, auxiliary relays, coupling relays, plug-and-socket control connections, bimetallic trip, control voltage mini circuit breaker, etc.
- for feeders of 110 kW and more only circuit breakers shall be used.
- position indications, signals, and the designation plate shall be accommodated on the front panels of the plug-in units.
- plug-in units with hand operated load-break switches and line-side fuses. The hand operated drive for the load-break switches shall be arranged on the front panels of the plug-in units.

Withdrawal or engagement of the plug-in units must only be possible with the power circuit open. To meet this requirement a mechanical/electrical interlocking shall be provided for each plug-in unit.

Each plug-in unit shall be equipped with a defined operating, test and inspection position. In the test position the power contacts must be separated, so that safe testing of the remote and local control system is ensured. In the inspection position the control circuits must also be interrupted.

Current transformers:
The thermal withstand capability of the instrument transformers shall be based on a disconnection time of min. 0.5 sec. in the outgoing feeders to consumers and min. 1.0 sec. in the infeeds.

Accuracy for measurement class	0.5
Accuracy for protection class	5P20

Cast-resin insulated, corona-free transformers shall be used. The current transformers must withstand the dynamic and thermal short-circuit stresses.

Separate cores for protection and measurement shall be provided.

Current transformer terminals must be equipped with short-circuiting links.

Multi-functional numerical relays (MFR) shall be provided for all MCC which shall be networked to a standalone Fault Monitoring System (FMS).

The relays shall be of communicable, numerical multifunctional type and shall be arranged for panel installation behind the doors or windows of the individual plug-in units or integrated in the circuit breaker. Indicating devices shall be provided which enable it to be seen when a relay has operated without the need to open the door.

Each circuit breaker shall be equipped with a three-phase, overcurrent time relay with continuously variable short-circuit trip.

All protection relays have to be selective and shall preferably be of multi-functional type. The Contractor may offer additional protection devices if he sees them necessary

The control of the motor plug-in units shall be effected with 240V AC. The control voltage is made by suitable transformers 415/240V for each half-bar of main switchgear and distribution.

The monitored control voltage shall be permanently wired from plug-in unit to plug-in unit so that in each main switchgear and distribution each half-bar has a separate control voltage circuit. In each motor plug-in unit the control voltage shall be protected by a mini circuit breaker, auxiliary changeover contacts of these shall be wired for trip indication to the central control room.

The motor plug-in units are to be remotely controlled from the central control room. Therefore, two coupling relays (ON/OFF, OPEN/CLOSE) are to be provided.

The self-holding of the contactors for continuously running motors must be provided in the plug-in units.

An undervoltage monitoring device for monitoring the busbar voltage shall be provided in each distribution and each half-bar of the main switchgear. The response value of the monitoring devices must be adjustable from 50 - 100% voltage, the delay time shall be adjustable from 1 to 15 seconds. This device shall provide necessary input to the DDCMIS system specified above for the defined disconnection from the automatic control level of all respective low voltage motors in the case of the failure of the busbar voltage.

The emergency consumers shall be reconnected after the emergency diesel generator has been started and emergency power is available.

MCCs shall receive power from breakers in the 415/240V switchgear. Switchgear feeder breakers, feeder circuits and MCC buses shall be sized for 10 percent (10%) future growth over the current maximum demand load.

415/240V Switchgear feeder breakers to MCCs shall be electrically operated. All motor starters up to an including 75KW shall be fully withdrawable.

Protection equipment shall be provided for all equipment 90kW and above and shall be microprocessor based. Thermal protection shall be provided for equipment below 90kW

415/240V equipment interrupting ratings shall be sufficient to interrupt the maximum fault current available. Ratings and settings specified shall be based upon calculations, including complete auxiliary electrical system load flow and fault current software analysis. All calculations and settings shall be reviewed and approved by the Employer prior to final equipment selections.

6.6 NON-SEGREGATED PHASE BUS DUCT

General

The connection from the 20/6.6kV Unit Auxiliary Transformers and 400/6.6kV Startup/Standby Transformer to the Unit Auxiliary Boards shall be of the phase non-segregated type. The design shall be in accordance with the best modern practice employed in the construction of heavy current air insulated equipment and particular attention shall be given to the necessity for withstanding without damage or danger, the electromechanical stresses which may arise during normal or fault conditions and which may be due to fixing, vibration, fluctuations in temperature, flashover or other causes. The design shall be such that any mechanical damage due to a fault on the connections themselves should be confined as far as possible to the immediate vicinity of the fault.

A common enclosure for the busbars shall be designed to exclude dust and moisture so that the installation is suitable for operation over long periods without the need for maintenance or cleaning of internal components.

Barriers shall be used to segregate the phases.

The connections at the transformer terminals shall be provided with suitable metal enclosures. The enclosures shall be formed of metal sheet fixed on substantial supports.

Where the busbar connections are installed external to the building the enclosure shall be completely weatherproof and where necessary shall be painted to ensure protection against the effects of adverse environmental conditions.

Where steel is used for supports it shall be galvanized to EN ISO 1461. Painting and finishing shall comply with relevant parts of the Specification.

Adequate means of access shall be provided to permit inspection, maintenance, insulator cleaning and the reading of temperature indicating devices used in the temperature rise test. It shall only be possible to remove bolted panels with a special key.

Conductors

The busbar and connections shall be copper.

Connections shall be as short and straight as possible.

Each length of conductor between joints shall, unless otherwise approved, be supported on not less than two sets of insulators. Positive contact must be made at all times between the conductor and the insulator top cap.

All busbar joints and connections shall be bolted or welded. The bolts and nuts shall be of high tensile non-magnetic material, and shall be securely locked by locknuts, locking plates or approved lock washers.

Earthing

The structures, enclosures, screens, and insulator supports shall be continuously and effectively earthed in an approved manner. All joint faces shall be tinned.

The busbar earthing facilities shall be provided with facilities for connection to the station earthing system.

6.7 ELECTRIC MOTORS

General Motor Design Criteria

These paragraphs outline basic motor design parameters and criteria for consideration in selection and purchase of electric motors.

The following design parameters shall be considered:

1. Environment.
2. System voltage, frequency, and phases.
3. Running kilowatt (horsepower) requirements and starting requirements and limitations.
4. Special duty cycle requirements.
5. Drive requirements.
6. Motor type (including but not limited to synchronous, induction, direct current) and construction.
7. Power factor.
8. Efficiency.
9. Service factor.
10. Speed and direction of rotation.
11. Insulation type.
12. Temperature limitations of winding insulation and enclosures.
13. Enclosure.
14. Bearing construction and lubrication requirements.
15. Cooling requirements.
16. Noise level for motor and motor driven equipment assembly.
17. Termination provisions for power, earthing, and accessories.
18. Installation, testing, maintenance, and operating requirements.
19. Accessories and special features including, but not limited to space heaters and temperature monitoring.

Codes and Standards

All motors shall be designed, manufactured, and tested in accordance with the latest applicable standards, codes, and technical definitions of IEC (NEMA/IEEE), AFBMA and applicable Bangladesh standards, and where supplemented by requirements of the specifications.

Electrical Design Criteria

Special requirements for individual motors and specifications for special application motors are to be included in individual specification technical sections and shall have precedence over these general motor requirements.

Rating

The motor nameplate kW shall be determined by the driven equipment operating range maximum input kW rating. Motor operating voltages (excluding motor-operated valves) are tabulated below:

Kilowatt	**Nominal System Voltage**	**Motor Nameplate Voltage**	**Frequency (Hz)**	**Phases**
Less than 200	415	415	50	3
Greater than or equal to 200	6600	6600	50	3
DC motors	220	220	DC	--

The table above is intended as a general guide. However, individual conditions and special applications such as distance from power source, voltage drop, motor availability, and cost may dictate deviations from the stated kilowatt/voltage criteria.

DC emergency motors shall operate continuously at the nominal system voltage with any supply voltage between 85 percent (85%) and 110 percent (110%) of the nominal system voltage.

Generally motors shall be designed for full voltage starting and frequent starting where required and shall be suitable for continuous duty in the specified ambient conditions. Intermittent-duty motors may be selected where recognized and defined as standard by the equipment standards and codes. Some specific motors may be designed for reduced voltage starting. Each motor shall be designed for use with its motor drive and its application.

The torque characteristics of all induction motors shall be as required to accelerate the inertia loads of the motor and driven equipment to full speed without damage to the motor or the equipment at any voltage from 90 percent to 110 percent (90% to 110%) of motor nameplate voltage except those to be individually considered. Motors shall be capable of starting with 80 percent (80%) terminal voltage.

Temperature Considerations

Motors shall be designed for an ambient temperature of 40°C. The design of motors located in areas where the ambient temperature may exceed 40°C shall take into account the specific conditions.

Windings and Insulation

In general, all insulated windings shall have Class F non-hygroscopic insulation systems rated for temperature rise Class B and ambient temperature in accordance with IEC (NEMA MG 1) standards.

All insulated stator winding conductors and wound-rotor motor secondary windings shall be copper. In general, all 415V motors shall be furnished with the manufacturer's standard insulation system. All medium voltage motors shall be furnished with a sealed insulation system consisting of vacuum pressure impregnation.

Space Heaters

In general, 415V outdoor motors equal or above 10kW (250 Frame Series) and indoor motor equal or above 22kW shall have 240V single-phase, 50 hertz, space heaters. All medium voltage motors shall have space heaters. Space heaters shall be suitable for operation on 240V, single-phase, 50 hertz.

Space heaters shall be either replaceable metal sheathed type or fixed flexible silastic wraparound type. Heaters shall be located and insulated so they do not damage motor components or the finish.

Medium Voltage Motors:

Enclosures

Motor enclosures shall be fully guarded for indoor and outdoor with adequate enclosure protection.

Bearings

All horizontal motors shall be provided with sleeve or antifriction bearings.

Grease or oil lubricated antifriction bearings shall be designed and fabricated in accordance with AFBMA standards to have a minimum L-10 rating life of not less than 40,000 hours under the load, speed, and thrust requirements for direct coupled service and not less than 30,000 hours for belt or chain connected service.

Temperature Detectors

Bearing temperature detectors complete with detector head and holder assemblies as required, shall be furnished on motors with sleeve type bearings.

415 Volt Motor:

Motors shall be coordinated with the driven equipment requirements and shall be in accordance with the requirements of IEC 60034 (NEMA MG 1).

Enclosures

Motors shall have IP54 enclosed (or totally enclosed, fan cooled -TEFC) for heavy dust or outdoor, or IP23 (or guarded open drip proof - ODP) enclosures for indoor.

Bearings
Antifriction bearings shall be provided for all motors.

Grease lubricated or oil lubricated antifriction radial and thrust bearings shall be designed and fabricated in accordance with AFBMA standards to have a minimum L-10 rating life of not less than 100,000 hours under the load, speed, and thrust requirements for direct coupled service and not less than 30,000 hours for belt or chain connected service.

Direct Current Machines
All direct current machines shall be designed and constructed for continuous operation and in accordance with the requirements of IEC 60034 (NEMA MG 1).

Fractional kW (Horsepower) Rated Motors
The type, design, and construction of each general, special, and definite purpose fractional kW (horsepower) rated motor shall be coordinated with the driven equipment requirements and shall be in accordance with the requirements of IEC 60034 (NEMA MG 1).

Motor Operators for Non-modulating Valve, Gate, or Damper Service
Motors shall be designed for high torque, reversing service in a 49 °C ambient temperature and Site ambient temperature and shall be in accordance with the requirements of IEC (NEMA MG 1 and MG 2).

The AC motors shall be rated 415V, 3-phase, 50 hertz. The DC motors shall be rated 220V DC to operate from a nominal 220V battery.

The motor time rating, for normal opening and closing service, shall comply with whichever of the following is greatest:

As required for three successive open-close operations.
As required for the service.
Not less than 15 minutes.

Motors shall be furnished with IP67 enclosed (totally enclosed, non-ventilated enclosures).

Bearings
Antifriction bearings having AFBMA minimum L-10 rating life of not less than 15,000 hours shall be furnished.

Space Heaters
All motor operators shall be supplied with 240V AC, single-phase space heaters located in the limit switch compartment and in the motor.

Crane, Hoist, HVAC, Elevator, and Miscellaneous Motors
Motors not related to power production shall conform to applicable requirements of IEC (NEMA MG 1) and shall otherwise meet the manufacturer's standard.

6.8 PLANT BATTERY

The plant battery shall provide power to the uninterruptible power supply “UPS” system, switchgear control power, control room lighting (backup supply), and for motors necessary for safe coast-down of rotating equipment, and other critical loads.

Each DC power supply system shall consist of the following major components:

1. Two (2) full capacity (2x100%) 110V DC flooded type lead acid plant batteries with two (2) full-capacity (2x100%) redundant solid-state chargers per battery for control.
2. Two (2) full capacity (2x100%) 220V DC flooded type lead acid plant batteries with two (2) full-capacity (2x100%) redundant solid-state chargers per battery for DC power supply.
3. Main DC distribution panel (per battery).

Each plant battery charger shall be sized to provide the normal continuous dc power requirements while recharging the battery in less than 24 hours (12 hours if both chargers are in service).

The plant battery shall be sized to safely shut down the power plant upon loss of all AC power, and supply essential DC loads for a minimum of 240 minutes, or as required by the steam turbine equipment, whichever is longer. The plant battery system shall be sized in accordance with IEC (or IEEE 485). Battery rating shall account for aging of the cells and temperature differences. DC power supply system panelboards shall be provided with at least 15 percent (15%) spare breakers for future use.

The battery shall be located in a space conditioned area so that suitable temperatures can be maintained, thus helping to ensure long battery life. The battery room shall be provided with ventilation to prevent hydrogen buildup.

Battery charging equipment
Each battery charger must be suitable for the charging and floating of the lead-acid battery and for supplying of all the DC consumers or the inverters for the 240V Safe AC system at the same time. Above requirements shall also be applicable if the battery was drained prior to start of charging.

The rectifiers are to be provided as thyristor controlled devices with current-voltage characteristic for stand-by parallel operation with the associated batteries.

The following technical features and monitoring equipment is to be provided for the individual battery chargers:

- radio interference suppression of the battery chargers according to the appropriate IEC regulations

- monitoring the charging circuit for interruption
- voltage monitoring of the incoming three-phase supply, with an overvoltage of + 15% and an undervoltage of –15%, automatic disconnection of the battery charger must occur
- voltage monitoring of the DC output, with an overvoltage of +15%, automatic disconnection of the battery charger must occur.

All cases of disconnection must be indicated as a fault alarm in the front door of the unit.

The local fault alarms and indications disconnections are to be connected to combine as a common alarm - rectifier fault - to the central control room (DDCMIS by serial interfaces).

The battery chargers are to be equipped with high rate charging stages that can be set at 2.65 V/cell between 1 to 6 hours after input failure.

On the front of the rectifier cubicles, the Contractor has to provide all the necessary monitoring equipment, measuring instruments, other devices, switches, indicator lamps and corresponding fixings for the cables.

Alternatively the Contractor may offer an integrated numeric control device (visible during normal operation through inspection window in front door), which combines all functions.

6.9 ESSENTIAL AC SYSTEM

The UPS shall consist of the following major components:

1. Two (2) full-capacity (2x100%), 230V AC, single-phase, 50 hertz inverters.
2. Two (2) solid-state static transfer switches.
3. One manual bypass switch.
4. Essential service AC panel boards for distribution of 230V AC essential service power.
5. One alternate source transformer and voltage regulator.

The UPS design configuration shall be of the dual redundant type.

A solid-state switch connected to the output of the inverter shall continuously monitor both the inverter output and the alternate AC source. Upon loss of the inverter output, the static switch shall automatically transfer essential AC loads without interruption from the inverter output to the alternate source. The power supply for the alternate source transformer and regulator shall be the AC power supply (415/240V) system.

During normal operation, the inverter-static switch-power panel combinations shall be dedicated to furnishing the power required by the UPS. The AC power supply (415/240V) system shall be utilized as a backup to the inverter systems.

A manual bypass switch shall be provided to enable isolation of the inverter-static switch from service for testing and maintenance without interruption to the UPS system loads.

The inverter shall be sized for approximately 120 percent (120%) of the total essential service AC system load of the power block and shall be maintained in synchronism with the alternate ac power source. Inverter sizing shall consider control systems which require multiple or redundant power sources.

The DC power supply system shall be sized to include the maximum inverter output. The DC power supply system shall be sized to provide power for a minimum of 1 hour after loss of AC power.

6.10 PLANT INTERCOMMUNICATIONS SYSTEM

The plant intercommunication paging system shall consist of the following major components:

1. Handsets
2. Amplifiers.
3. Speakers and supports
4. Associated raceway and wiring.

It shall accommodate a minimum of five (5) party lines. Handset/Speaker stations shall be located throughout the Plant. Installation locations shall include but not be limited to the central control building, steam turbine generation (STG) building, boiler building, coal yard, water treatment area, flue gas desulfurization area, and any other areas normally occupied by the Plant’s personnel.

Outdoor, corrosive and/or hazardous locations shall be provided with equipment suitable and classified for the environment in which it shall be installed.

6.11 COMMERCIAL TELEPHONE SYSTEM

The Contractor shall provide a permanent telephone system, including connection to the Bangladesh public network including isolated equipment. The Contractor shall make provision for an exchange compatible with the Employer’s network.

The number of telephones to be provided shall commensurate with maintaining a satisfactory level of communications facilities. Telephones which are to be located in noisy areas shall be provided with acoustic hoods together with light beacons.

A further independent telephone exchange such as direct wire system for direct telecommunication between the CCR and operational Plant areas within the Power Station for use in the event of failure of the main telephone system shall be provided.

A permanent UHJ radio telephone system incorporating portable transceiver together with a VHR radio paging system shall also be provided by the Contractor. It shall be the Contractor's responsibility for any radio frequency application and approval from the relevant authorities and government bodies.

A siren based annunciation system shall be provided to cover all areas within the Power Station. The control facilities shall be located in the CCR. The system shall zoned according to Plant areas. At least 2 spare zones shall be provided for future use. It shall be possible to annunciate the above signals in any or all of the Plant areas throughout the Power Station.

6.12 EARTHING

Earthing requirements of IEC 60479 (or NFPA 70) shall be met for all electrical equipment and systems at the Plant. The earthing (grounding) system shall be provided to protect the Plant's personnel and equipment from the hazards which can occur during power system faults and lightning strikes, and it shall provide the ability for protective devices to detect line-to-ground faults.

The station earthing system shall be an interconnected network of bare copper conductor and copper-clad ground rods. The size and quantity of grid conductor, and length and quantity of ground rods shall be calculated for acceptable step and touch potentials, in accordance with IEC 60479 (or IEEE 80) Standard. Calculations shall be based on soil resistivity determined by test performed in accordance with these standards.

The Contractor shall coordinate the Plant's earthing system with the Employer's transmission line and substation earthing systems.

Design Basis

The station earthing grid shall be designed for adequate capacity to dissipate heat from ground current under the most severe conditions in areas of high ground fault current concentrations, with grid spacing such that safe voltage gradients are maintained.

Bare conductors installed below grade shall be spaced in a grid pattern to be indicated on the construction drawings. Each junction of the grid shall be bonded together by an exothermal welding or irreversible compression connection process.

In the Plant area, earthing stingers shall be brought through the ground floor and connected to the building steel and selected equipment. The earthing system shall be extended, by way of stingers and conductor installed in raceway, to the remaining plant equipment.

Equipment grounds shall conform to the following general guidelines:

1. Grounds shall conform to the IEC 60479 (or NEC and NESC).
2. Major items of equipment, such as switchgear, secondary unit substations, motor control centers, relay panels, and control panels, shall have integral ground buses which shall be connected to the station ground grid.

3. Electronic panels and equipment, where required, shall be grounded utilizing an insulated ground wire connected in accordance with the manufacturer's recommendations. Where practical, electronics ground loops shall be avoided.
4. Motor supply circuits to 415V motors, which utilize three-conductor cable with a ground in the interstices, shall utilize this ground for the motor ground. For 415V motor supply circuits which utilize three single-conductor cables, the ground conductor shall be sized in accordance with the applicable codes.
5. All 6.6kV and higher voltage rated motors shall have a minimum of one 50 mm^2 bare copper ground conductor connected between the motor frame and the station ground grid.
6. A copper earthing conductor shall be routed parallel to all power conductors operating above 240V in accordance with the applicable codes.
7. All ground wires installed in conduit shall be insulated.

Remote buildings and outlying areas with electrical equipment shall be grounded by establishing local sub-grade ground grids and equipment earthing systems in a manner similar to the plant area. Remote grids shall be interconnected with the station ground grid to reduce the hazard of transferring large fault potentials to the remote area through interconnecting instrumentation and communication cable shields.

Materials
Earthing materials shall be as follows:

1. Rods shall be copper-clad. Ground rod length and diameter shall be determined by soil resistivity and subsurface mechanical properties. Where required ground rod length exceeds 3 m, standard sections shall be exothermally welded together using a guide clamp.
2. Cable shall be soft-drawn copper with Class B stranding.
3. Exothermal welds shall use molds, cartridges, and materials manufactured by an approved supplier.
4. Clamps, compression or bolted connectors, and other hardware used with the earthing system shall be made of copper or other suitable material and manufactured by an approved supplier.
5. Ground wires installed in conduit shall be soft-drawn copper with Class B stranding, and green coloured 600V PVC insulation.

6.13 LIGHTNING PROTECTION

Lightning protection shall be provided for all structures and equipment as recommended by the site evaluation. The site evaluation shall be conducted by using the method of NFPA 780, Annex L. Lightning protection devices shall be installed in accordance with the guidelines of IEC 61024, NFPA 780, NFPA 850, IEEE 142, and Bangladesh standards. Plant earthing system shall be designed to accommodate connection to lightning protection systems.

The Contractor shall coordinate the plant lightning protection system with the Employer's transmission line and substation lightning protection system.

6.14 RACEWAY AND CONDUIT

The design and specifications for the raceway and conduit systems used in supporting and protecting electrical cable shall generally be in accordance with the provisions of IEC (or NEC). One exception is the methodology of allowable cable placement and tray fill for open cable tray systems.

Cable Tray
All cable trays (except electronic tray) shall be of trough or ladder type construction with a maximum rung spacing of 250mm, nominal depths of 100 to 150mm, and various widths as required. The electronic tray shell solid bottom type with solid cover. A maximum spacing between cable tray supports shall be 3m except fittings (including but not limited to elbows, tees) which shall be supported in accordance with NEMA standards.

Cable tray fittings shall have a radius equal to or greater than the minimum bending radius of the cables they contain.

Individual tray or raceway systems shall be established for the following services:

1. MV power cables.
2. 415V power and control cables.
3. Special noise-sensitive circuits or instrumentation cables.

Further division shall be provided where required by equipment manufacturer.

Each cable tray system shall be identified by a 150 mm wide, coloured band painted on the tray on 6m centers. The Employer shall provide the colour code.

The summation of the cross-sectional areas of cable in tray shall be limited to 60 percent (60%) of the usable cross section of the tray for medium voltage power cables and to 60 percent (60%) for low voltage power and control cables. 30 percent (30%) spare capacity of cross-sectional area of cable tray shall be maintained in cable trays for future cable installation.

The minimum design vertical spacing for trays shall be 250mm measured from the bottom of the upper tray to the top of the lower tray. At least a 250mm clearance shall also be maintained between the top of a tray and beams, piping, or other obstacles to facilitate installation of cables in the tray. A working space of not less than 600mm shall be maintained on at least one side of each tray.

Solid covers shall be provided for the top tray of horizontal tray runs located outdoors, under grating floor or insulated piping and for all tray routed in areas where coal dust or oil might enter or accumulate.

Vertical cable trays passing through a floor shall have covers for the first 2.5m of cable tray past the floor penetration.

Conduit

Conduit shall be used to protect conductors to individual devices, in hazardous areas, and where the quantity of cable does not economically justify the use of cable tray.

Electrical metallic tubing (EMT) shall be used indoors in non-hazardous areas for lighting branch circuits and communication circuits.

PVC conduit shall be used for duct banks and for some below grade concrete encased conduit.

Liquid-tight flexible metallic conduit shall be used for connections to accessory devices including, but not limited to solenoid valves, limit switches, pressure switches for connections to motors or other vibrating equipment, and across areas where expansion or movement of the conduit is required.

All other conduit shall be rigid galvanized steel (RGS) or intermediate metal conduit (IMC), unless specific environmental requirements dictate the use of plastic or aluminium.

Exposed conduit shall be routed parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical conduit bends or fittings.

Conduit shall be sized in accordance with the IEC (or NEC).

Conduit shall be securely supported within 1m of connections to boxes and cabinet and in accordance with the following table:

Conduit Size	Maximum Distance Between Supports / meters
13 mm through 32 mm	2.5
40 mm and larger	3

Duct Banks

Underground duct banks shall be used for cable routed between buildings/structures and other remote areas as necessary.

All underground duct banks shall consist of Type DB (can be directly buried) plastic conduit encased in concrete. The nominal diameter of the plastic ducts shall be 100mm, unless otherwise required. A galvanized steel conduit shall also be installed where required for digital and analog low-level circuits requiring noise immunity from adjacent power circuits.

Duct bank risers and conduit from manholes to the equipment at remote locations shall be changed to rigid steel prior to emerging from below grade. All below grade steel conduit shall be encased in concrete or other suitable material.

Ducts shall be sloped to manholes to provide adequate drainage. Low spots in duct runs shall be avoided.

Reinforced concrete manholes, handholes, and vaults shall be provided, where required, so that cable may be installed without exceeding allowable pulling tensions and cable sidewall pressures. Each manhole shall have the following provisions:

1. Attaching cable pulling devices.
2. Racking cables.
3. Manhole covers shall be of sufficient size to loop feed the largest diameter cable through the manhole without splicing.
4. Sealed bottoms and sumps.
5. Water stops at duct bank entrances.

6.15 POWER AND CONTROL WIRING

Design Conditions

Cable feeders from 6.6kV power equipment shall be sized so that a three-phase short-circuit fault at the terminals of the load shall not result in damage to the cable prior to normal operation of fault interrupting devices.

Single conductor cables for service above 3kV shall be shielded, thereby accomplishing the following results:

1. Confinement of the dielectric field within the cable.
2. Obtaining a symmetrical radial distribution of voltage stress within the dielectric.
3. Reducing the hazard of shock to personnel.
4. Allowing circuits to be dc high potential tested after installation.

Instrument cable shall be shielded to minimize electrical noise attenuation as follows:

1. Aluminium-polyester tape with 100 percent (100%) coverage and copper drain wire shall be used for shielding.
2. Low level analog signal cables shall be made up of twisted and shielded pairs.
3. Digital signal cables shall be twisted.
4. Except where specific reasons dictate otherwise, cable shields shall be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, a point on the terminal block shall be used for connecting the shields.
5. For multi-pair cables utilizing individual pair shields, the shields shall be electrically isolated from each other.

To be effective, instrument cable shields shall be grounded on one end as follows:

1. The shield on instrument circuits shall be earthed at the power supply end.

2. The shields on earthed as well as unearthed thermocouple circuits shall be earthed at the thermocouple well, unless dictated otherwise by the control equipment supplier.
3. Multipair cables used with thermocouples shall have individually isolated shields so that each shield shall be maintained at the particular couple earth potential.
4. Each resistance temperature detector (RTD) system consisting of one power supply and one or more RTD shall be earthed at only one point.
5. RTDs embedded in windings of transformers and rotating machines shall be earthed at the frame of the respective equipment. The shields shall also be earthed at the equipment, unless dictated otherwise by the control equipment supplier.
6. The low or negative potential side of a signal pair shall be earthed at the same point where the shield is earthed. Where a common power supply is used, the low side of each signal pair and its shield shall be earthed at the power supply.

Conductors

All current carrying conductors, except for thermocouple wiring, shall be copper.

The maximum ampacity for any cable shall depend upon the worst case in which the cable shall be routed (tray, conduit, duct, or direct buried). In addition to ampacity, special requirements such as voltage drop and available fault current shall be taken into consideration in sizing of cable.

The allowable ampacity of power cables shall be in accordance with IEC and ICEA or NEC) requirements.

Cable Constructions

Cable insulation and construction shall be as follows.

<u>Flame Retardant</u>

To minimize the damage that can be caused by a fire, insulated conductors installed in cable tray shall have non-propagating and self-extinguishing characteristics. These cables shall meet the flame test requirements of IEC 60332 and IEEE 383).

<u>Sunlight Resistance</u>

Cable used in outdoor application and exposed to sunlight shall be provided with jacket material resistant to the damaging effects of sunlight and ultra violet radiation.

<u>Medium Voltage Power Cable</u>

Single conductor shielded power cable, with stranded copper conductor, Cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulation, and flame retardant polyvinyl chloride (FR-PVC) jacket shall be used on service above 6000V. The insulation level versus service voltage shall be as follows:

Service Voltage	ICEA Insulation Level
6.6 kV	6 kV 100 percent

This cable shall be suitable for installation indoors or outdoors, in trays, conduits, or ducts.

600 Volt Power Cable

Cable with 600/1,000 V rated thermosetting insulation shall be used to feed 240, 415 volt ac, 110V and 220V DC power loads, and 415V AC motor loads.

Loads requiring 3-phase 4 mm^2 to 95 mm^2 conductors shall be fed with a power cable which utilizes three insulated copper conductors utilizing flame retardant or non-flame retardant XLPE or EPR insulation, a bare ground wire, and with an FR-PVC overall jacket.

Loads requiring 120mm^2 and larger conductors shall be fed with single conductor power cable which utilizes stranded copper conductor flame retardant cross-linked polyethylene (FR-XLPE) insulation without an overall jacket.

These cables may be routed in trays, conduits, or ducts.

600 Volt Control Cable

Cable with 600V rated insulation shall be utilized in 240V AC and all DC control, metering, and relaying applications.

Direct current circuits, which are routed underground, shall utilize multiple conductor control cable having 6mm^2, 4mm^2, or 2.5mm^2 stranded copper conductors, XLPE or PVC insulation, and with a FRPVC overall jacket.

Direct current circuits which are routed above ground, and all 240V AC circuits, shall utilize the same construction as below grade dc circuits, as stated above, or may utilize multiple conductor control cable having 6 mm^2, 4mm^2, or 2.5mm^2 stranded copper conductors, tray cable with XLPE/PVC/nylon (NEC type THHN or THWN) insulated conductors, and with an FR-PVC overall jacket.

The conductor size for current transformer circuits shall be 6mm^2 or larger. Cables shall be routed in trays, conduits, or ducts with the constructions indicated.

300 Volt Instrument Cable

Instrument cable shall be used for circuits that require shielding to avoid induced currents and voltages. Cables shall be routed in trays, conduits, or ducts and shall be routed separate from 415V power circuits. The following cable constructions shall be utilized:

1. 300V, single pair and single triad shielded instrument cable, 1.5mm2 (16 AWG) stranded copper conductors; PVC insulation; FRPVC jacket overall.
2. 300V four and eight pair, shielded instrument cable with individually shielded pairs and overall shield, 0.52mm^2 (20 AWG) stranded copper conductors; PVC insulation; FRPVC jacket overall.

Thermocouple Extension Cable

Thermocouple extension cable shall be used for extension leads from thermocouples to junction boxes and to instruments for measurements of temperature. Cables may be routed in trays, conduits, or ducts.

The following cable construction shall be utilized:

1. 300V, one, four, and eight pair, solid alloy conductor with the same material as the thermocouples, with shield over each pair (except for one pair construction) and with an overall shield, 1.5mm^2 on one pair, 0.5mm^2 on four and eight pairs; PVC insulation; FRPVC jacket overall.

High Temperature Cable

High temperature cable shall be used for wiring to devices located in areas with ambient temperatures above 74°C. Cables may be routed in conduit. Cable lengths shall be minimized by terminating the cable at terminal boxes or conduit outlet fittings located outside the high temperature area and continuing the circuit with control or thermocouple extension cable. The following cable construction shall be utilized:

1. Single-conductor control cable; 4mm^2); stranded copper conductor; silicone rubber insulation; braided glass jacket.
2. Single pair shielded thermocouple extension cable; solid alloy conductor with the same material as the thermocouples; 0.5mm^2 ; fluorinated ethylene propylene (FEP) Teflon insulation; FEP Teflon jacket overall.

Lighting and Fixture Cable

Lighting and fixture cable with 600 volt insulation shall be used as follows:

1. Moisture and heat resistant polyvinyl chloride or cross-linked synthetic polymer (NEC Type XHHW) with copper conductor for 240 volt circuits in outdoor or unheated areas. All circuit runs totally in conduit.
2. Moisture and heat resistant thermoplastic (NEC Type THWN) with copper conductor for 240 volt circuits in heated areas. All circuit runs totally in conduit.
3. Circuit runs for roadway or outdoor area lighting installed in hot galvanized steel conduit, stranded copper conductors, with moisture and heat resistant polyvinyl chloride or cross-linked synthetic polymer conductor insulation (NEC Type XHHW).
4. Fixture wire, silicone rubber insulation, braided glass jacket (NEC Type SF-2), with copper conductor,

Lighting and fixture cable designations and conductor sizes shall be identified on the drawings. Minimum conductor size shall be 2.5mm^2.

Earthing Cable

Earthing cable shall be moisture and heat resistant PVC or thermoplastic (NEC Type THW or THHN) insulated and un-insulated copper conductors sized as required.

Switchboard and Panelboard Cable

Switchboard and panelboard cable shall be insulated for 600V with FR-XLPE or FR-EPR moisture resistant insulation.

Special Cable

This type of cable includes, but not limited to cable supplied with equipment, prefabricated cable, coaxial cable and communication cable. This cable shall normally be supplied by a particular manufacturer.

Special cable shall be routed in accordance with manufacturer's recommendations.

Miscellaneous Cable

If other types and construction of cable are required as design and construction of the unit progress, they shall be designated and routed as required.

Testing Requirements

Preoperational tests shall be performed on all insulated conductors after installation:

1. All insulated conductors with insulation rated 4000V and above shall be given a field dc insulation test after installation as specified in Part 6 of ICEA Standard S-68-516.
2. Cables with 300V or 600V rated insulation shall be either insulation resistance tested prior to connecting cables to equipment or functionally tested (at equipment operation voltage) as part of the checkout of the equipment system.

Installation

Cable installation shall be in accordance with the following general rules:

1. Cables and conductors shall be routed continuously in raceway with no gaps in the raceway.
2. Cables shall be routed as indicated in the circuit list. Each circuit shall be assigned a unique number.
3. The pulling tension of cable shall not exceed the maximum tension recommended by the cable manufacturer, and the sidewall pressure at a bend shall not exceed the cable manufacturer's recommendations.
4. Both ends of all circuits shall be identified with a unique circuit number. Circuits shall also be identified in junction boxes, pull boxes, manholes and handholes.

Connectors

This subsection defines methods of connecting cable between electrical systems and equipment. In this subsection, the term "connector" applies to devices that join two or more conductors or are used to terminate conductors at equipment terminals to provide a continuous electrical path.

Connector material shall be compatible with the conductor material to avoid the occurrence of electrolytic action between metals.

Connectors shall meet IEC connector requirements (bolt hole requirements of Paragraph CC1-4.05 of NEMA standard publication for Electric Power Connectors, Publication CC1).

Power cables shall utilize pressure type crimp connectors except when terminating to devices which are normally provided with clamp type connectors, such as molded case circuit breakers.

Medium voltage shielded cables require stress cones at the termination of the cables and at points where cables are spliced. Stress cones shall be of the preformed type suitable for the cable to which they are to be applied.

6.16 LIGHTING

The lighting system shall provide personnel with illumination for plant operation under normal conditions, means of egress under emergency conditions, and emergency lighting in the control room to perform manual operations during a power outage of the normal power source. The power supply for the lighting system shall be from 415V, 3-phase, four wire lighting panelboards. Emergency lighting in the generating complex shall be powered from 220V DC. Emergency lighting in normally occupied buildings shall be powered from self-contained batteries within emergency lighting units. Power used to supply outdoor roadway and area lighting fixtures shall be at 240V AC.

Light Sources

The lighting system shall be designed in accordance with the Illuminating Engineering Society (IES) to provide illumination levels as specified herein, as summarized in Table 6.17-1 (Illumination Levels) and as required by the standards and organizations set out below.

Light fixtures shall be in accordance with IEC 60598 and IEC 60570. Light sources and fixture selections shall be based on the applicability of the luminaries for the area under consideration. All light fixtures shall be selected and installed to provide zero up-light to minimize light pollution to the outdoor environment.

Three types of lamps shall be used for the light sources in the lighting system, including fluorescent, high-pressure sodium or other high intensity discharge (HID) type, and incandescent. Generally, fluorescent lamps shall be used in indoor, enclosed areas; high-pressure sodium or other HID lamps shall be used outdoors; and incandescent lamps shall be used for emergency lighting.

Table 6.16-1
Illumination Levels

Interior Location		Illumination (LUX)
Air Conditioning Equipment, Air Preheater and Fan Floor, Ash Sluicing		100
Assembly Rooms		1000

Table 6.16-1 Illumination Levels		
Interior Location		**Illumination (LUX)**
Auxiliaries, Battery Rooms, Boiler Feed Pumps, Tanks, Compressors, Gauge Area, Inverter Rooms		200
Boiler Platforms		100
Burner Platforms		200
Cable Room, Circulator, or Pump Bay		100
Chemical Laboratory		1000
Coal Conveyor, Feeder, Scale Areas, Pulverizer, Fan		100
Condensers, Deaerator Floor, Evaporator Floor, Heater Floors		100
Control Rooms and Offices		500
Control Room Emergency Lighting		150
Hydrogen Manifold Area		200
Precipitator Area		100
Soot Blower Platform		100
Switchgear, Power		200
Toilets		300
Turbine Building		200
Operating Floor of Turbine Building		300
Water Treatment Building		200
Indoor Desalination Areas		200
Catwalks		20
Coal Storage Area		1
Coal Transfer Towers		100
Coal Tripper Rooms		100
Conveyors		20
Roadway:		
Between or along buildings or structures		10
Not bordered by buildings or structures		5

For design purposes, lighting is categorized by the following areas:

1. Indoor unfinished areas.

2. Outdoor areas.
3. High bay.
4. Roadway and area.
5. Egress and emergency.
6. Hazardous.
7. All control rooms.
8. Construction.
9. Aviation obstruction.

Indoor Unfinished Areas
This category includes indoor areas in outlying structures such as electrical equipment rooms and storage rooms. These areas shall generally be lighted using industrial fluorescent fixtures.

Outdoor Areas
This category includes most of the bays of the generation structures such as the ground floor, boiler platforms, and operating floor lighting of equipment located outdoors and outdoor platforms. High-pressure sodium fixtures suitable for use in wet locations shall be used.

High Bay
The turbine operating floor shall be lighted using fixtures with high-pressure sodium lamps.

Roadway and Area
Roadway and area lighting shall be designed using high-pressure sodium light sources. The light fixtures shall be installed on poles.

Egress and Emergency
Adequate emergency lighting shall be provided to enable safe operation and exit from the Plant on failure of the main lighting. Emergency lighting shall be required in all operating areas.

Green internally illuminated EXIT signs shall be provided at emergency exit doors and where required to guide people to emergency exits. The emergency lighting systems primarily consists of lights fed directly from the DC station battery for control room, electrical, and computer equipment room areas. This system shall be supplemented by self-contained battery pack units and emergency lights, the self-contained battery pack units shall be 2-hour rated with nickel cadmium cells. Testing facilities shall be provided as an integral part of these units, each battery shall be automatically maintained charged by a mains power supply dedicated to emergency lighting circuits.

Each emergency light shall switch on automatically upon loss of its battery charger power supply and on failure of the local area lighting when the average residual lighting level is below twice the minimum level specified for the emergency lighting and switch off at four times the minimum level.

Buildings equipped with artificial illumination shall have adequate and reliable illumination provided for egress to exit facilities. The emergency lighting system shall be used in the generating complex for such areas as the control room where illumination is required to perform manual operations during a power outage of the normal source. The egress and emergency lighting shall be powered from 220V DC source upon failure of the normal power source. Emergency lighting units with self-contained batteries shall be used in normally occupied buildings.

Hazardous Area

Illumination for the enclosed coal handling areas shall be provided with fluorescent and/or high-pressure sodium light sources installed in dust-ignition proof NEC Class II, Group F, Division 1 light fixtures.

Control Room

The control room lighting shall consist of general area, control area, emergency, and exit lighting. Control room general area lighting and control area lighting shall be provided by fluorescent light fixtures. The fixtures shall be powered from the plant reliable service. The emergency light fixture shall be normally "on". The emergency lighting units shall be 220V DC battery operated. Exit lighting fixtures shall be incandescent.

Aviation Obstruction

Aviation obstruction lighting shall be provided in accordance with the requirements of Aerodromes (Annex 14 to the Convention of International Civil Aviation) and with the applicable local regulations. Aviation obstruction lighting system shall be installed on the chimney.

Lighting Control

Electric power to light fixtures shall be switched with wall mounted light switches in areas where the light can be "off" when the area is not occupied. Wall mounted switches shall be provided at the entrance to storage, battery, and equipment rooms.

Electric power to light fixtures in the generating complex shall be switched at the panelboard.

Electric power to light fixtures located outdoors shall be switched with photoelectric controllers.

Lighting Fixture Supports

In plant areas below the operating floor and areas that are congested with piping, raceway, and overhead equipment, the lighting fixtures shall be supported from continuous row Unistrut type channel. In other areas of the plant, light fixtures shall be supported by rigid steel conduit pendants where they cannot be mounted directly on the underside of decks, on structural steel, or in finished ceilings.

Wiring Devices

Convenience outlets throughout the indoor areas of the plant and in the outlying structures shall be earthing type receptacles. Convenience outlets located outdoors shall be provided with weatherproof snap-action covers. The outlets shall be spaced to provide access to almost any point in the plant or structure with a 15m extension cord.

In hazardous locations, except for coal handling areas, convenience outlets shall be suitable for the NEC class and group requirements.

Switches used throughout the plant shall be rated for 125 percent (125%) of connected load with enclosures suitable for the location in which they are installed.

Power outlet Sockets

Stores, workshops, the turbine halls, unloading bay areas and rooms containing relays and switchgear shall also have three phase socket outlets rated not less than 20A at intervals not exceeding 20m along the walls and 0.5m above workbenches in workshops. These shall be additional to outlets required for building services, operational and general equipment requirements. These power outlet sockets are to be provided in accordance with the relevant Bangladesh standards.

All items of outdoor plant shall have one single phase and one three phase socket outlet installed at a convenient junction box within 20m of it. The junction box shall be shared with cabling for the plant or outdoor lighting, but shall not be inside a cubicle containing moving parts such as mechanism boxes associated with equipment.
Residual current devices shall be fitted to all sockets that shall be used to supply equipment or appliances located either outdoors or in a wet or damp environment.

6.17 PROTECTIVE RELAYING

The purpose of this section is to describe the design criteria to be used in the selection and application of protective relaying for the electrical generation and distribution power system.
Generator terminal system, connections to the primary power supply system, turbine generator system, and the electrical loads powered from these systems. Protective relaying and monitoring for all protective relaying applications shall be selected in compliance with Prudent Utility Practices, to provide detection and corrective/isolation action.

The following general requirements apply to all protective relaying applications:

1. Protective relay shall be designed to remove or alarm abnormal operating occurrences occurring on equipment designed for electrical power generation, voltage transformation, energy conversion, and transmission and distribution of electrical power.
2. To limit damage to faulted equipment.
3. To minimize possibility of fire or explosion.
4. To minimize hazard to personnel.

Protective relaying shall be a coordinated application of either individual relays, multifunction relays, or a combination of individual and multifunction relays. For each monitored abnormal condition, there shall be a designated primary device for detection of that condition.

Primary and backup protection shall not be included in the same multifunction protection relay.

A failure of any primary relay shall result in the action of a secondary overlapping scheme to detect the effect of the same abnormal occurrence. The secondary relay may be the primary relay for a different abnormal condition. Alternate relays may exist which detect the initial abnormal condition but which have an inherent time delay so that the alternate relays shall operate after the primary and secondary relays. Similar to secondary relays, the alternate relays may be primary relays for other abnormal conditions. All protective relays shall be selected to coordinate with protective devices supplied by manufacturers of major equipment and the thermal limits of electrical conductors and electrical equipment, such as transformers and motors.

Secondary current produced by current transformers shall be in the 1 ampere range, and voltage signals produced by voltage transformers shall be in the 100V range.

Generator Protection

A fully redundant protective relay and monitoring system shall be provided to minimize the effects from generator faults and malfunctions. Two (2) fully redundant and independent multi-function microprocessor relays shall be provided for each steam turbine generator. Protective relaying and monitoring shall be selected to provide, as a minimum, detection and corrective/isolation action as required for the faults and malfunctions for the generator classifications, including:

Steam Turbine Generator:

1. Generator phase faults.
2. Generator stator ground faults.
3. Stator unbalanced currents (Negative sequence).
4. Loss of excitation.
5. Backup protection with distance relay for external system faults.
6. Reverse power.
7. Generator voltage transformer circuit monitoring.
8. Under frequency.
9. Under voltage.
10. Over voltage, phase and neutral
11. Out-of-step.
12. Inadvertent energization of the generator from the primary power system.
13. Synchronism check

Emergency generator:

1. Generator phase faults.
2. Generator stator ground faults.
3. Stator unbalanced currents (Negative sequence).
4. Loss of excitation.
5. Reverse power.
6. Under frequency.
7. Under voltage.

8. Over voltage.
9. Inadvertent energization of the generator from the primary power system (if applicable)

The steam turbine generator package shall be purchased with equipment to protect against the following:

1. Under excitation (Excitation package).
2. Over excitation (Excitation package).
3. Generator field ground faults.
4. Exciter field ground faults.
5. Excessive volts per hertz.
6. Generator overheating.
7. High bearing temperatures.
8. Over speed conditions.
9. Excessive vibrations.

Generator lockout relays shall be used to receive signal inputs from protective relays and to provide the contacts needed to initiate protective action and alarms. Redundant protection relays shall be provided with separate lockout relays.

Power Transformer Protection

Generator Step-Up Transformer

The generator transformer system of protection shall be provided with devices to detect and take appropriate action against the effects of, amongst others, the following conditions:

1. Phase faults.
2. Ground faults.
3. Sudden pressure.
4. Excessive tank pressure.
5. Oil level.
6. High temperature.

Lockout relays shall be used to receive signal inputs from protective relays and to provide the contacts needed to initiate protective action.

Unit Auxiliary Transformers

The main unit transformer system of protection shall be provided with devices to detect and take appropriate action against the effects of, amongst others, the following conditions:

1. Phase faults.
2. Ground faults.
3. Overloads.
4. Sudden pressure.
5. Excessive tank pressure.
6. Oil level.
7. High temperature.

Dedicated lockout relays shall be used to receive signal inputs from protective relays and to provide the contacts needed to initiate protective action.
For Standardization of Operation, Performance, facilities and spares requirements the main protective relays and control system (SAS) including complete panels to be supplied under this project shall comprise Alstom (France/UK), ABB (Switzerland/Sweden), Siemens (Germany) and Mitsubishi (Japan) make manufacture.

Metal-Clad Switchgear and/or High Voltage MCC
A summary of the protective functions used in the auxiliary electrical system medium voltage metal-clad switchgear lineups and/or high voltage motor control center lineups are discussed in the following paragraphs. The relays for the auxiliary electrical protective relay system shall be selected and set to provide a coordinated tripping philosophy to mitigate the faulted condition.

Bus and Incoming (Source) Breakers
Each incoming (source) breaker shall be provided with protective relay type devices. These devices may be single element type relays or multifunction relays. The incoming breakers and bus shall be provided with devices to detect and take appropriate action against the effects of, amongst others, the following conditions:

1. Phase faults.
2. Ground faults.
3. Overloads.
4. Source side voltage
5. Load bus under voltage.

For transfer of auxiliaries during normal operator actions, the control and protective relay scheme shall be an automatic fast transfer with automatic tripping of the previous source. Synchronism check relays shall be used as required to prevent paralleling alternate sources that are out-of-phase with each other. An anti-parallel scheme shall prevent the two (2) sources of power to the switchgear from being parallel for an extended period of time.

Each switchgear shall be equipped with a bus differential relay.

Remote Switchgear or High Voltage Motor Control Center Feeder(s)
Each remote switchgear or high voltage motor control center feeder shall be provided with protective devices to detect and take appropriate action against, amongst others, the effects of the following conditions:

1. Phase faults.
2. Ground faults.
3. Overloads.

Secondary Unit Substation Feeder(s)

Each secondary unit substation transformer shall be provided with protective devices to detect and take appropriate action against the effects of, amongst others, the following conditions:

1. Phase faults.
2. Ground faults.
3. Overloads.

Motor Feeder(s)

Each motor feeder shall be provided with protective devices to detect and take appropriate action against the effects of, amongst others, the following conditions:

1. Phase faults.
2. Ground faults.
3. Overloads.
4. Current unbalance
5. Stator winding temperature monitoring
6. Motors rated 6.6 kV above 3 MW shall also be equipped with a discrete motor differential relay using a self-balancing relay scheme.

The required rating of motors shall be proposed by the Contractor based on the engineering and design requirements for the Plant and in accordance with Prudent Utility Practices.

415/240 Volt Secondary Unit Substations

Overload, phase fault and ground fault protection for loads connected to the 415/240V secondary unit substations (SUS) shall be provided by solid-state trip devices which are an integral part of draw-out type air circuit breakers or by magnetic or solid state trip devices as part of molded case circuit breakers.

Breakers supplying motors or other devices which do not require coordination with downstream trip devices shall have adjustable long-time and instantaneous elements for phase protection.

Main breakers, tie breakers, and breakers supplying motor control centers or other loads which contain trip devices shall have adjustable long-time and short-time solid-state trip devices elements for phase protection for air circuit breakers or integral trip device for molded case circuit breakers. The pickup point and time settings shall be adjustable to allow for proper coordination with all downstream trip devices.

415 Volt Motor Control Centers

Each magnetic starter within a motor control center which supplies power to a motor shall be equipped with a magnetic-only molded case circuit breaker and thermal overload protection in the starter to protect motors against overload.

Certain loads shall be fed from motor control center feeder circuit breakers. The breakers shall be thermal magnetic molded case breakers sized to protect supply cable and individual loads.

415 Volt Power Panels

Power panels shall be supplied with thermal-magnetic circuit breakers sized to protect supply cable and individual loads.

6.18 CLASSIFICATION OF HAZARDOUS AREAS

Areas where flammable and combustible liquids, gases, and dusts are handled and stored shall be classified for the purpose of determining the minimum criteria for design and installation of electrical equipment to minimize the possibility of ignition. The criteria for determining the appropriate classification are specified in IEC 60079-*10 Electrical apparatus for explosive gas atmospheres - Classification of hazardous areas* and IEC 61241-*10 Electrical apparatus for use in the presence of combustible dust — Part 10 Classification of areas where combustible dusts are or may be present*. The application of these criteria to specific areas at generating stations is provided in IEC 60079 part of application and IEC 61241 part of application.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 7 – CONTROL AND INSTRUMENTATION

CONTENTS

7 CONTROL AND INSTRUMENTATION

This section covers the design criteria and requirements for all Plant Control works related to the Project. The indicative Plant Control System Configuration is shown in drawing No. 10-PE-PAY-03 as attached in Attachment B4 of Section 5.

7.1 I&C OBJECTIVES

The following are the overall I&C objectives to be fulfilled via the DCS system;

i) Centralized control mode shall be adopted for the boiler, turbine and generator. The two 2 x 660MW units shall share one central control room, which is located inside the centralized control building between the two units.

ii) The electrical network control information is displayed in the central control room.

iii) Centralized monitoring shall also be adopted for the BOP systems. The Contractor shall set up a centralized control point for whole plant BOP system to realize centralized monitoring of the whole plant BOP systems including water treatment, coal handling, ash handling systems, etc.

iv) The flue gas desulfurization system for the two 2 x 660MW units shall be included in the main DCS for centralized monitoring. Control point shall be set in the central control room.

v) Realise the complete monitoring facilities with LED screens/keyboard and large displays, for 2-3 monitoring personnel;

vi) Provide closed circuit television monitoring system and access control management system for the entire plant. Unit, function group and function subgroup control shall be streamlined for DCS sequential control and/or hierarchical co-ordination.

vii) Provide unit start/stop in the central control room with the co-ordination of a few on-spot patrol personnel. The central control system shall be with complete monitoring and adjustment operations functionalities during normal running including alarm and handling under any abnormity or emergency;

viii) To use coordinated control system to ensure that the steam turbine generator and boiler operate as a whole and respond to changes in load and coordinate each control sub-system within the variation range of permissible load, so as to remove the various interferences generated during the operation and maintain a stable range of the major operational parameters.

ix) Capable of, among others

- automatic status scanning
- plant signal and data processing
- start-up/stop functionalities
- manage regular operations and unusual operatinal conditions

- performance computations
- provision of operational instruction for personnel
- automatic alarming when parameters goes beyond range
- event sequence recording
- printing of historical events
- trending for a certain period before and after an event in case of tripping;
- Set point setting.

x) Integrate monitoring system into the DCS to realize centralized control of boiler, generator and turbine;

xi) BOP systems, among others (includes Water treatment system, Ash handling system, Coal handling system etc.) will be controlled by PLC.

xii) Monitoring of all the relevant systems shall be integrated to the DCS system.

7.2 DCS EQUIPMENT LAYOUT AND CONFIGURATION

The Bidder shall propose the Control Room layout and functional structure. The following describes the possible system interfacing, functionalities and layout configuration to be considered by the Bidder:

i) The central control room of the Plant shall be located in the front of the operation floor of centralized control building; on the same floor are the DCS and DEH (Digital Electro-hydraulic Control System), engineer room, shift charge room and PIS (Plant Information System) room. Central electronic room shall be located in the rear of the operation floor of centralized control building. Cable interlayers shall be provided for both central control room and central electronic equipment room.

ii) The electronic equipment room shall be provided with DCS RTU, DEH control machine cabinet, protection cabinet, power source cabinet, ETS, TSI and dedicated device control cabinets. Engineer room shall be provided with two sets of DCS, DEH and engineering work station for the auxiliary control network. PIS room shall be used for placement of the PIS server cabinet and work station.

iii) LED screens/keyboard and large size projector shall be provided for control. Operations desk shall be set inside the central control room, as major monitoring platform for the operational staff. DCS Operator Stations shall be installed in the Central Control Room along with emergency push buttons for the safe shutdown of the boiler, steam turbine and other important auxiliary emergency systems. The central monitoring wall with the large size projection, furnace flame television, entire plant industrial CCTV and large size parameter display, shall be placed at the front of operational desk. The fire alarm and coordinated control panel shall be also placed inside the central control room.

iv) The operational desk of the central control room shall be provided with displays, operator stations for auxiliary control network, entire plant industrial CCTV and electrical engineering related information.

7.3 DESIGN CODES AND STANDARDS

Design and specifications of all works shall comply with all applicable Laws and applicable codes. A summary of the major international codes and industry standards to be used in the design and construction are provided as below. In case of conflict between them, the Bangladesh legislation, regulations, and codes are mandatory and represent the required minimum compliance, where compliance to more stringent standards are desirable. Contractor may adopt alternative standards not covered by the list presented below, provided the Contractor has requested and demonstrated to the Employer, and the Employer's satisfaction and approval that such alternative standard as being equivalent to the standards listed below;

1. American National Standards Institute (ANSI).
2. American Society of Mechanical Engineers (ASME).
3. The Institute of Electrical and Electronics Engineers (IEEE).
4. International Society of Automation (ISA).
5. International Electrotechnical Commission (IEC)
6. National Electrical Manufacturers Association (NEMA).
7. National Electrical Safety Code (NESC).
8. National Fire Protection Association (NFPA).
9. Measurement Control and Automation Association (MCAA, formerly SAMA).

Other recognized standards shall be utilized by the Contractor as required to serve as the design, fabrication, and construction guidelines when not in conflict with the above listed standards. If any conflict arises, the more stringent standard shall apply.

7.4 GENERAL REQUIREMENTS

All equipment procured for this project shall be in accordance to the Employer's Requirements or specifically Employer approved for use in this project.

7.4.1 AMBIENT CONDITIONS

Field mounted instruments and control devices shall be designed to withstand the applicable site ambient indoor/outdoor temperature and humidity conditions appropriate to their mounting location or shall be suitably protected. Provisions for ambient conditions may include, among others: corrosion resistance, rain etc.

The evaluated operating conditions for instruments and control devices installed in air-conditioned areas shall include air conditioning failure and shall be designed with a temperature margin allowance for heat buildup inside the enclosure in which the device is mounted.

All equipment, devices and systems provided under this contract shall be acclimatized to the Bangladesh environment at all times.

7.4.2 POWER SUPPLIES

All instruments and control devices shall be designed to operate on power supplies with the following characteristics:

Equipment:

240V AC, 50 hertz, single-phase for logic and low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from – 5% to 10% of the nominal voltage
110V DC for logic and low torque drives.
415V AC, 50 hertz, 3-phase for high torque drives.

Any voltage required other than the above shall be furnished with ‘voltage ttransformers’ when necessary by the equipment supplier.

Instruments:

24 V DC, loop powered where possible

Electrical control System, including vendor packages:

230V AC from UPS or 110 V DC.

Contact Interrogation Voltage:

24 VDC

SOE Contact Interrogation Voltage:

24 VDC (DCS vendor standard).

7.4.3 COMMUNICATION NETWORK PROTOCOLS / PLATFORMS

The Contractor shall select equipment in a manner that minimizes the different types of communication network protocols / platforms used. The Contractor shall submit the network protocols to be implemented in the project to the Employer for his review and approval. Preferable protocols shall be IEC 101 or IEC 104.

7.4.4 STANDARD RANGES OF ANALOG SIGNALS

The ranges of analog signals shall normally be as follows:

1. Electrical: 4 to 20 mA hardwired
2. Pneumatic: 20 to 100 kPaG.
3. Thermocouple: Type E and Type K.
4. RTD’s: 100 Ω pt at 0 °C.

The use of any signal range other than the above shall be avoided unless specifically Employer approved. Pulse input/output signals required by special applications shall be verified during the detail design stages.

7.4.5 CONTACT RATINGS

The ratings of all instrument contacts used for alarm and interlocking shall be coordinated to meet the requirements of the interfacing/interlocking system. The ratings of all solid-state control system output contacts shall be coordinated to meet the requirements of the driven device/equipment. Consideration shall be given to the voltage and current rating, continuous rating, maximum rating (break), and switch rating (break).

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where it is necessary for higher current ratings or isolation, interposing relays shall be used.

7.4.6 LEVEL OF AUTOMATION

Monitoring and control of the Plant equipment shall be centralized in the central control room DCS. Plant start-up, shutdown, normal and abnormal operation shall be monitored and controlled from the central control room DCS operator workstations. DCS system design shall be such that all start-up, shutdown and normal operations, including realignment of redundant trains of equipment, can be accomplished from the central control room with no local manual operator actions except for cleanup operation (which shall include the water cleanup operation applied through the boiler plant on the startup operation), water filling operation and preparation for startup.

The stand-alone equipment package systems shall be equipped with supervisory instrumentation and control equipment near the auxiliary system equipment or in a local control area. The DCS supervising control and monitoring shall be implemented, the parameters, equipment operation status and alarm signals shall be sent to the DCS for display on the central control room operator screens.

7.4.7 BOILER SUPPLIER REQUIREMENTS

The following scope of supply, among others, is expected from the boiler vendor;

- FSSS local equipment, including: Oil gun, igniter/propulsion device, oil valve, local ignition box, etc.
- Furnace flame industrial television, including: Display, camera, cooling system and control device.
- Soot blowing system (controlled by DCS）
- Control device for flue gas temperature probe at furnace outlet
- Actuating mechanism provided by boiler supplier
- Instrumentation and instrument valve provided by boiler supplier
- Turbine DEH system
- Turbine ETS system

- Turbine TSI system
- Turbine turning gear control device
- Instrumentation and instrument valve provided by turbine supplier

Model selection and configuration of the instrument and control equipment provided by the turbine supplier shall meet the entire plant integrated automation level and interface requirements. DEH must use the same hardware as the unit DCS and the control strategy compliance is the responsibility of turbine supplier.

7.4.8 OBSOLESCENCE AND FUTURE UPGRADING OF THE DCS

The DCS will be designed in such a manner that it is possible to be incrementally upgraded at any time during or after its intended operational life cycle. The life cycle of the DCS shall be designed to be at least 10 years with such designs being coordinated with spare parts guarantees from manufacturers for at least 10 years. This highly modular design of the DCS system and its sub-systems is to be demonstrated in detail during the detail design stages for Employer’s approval. The DCS shall be operationally modularized into the following components, among others;

i) MMI sub-system
ii) Database server
iii) I/O panels
iv) Displays
v) Printers
vi) Backbone fibre communications
vii) Operator stations
viii) PCs

The biggest design concern will be the selection and implementation of the DCS backbone fibre protocol that communicates to all the protocol based devices on the DCS architecture network, as shown in the drawings. The protocol, if it is still in use after the DCS life cycle, would require the new components and subsystems added to be only ‘backward’ compatible with this protocol. The choice and details of this protocol implementation shall be subjected to the approval of the Employer.

The Contractor shall provide a ‘hardened version’ of Windows 7 or better operating system for the MMI and database subsystems. However, the database subsystem shall be designed on a distributed architecture basis to keep it modular but functionally integrated. This network level operating system shall be subject to approval by the Employer prior to its implementation.

7.5 INSTRUMENTS

Instrument housings shall be in accordance with IEC or other equivalent or better rating for the area in which the instrument is located. All instruments shall be furnished with individual name tags to identify the instrument tag name and service description. All supplied instruments shall be tagged according to the Project's designated tagging system.

The local instruments shall be calibrated in the factory in accordance with the equipment supplier's standard before it is delivered to Site. The calibration of instruments on-Site shall be performed by the Contractor following the relevant supplier's recommendation. Calibration certificates signed by the Contractor shall be handed to the Employer for verification.

Tubing/piping shall use materials as shown below except where higher corrosion resistance is required. Required higher corrosion resistant materials shall be acceptable to the Employer.

7.5.1 INSTRUMENT PRIMARY PIPING (IMPULSE LINES)

Instrument primary piping/tubing is defined as the piping or tubing directly connected to the process, beginning at the outlet of the root valve and terminating at the blowdown valve, and at the point of connection to the instrument itself. All pipe to tube adapters required for connecting the tubing to the process root valves shall be furnished by the Contractor.

7.5.1.1 INSTRUMENT PRIMARY TUBING

The preferred material for installation of instrument primary tubing is stainless steel tubing using grip type fittings. Socket weld fittings may be used on tubing having 2mm or greater wall thickness. Changes in instrument primary tubing direction shall utilize tube fittings, or for 1.65mm wall thickness, tubing may be bent.

7.5.1.2 INSTRUMENT PRIMARY TUBING DESIGN PRESSURE AND TEMPERATURE

Instrument primary tubing design pressure and temperature shall be selected consistent with the requirements discussed in sub-clause 5.2 (Piping) of Chapter 5 of this Employer's Requirements for the process pipe to which the instrument primary tubing is connected, and in accordance with ANSI/ASME B31.1.

7.5.1.3 SIZES OF INSTRUMENT PRIMARY TUBING

Instrument primary tubing size shall be as follows:

1. Pressure measurement tubing shall be 12.7mm minimum outside diameter with minimum wall thicknesses of 1.24mm, 1.65mm or 2.1mm, depending on the pressure and temperature of the process.
2. Flow and level measurement by differential pressure shall also use primary tubing conforming to the above requirements.

Direct manifold mounting of the instrument to the manifold is preferred.

7.5.1.4 MATERIALS FOR INSTRUMENT PRIMARY TUBING

Materials for instrument primary tube shall be ASTM A213, GR TP316 seamless tubing. The Rockwell hardness shall not exceed 90 Rb Rockwell. ASTM A213 EAW and ASTM A269 are not acceptable materials. Other types of stainless steel materials such as 316L or 446 may be utilized for the design due to environmental considerations such as seawater exposure.

7.5.1.5 SUPPORT OF INSTRUMENT TUBING

Instrument primary tubing shall be supported in accordance with ASME B31.1. In general, 20mm or smaller OD stainless steel tubing shall be supported continuously and shall not exceed 1.5m in horizontal runs or 3m in vertical runs, or shall be continuously supported in tube tray. The support system shall allow for thermal expansion of tubing and equipment.

Pneumatic signal and air supply tubing shall be continuously supported.

Instruments shall be mounted 1.3m (+/- 150mm) from grade or platform. Piping and tubing shall be installed with a minimum of 2.25m of headroom over passageways and walkways, whenever possible.

7.5.1.6 INSTRUMENT PRIMARY PIPING/PIPE

Instrument primary piping shall only be used when specified as a contract requirement or to physically support the instrument and shall normally be all socket welded.

7.5.1.7 INSTRUMENT PRIMARY PIPING DESIGN PRESSURE AND TEMPERATURE

Instrument primary piping design pressure and temperature shall be selected consistent with the requirements discussed in sub-clause 5.2 (Piping) of Chapter 5 of this Employer's Requirements for the process pipe to which the instrument primary piping is connected. The following criteria shall also apply:

1. Instrument primary piping for flowing steam systems shall be designed for the maximum sustained process design pressure and the maximum sustained process system temperature.
2. Instrument primary piping for other than steam systems shall be designed for the appropriate sustained process system design pressure and the appropriate sustained process system design temperature.

7.5.1.8 SIZES OF INSTRUMENT PRIMARY PIPE

Instrument primary piping shall not be smaller than the connection at the process pipe root valve and/or the following, where applicable:

1. Pressure connections for steam and feedwater applications shall be 12.7mm socket weld (process) and threaded (instrument).
2. Pressure connections for all other pipe applications shall be 12.7mm socket weld (process and instrument).
3. Temperature connections for steam applications shall be 40mm socket weld.
4. Temperature connections for all other pipe applications shall be 25mm threaded.
5. Level switch connections shall be 25 mm socket weld.
6. Level controllers and level transmitters of the displacement type shall be 50mm socket weld.
7. Level controllers and level transmitters of the differential pressure type shall be in accordance with the pressure connections above.
8. Instrument columns at tanks and pressure vessels shall generally be 65mm minimum.
9. Flow transmitter connections shall be 25mm socket weld. Except for orifice flange applications which shall be 13mm threaded.
10. All instrument connections for air and flue ducting shall be 50mm threaded half couplings. Pressure connections shall include arrangement for plugged cleanout ports.

7.5.1.9 MATERIALS FOR INSTRUMENT PRIMARY PIPE

Material for instrument primary piping connecting to the root valve shall preferably be the same as that used between the system process header and the root valve. Higher strength materials may be substituted in the interest of standardization; however, welding procedures at the point of joining the instrument primary piping to the root valve must be appropriate to the combination of materials involved. Copper or brass may be used only for compressed air or for water services that use copper, brass, or nonmetallic process piping.

7.5.1.10 SUPPORT OF INSTRUMENT PIPE

Instrument primary piping shall be supported consistent with the requirements in sub-clause 5.3 (Pipe Support and Hangers) of Chapter 5 of this Employer's Requirement.

7.5.1.11 INSULATION OF INSTRUMENT PRIMARY PIPING/TUBING

Instrument primary piping/tubing connecting to high temperature systems, which might become hot enough to injure personnel during blowdown of the instrument line, shall be insulated where such hazard exists. Insulation materials, exterior finish, and metal lagging shall conform to the standards adopted for the process piping.

7.5.1.12 CRITERIA FOR ROUTING OF INSTRUMENT PRIMARY PIPING/TUBING

Routing of instrument primary piping/tubing, including piping from the process connection through the root valve and the instrument primary piping/tubing, shall be in accordance with the following criteria.

Special fittings such as reservoirs and other devices shall be installed at differential pressure connections as required by the process parameter to be measured and the design of the instrument.

Pressure sensed by the instrument shall differ from pressure in the process if there is a head of liquid in the instrument line. This effect may be significant if the instrument line static head is large in comparison with the pressure being sensed. This effect can be accounted for in calibration of the instrument if the static head is constant. To assure a constant static head, the connections from low-pressure steam and low-pressure liquid filled lines shall preferably slope downward continuously from the primary element connection to the instrument. Horizontal runs shall have a slope of not less than 1:24 and shall be adequately supported to maintain a constant slope. If downward slope is not feasible, the line shall slope upward continuously and a loop seal (steam service only) shall be installed at the instrument to assure a water seal for temperature protection. Upward sloping liquid lines shall be used only if the process pressure is sufficient to assure a head of liquid at the instrument. Provision for venting of air shall be provided in the high point of the line, preferably at the instrument. Upward sloping steam lines shall not be less than 25mm size. Vacuum connections to the condenser and low-pressure extractions shall always slope upward to the instrument.

Instrument primary piping/tubing for steam flow, liquid flow, and manometer level measurement systems should preferably slope downward from the primary element connections to the instrument. Instrument primary piping/tubing for fuel gas, compressed air, flue gas, and airflow measurement systems should preferably slope upward from the primary element connections to the instrument. If these requirements cannot be met, special venting or drain provisions shall be required.

Pressure taps shall be located on the top or side of steam, gas, or air piping, and on the top (if pressure is high enough to vent any air in the instrument line) or side (preferred) of liquid filled piping. Pressure taps on boiler gas and air ducts shall be located on the top or side to permit draining condensation.

Air purge devices shall be provided on instrument primary piping used for flue gas measurements which may be susceptible to pluggage.

7.5.2 THERMOWELLS AND PROTECTING TUBES

The selection, construction, and location of thermowells shall be in accordance with the recommendations and standards set forth in the following references:

1. ASME PTC19.3: Temperature Measurement.
2. ANSI/ASME B31.1: Power Piping.
3. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

Thermowells shall be selected to provide the insertion lengths recommended in the ASME PTC appropriate to the process being monitored. For applications not covered by PTC recommendations, the tip of the thermowell should normally extend into flowing pipelines not less than 75mm, but not beyond the pipe center line. Shorter insertion lengths may be used where the thermowell structural integrity (pressure and vibration) dictate the design.

Two methods are generally used to install thermowells in pipe:

1. Perpendicular to the pipe.
2. For lines smaller than 100mm, a short section of expanded 100 mm pipe shall be provided for installation of the thermowell.

Thermowells shall generally be installed into welded forged steel screw end adapters. Pipe couplings shall not be used.

Fluid system temperature sensors shall be equipped with thermowells. On pressure parts fabricated from 316 stainless steel, thermowell shall be made of one piece, solid bored type 316 stainless steel of stepless tapered design in accordance with ASME PTC 19.3. On pressure parts fabricated from materials other than 316 stainless steel, thermowell will be made from compatible corrosion resistant material and shall be made of one piece, solid bored of stepless tapered design in accordance with ASME PTC 19.3. Where the process conditions require (i.e. where design pressures are higher than 10MPa or design temperatures are higher than 500°C), threaded temperature wells are to be engaged and seal welded in accordance with ASME B31.1. Normal bore diameter shall be sized to accommodate 8 mm sheaths. Maximum bore internal diameter shall be 9.8mm.

Thermowells in main steam, hot and cold reheat steam, auxiliary steam, extraction steam, and feedwater piping shall be designed to prevent damage caused by vortex-induced vibration over the range of velocities encountered in normal service in accordance with ASME Performance Test Code 19.3, Temperature Measurements.

Thermowells in P91 and other high chromium alloys may be shop welded in to the pipe and fabricated of the same material as the pipe, prior to the steam blow. All thermowells in steam piping shall be permanently installed (welded or threaded with seal welding) before steam blow. All other thermowells shall be installed prior to hydrostatic testing.

Test wells shall be provided on main steam, reheat steam, extraction steam, feedwater, condensate, and other piping as required to meet ASME or other Project designated test requirements.

Temperature detectors in boiler gas and air ducts shall be mounted in protecting tubes to provide mechanical support and to permit replacement while in operation. Protecting tubes shall be made of Type 316 stainless steel pipe not smaller than 13mm size, with screwed pipe bushings welded to the tubes for attachment to the ducts. The protection tubes are enclosed on the gas sensing end. Duct connections shall consist of screwed couplings or adapter flanges welded to the ducts, into which the bushings on the protecting tubes can be threaded. Duct connections shall be located to minimize the effect of temperature stratification within the ducts. Protecting tubes exceeding 1m in length shall be provided with additional supports within the boiler casing or duct. Alternate materials such as Yoloy (nickel-copper alloy steel), 316L stainless steel, or 446 stainless steel may be considered for applications downstream of FGD scrubbers.

7.5.3 THERMOCOUPLES AND RESISTANCE TEMPERATURE DETECTORS

Project temperature measurements for remote use shall be by temperature detectors.

Temperature detectors will preferably be thermocouples. Thermocouples shall generally be of the chromel-constantan type (ISA Type E) with Type EX extension wire or chromel-alumel (ISA Type K) with Type KX extension wire. Thermocouples and extension wire shall comply with the standard limits of error in accordance with ANSI MC96.1-1975. The elements as a rule shall be separate from ground (ungrounded). "Special" accuracy thermocouples shall be provided where required for performance calculations.

Resistance temperature detectors (RTD's) shall be of the three wire platinum type. The nominal resistance of the platinum detectors shall be 100 ohms at 0°C with an "alpha" or resistance/temperature slope of 0.00385 ohm/°C. All RTD's for measurement of fluid system temperature shall be ungrounded, metal sheathed, ceramic packed, and suitable for the design temperature, pressure, and velocity of the fluid system.

Thermocouples and RTD's shall have sheathed elements spring-loaded to provide good thermal contact with the well or protecting tube. The sheath shall be made of stainless steel having swaged type magnesium oxide insulation. All connection heads shall be weatherproof, made of cast iron with screwed covers, and supported from the well by a stainless steel extension nipple.

7.5.4 TRANSMITTERS

Transmitters shall generally be used to provide the required signals for control and remote monitoring. Transmitters connected to the control system will be hardwire based. HART or equivalent compliant smart transmitters with 4 to 20 mA DC output, two wire, capable of driving a 750 ohm load, designed with provisions for zero and span adjustments shall be used. The total load of the current loop including cable resistance shall be between minimum 230 ohm and maximum 1100 ohm. In general, all transmitters will be "smart" and capable of interfacing with a handheld calibrator. Transmitters shall have an accuracy of 0.25 percent (0.25%) or better over the full signal range. Transmitter shall be furnished with local indicators with a scale of 0% to 100% of range. Explosion proof construction shall be furnished where required.

7.5.4.1 STATIC PRESSURE AND DIFFERENTIAL PRESSURE TRANSMITTERS

Sensing elements for static pressure and differential pressure transmitters shall be of either the capacitance, strain gauge or piezo-resistive type.

Static pressure transmitters shall be equipped with a two-valve manifold and differential pressure transmitters shall be equipped with a three-valve manifold. Steam flow transmitters shall be furnished with five (5) valve manifolds. Manifolds are to be constructed and tested to ANSI/ASME B31.1.

7.5.4.2 LEVEL TRANSMITTERS

Sensing elements for level transmitters shall be, among others, of the following types:

1. Static head or submersible devices for vessels exposed to atmospheric pressure.
2. Submersible static head transmitters for open-air process such as cooling towers.
3. Displacement float or guided wave radar type for feedwater heaters and enclosed vessels (where practical).
4. Differential pressure type with constant head chamber for high-pressure and temperature applications where installation of float cage becomes impractical (i.e. deaerators). (Level transmitters of this type are the same as differential pressure transmitters)
5. Moving float or radar type for fuel oil storage tanks.
6. Ultrasonic type for specialized applications including, but not limited to ash hoppers and coal feeders.
7. Ultrasonic or radar type sensors for coal silos, limestone hoppers.
8. Ultrasonic probe type for sludge and slurry, or waste water applications.

7.5.4.3 FLOW TRANSMITTERS (DIFFERENTIAL PRESSURE)

Flow transmitters for general applications shall be of the differential pressure (DP) type.

Primary Elements: Flow nozzles shall be used for feedwater flow and other critical measurements where weld-in construction is required. Flow nozzles shall be made of stainless steel, with dual sets of pressure taps installed in the pipe wall where required. Installation of flow nozzles and pressure taps shall be made in the flow nozzle manufacturer's shop or in the pipe fabricator's shop, and shall be witnessed by a representative from the flow nozzle manufacturer.

Paddle type orifice plates shall be used for other flow measurements where flanged construction and higher pressure loss are acceptable. Orifice plates shall be made of stainless steel. Orifice flanges shall be of the raised face weld neck type with dual sets of taps unless design dictates otherwise.

Construction and installation of uncalibrated flow nozzles, flow sections, and orifice plates shall conform to the requirements of ASME-MFC-3M and discharge coefficients shall be predicted in accordance with data published in ASME Research Report on Fluid Meters. Calibrated flow sections shall conform to ASME-MFC-3M and ASME PTC 6.

Annubars, airfoil or venturi flow sections, or averaging type pitot tubes, may be used for measuring boiler combustion airflow.

A special high accuracy flow nozzle pipe shall be provided to determine feedwater flow to the economizer. This nozzle shall be hydraulically calibrated and utilized for turbine testing as described in ASME PTC 6 and ASME-MFC-3M.

Annubars, piezometers, and pitot tubes shall be used for measuring fan inlet flows and flows in large pipes or ducts where installation of flow nozzles, orifice plates, or airfoils is impractical. Doppler Effect type flowmeters may be used for sludge and slurry applications.

Secondary elements for differential type flow sensors shall be strain gauge or capacitance type differential pressure transmitters. Square root extraction required for the differential pressure (DP) transmitters will be performed electronically in the DCS or PLC which receives the transmitter output signal.

7.5.4.4 FLOW TRANSMITTERS (NON-DIFFERENTIAL PRESSURE)

Where differential pressure measurement is not practical or reliable, the following are acceptable alternatives for the listed service:

1. Waste, sludge, slurry, service water, and cooling tower blowdown: Ultrasonic or in-line Magnetic
2. Large water ducts (non-control applications): Magnetic point
3. Low flow water with low head loss: Vortex shedding
4. Oil flow for custody transfer or inventory accuracy: Positive displacement (helix or piston) or Coriolis
5. Nonintrusive mass flow: Coriolis
6. Water or Gas (non-control applications): Turbine flowmeters
7. Non-control applications with low accuracy: Propeller flowmeters
8. Channel flow signals: Ultrasonic weir
9. BFP suction, main steam, cold reheat, auxiliary steam, and other steam/water flows where unrecovered pressure loss is a concern: Annubars

Any others will require specific and explicit Employer approvals.

7.5.4.5 POSITIVE DISPLACEMENT FLOW TRANSMITTERS

Positive displacement flow transmitters shall be of proven reliability, and fully suitable for the application proposed, and shall be provided with a pulse transmitter. The flowmeters shall be of the rotary vane type with double case design suitable for the maximum working pressures and flow rates. An electronic totalizer shall be provided for each flowmeter and the location of the totalizers shall be acceptable to the Employer. Air eliminators shall also be provided to ensure maximum accuracy.

7.5.4.6 TEMPERATURE TRANSMITTERS

Temperature transmitters may be utilized when a low concentration of temperature inputs in a particular area does not justify a temperature I/O card at the DCS or where 4 to 20 mA DC signals are required by the interfacing system.

Temperature transmitters with filled-bulb (gas-actuated) type sensing elements shall not be used.

7.5.5 ANALYZERS

Analyzers shall generally be used to provide the required signals for control, local indication and remote monitoring. The preferred interface to the Distributed Control System (DCS) will be hardwire based. A 4 to 20 mA DC output, two wire, capable of driving a 750 ohm load, designed with provisions for zero and span adjustments shall be used. Local indication shall consist of a 3½ digit or better display with 13 mm numerals, minimum.

7.5.5.1 SPECIFIC CONDUCTANCE ANALYZERS

Specific conductance analyzers shall consist of a conductivity cell and monitor. Conductivity cells shall be provided with a cell enclosure and an automatic temperature compensator compatible with the monitor. Cell constants shall be acceptable to the Employer. Each monitor shall produce 4 to 20 mA DC output signals and shall include alarm contacts. Specific conductance analyzers shall be easily accessible for maintenance and calibration.

7.5.5.2 CATION CONDUCTIVITY ANALYZERS

Cation conductivity analyzers shall be furnished with an ion exchange column with an indicating resin, conductivity cell, and monitor. The discharge from each ion exchange column shall be piped to a conductivity cell, complete with a cell enclosure and an automatic temperature compensator compatible with the monitor. Cell constants shall be acceptable to the Employer. Each monitor shall produce 4 to 20 mA DC output signals and shall include alarm contacts. Cation conductivity analyzers shall be easily accessible for maintenance and calibration.

7.5.5.3 PH ANALYZERS

pH analyzers shall consist of a pH cell and monitor. pH cells shall be diffusion type electrodes and shall be provided with a polypropylene cell enclosure and an automatic temperature compensator compatible with the monitor. Each monitor shall produce 4 to 20 mA DC output signals and shall include alarm contacts. pH analyzers shall be easily accessible for maintenance and calibration.

7.5.5.4 SODIUM ANALYZERS

Sodium analyzers shall be automatic, continuous, electrode type analyzers. Each analyzer shall be furnished with a calibration kit. Sodium analyzers shall be easily accessible for maintenance and calibration. The analyzer shall have the following design features:

1. Range: 0.1 to 1,000 μg/L standard range.
2. Temperature compensator: Located in the measuring circuit of the sensing cell.
3. Accuracy: ±2 percent of monitor reading.
4. Sensitivity: 0.1 μg/L.
5. Output: 4 to 20 mA.
6. Calibration: All required components.

7.5.5.5 DISSOLVED OXYGEN ANALYZERS

Dissolved oxygen analyzers shall be automatic, continuous electrode type analyzers and shall be furnished complete with a flow cell assembly. Flow cell assemblies shall be easily accessible for maintenance and calibration. The analyzer monitor shall be mounted in a location that is easily visible and accessible in relation to the flow cell assembly. Each analyzer shall be furnished with a calibration kit. Each analyzer shall have the following design features:

1. Range: 0 to 200 percent (0% to 200%) rel, 0 to 20 mg/L, 0 to 20 μg/L, 0 to 200 μg/L, and 0 to 2,000 μg/L.
2. Temperature compensator: Located in the measuring circuit of the sensing cell.
3. Accuracy: ±0.5 μg/L.
4. Sensitivity: <1 μg/L.
5. Output: 4 to 20 mA.
6. Calibration: All required components.

7.5.5.6 SILICA ANALYZERS

Silica Analyzers shall be automatic, colorimetric analyzers. Each analyzer shall be furnished with a calibration kit. Silica analyzers shall be easily accessible for maintenance and calibration. The analyzer shall have the following design features:

1. Accuracy: ±1 percent (±1%) of full scale.
2. Output: 4 to 20 mA.

3. Calibration: All required components.

7.5.5.7 CHLORINE ANALYZERS

Chlorine analyzers shall be automatic and operate continuously or utilize cycle times of less than 3 minutes. Analyzer shall be designed to measure free or residual chlorine as required by the process. Each analyzer shall produce 4 to 20 mA output signals and shall include alarm contacts. The analyzer shall have the following design features:

1. Range: 0.0 to 5.0 mg/L free or residual chlorine
2. Accuracy: ± 5 percent (±5%) or 0.035 mg/L as Cl_2, whichever is greater.

7.5.6 PROCESS MEASUREMENT SWITCHES (TEMPERATURE, PRESSURE, LEVEL AND FLOW)

Process measurement switches shall generally have single-pole, double-throw (Form C) contacts for each actuation point and shall be equipped with screw type or compression type terminal connections on a terminal block for terminating field wiring. Switch set point shall be adjustable. Contacts shall be of the snap-acting type.

7.5.6.1 TEMPERATURE SWITCHES

Temperature switches shall be actuated by gas filled-bulb type elements equipped with standard length armored capillary tubing.

7.5.6.2 PRESSURE SWITCHES

Pressure switches shall be actuated by piston, disk, or diaphragm type elements. Pressure switches shall be classified into the following types:

1. General static pressure switches and general differential pressure switches for normal static pressure ranges.
2. Low differential pressure switches for low static pressure ranges (≤3.4 MPaG).
3. High differential pressure switches for high static pressure (≥3.4 MPaG) and/or applications requiring both indication and pressure switch contacts.

7.5.6.3 LEVEL SWITCHES

Level switches shall be actuated by elements, among others, of the following types:

1. Static head devices for vessels exposed to atmospheric pressure.

2. Differential type for high-pressure and high temperature applications. (Level switches of this type are the same as differential pressure switches.)
3. Displacement float type for feedwater heaters, enclosed vessels, and sumps.
4. Moving float type for open tanks and sumps.
5. Capacitance, RF/admittance, or ultrasonic type for specialized applications (e.g. bulk materials).

Switching elements of moving float and displacement float type level switches shall have 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, snap-acting type magnetically coupled to the float. One (1) SPDT switch element shall be available at each level point monitored.

Each switch element shall be reversible for NC or NO operation or shall be double-throw construction. Switch element leads shall be of high temperature construction as required, and terminated on terminal blocks within the switch housing. Switch housings shall be IP56 construction, unless otherwise specified.

Cages of float type switches shall be ASME B31.1 compliant and of the all-welded construction type.

7.5.6.4 FLOW SWITCHES

Variable area or differential pressure type actuating elements shall be used for low flow and low-pressure applications.

The flow switch shall be of the vane type and the size and flow range shall be suitable for the application. The flow switch shall provide local indication and one SPDT switch.

7.5.6.5 ELECTRONIC SWITCHING DEVICES

Electronic switching devices, instead of the mechanical type sensing switches mentioned above, may be used as required and in high-pressure and high temperature applications. This type of switching device shall provide high-low contact closures by monitoring the output signals (4 to 20 mA DC) from transmitters and signal converters.

7.5.7 LOCAL INDICATORS

7.5.7.1 LOCAL TEMPERATURE INDICATORS (THERMOMETERS)

Thermometers for local mounting shall be 100mm minimum dial, every angle and bi-metal. Thermometers for panel mounting shall be gas-actuated with stainless steel armored capillary tubing of the length required for installation, with 100mm minimum dial size. Dial scales shall be such that the normal operating range is in the middle third of the dial range. All dials mounted on one panel or board, or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading with the scale clearly marked. The dials shall be engraved with service legends, or separate nameplates shall be furnished to identify the service. Separate nameplates shall be engraved phenolic attached to the dial face or stamped stainless steel attached to the thermometer by stainless steel wire. Thermowells or protection tubes (for boiler gas and air ducts) shall be furnished for all thermometers.

7.5.7.2 LOCAL PRESSURE INDICATORS (PRESSURE GAUGES)

Gauges for control air supply and signal pressures integral to an instrument shall be in accordance with the instrument manufacturer's standards. All other gauges shall be 100mm minimum dial size. Dial scales shall be so that the normal operating range is in the middle third of the dial range. All dials mounted on one panel or board, or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading with the scale clearly marked. Separate nameplates shall be engraved phenolic attached to the dial face or stamped stainless steel attached to the gauge by stainless steel wire. All gauges, except on gas service, shall have stainless steel movements. Gauges for panel mounting shall be of the flush mounting type. Gauges for separate mountings shall have 13mm NPT bottom connections. Gauges that are expected to pulse more than ±5 percent (±5%) of scale shall be furnished with a pulsation dampener made of the same material as the Bourdon tube or stainless steel. Gauges used in compressed gas applications or those equipped with diaphragm seals shall not be furnished with pulsation dampeners. Gauges for fluids which may be corrosive to the gauge internals shall be furnished with diaphragm seals. Gauges installed on steam service shall be equipped with a pigtail or siphon. Gauges shall be furnished with engineered dynamic dampening mechanism without case fill. Gauges required by a specific code (such as NFPA 20) shall be supplied in accordance with the code.

7.5.7.3 LOCAL PRESSURE INDICATORS (DIFFERENTIAL PRESSURE GAUGES)

Differential pressure indicator gauges shall be 100mm minimum dial size. Full scale pointer travel shall be at least 80 degrees. Dial scales shall be ranged such that the maximum operating differential is in the middle third of the dial range. All dials mounted on one panel or board, or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading with the scale clearly marked. Separate nameplates shall be engraved phenolic attached to the dial face or stamped stainless steel attached to the gauge by stainless steel wire. Indicator shall be equipped with a pressure relief device designed to protect the operator from high pressure blowout of the indicator. Each indicator shall have a stainless steel movement, wetted parts, and socket unless the application requires other materials. The housing shall be dust and moisture-resistant and shall be furnished with laminated safety glass. Each indicator shall be provided with overpressure stops to protect against pressure surges outside the scale range limits.

7.5.7.4 LOCAL LEVEL INDICATORS (SIGHT GLASSES OR GAUGE GLASSES)

Tubular gauge glasses shall be used for low-pressure applications. Transparent or reflex gauges will be used for high-pressure applications. All gauge glasses shall be equipped with gauge valves including a safety ball check.

Depending on the application, gauge glasses may be equipped with red and white flags in the external indicator strip which then flip to their "colour side" as the magnetic ball float passes up and down the magnetic gauge column as part of the local level indicator to provide level indication to either local control system, or plant control system, or both.

7.5.7.5 FLOW INDICATORS

Sight flow and variable flow indicators shall be used for low-pressure and low temperature applications. The use of sight and variable flow indicators shall be restricted to applications where accurate measure of flow is not required.

Accuracy shall be within ±1 percent (±1%) of full scale range.

7.5.8 SOLENOID VALVES

Where ever possible, solenoid coils shall be Class H high temperature construction and shall be designed for continuous duty. Three-way solenoid valves shall be designed for universal operation so that the supply air may be connected to any port.

7.5.9 PANEL MOUNTED INDICATORS

Panel mounted indicators which receive transmitted electronic signals shall be of the vertical scale solid-state type for process signals or circular scale for electrical signals. All indicators shall have a digital LED display with flat glass/plastic face. The use of indicators will generally be limited to auxiliary electric systems or "packaged" system local control panels. Drum level indicators will be vertical array red/green indicators with center zero at normal water level.

7.5.10 ACTUATORS

Actuators shall be sized to operate against the maximum expected resistance. Actuators may be pneumatic (diaphragm or piston type), electro-hydraulic or electric motor.

Motor and electro-hydraulic drive actuators shall be designed to fail safe upon loss of power.

Pneumatic actuators shall be operated using 5 to 8.5kPa compressed air. Pneumatic actuators shall be designed to move the primary control device to the fail safe position upon loss of air. Each actuator shall be supplied with a solenoid valve or E/P positioner and air filter/regulator.

Positioner shall be microprocessor based electronic-pneumatic design. Positioner shall be designed for a 4-20mA input and an output signal from zero to the full supply air pressure required by the actuator. Positioner shall be equipped with a filter regulator air supply set mounted on the valve yoke. Positioner shall be capable of split-range sequencing and direct or reverse action. Other features shall include speed and gain adjustment, failure mode choice, non-interactive adjustments, easy pilot access for cleaning, characterization, automatic zero/span calibration, and “HART or equivalent” protocol for valve position feedback configuration and calibration.

Positioner transmitters shall be integral to valve positioner and shall produce 4-20 mA output in direct relationship to the valve position. The output signal shall be 2 wire, isolated and ±1% linear.

Position switches shall be provided on all actuated valves in on-off service.

The motor drive actuator shall be provided with an integral starter with local control station. For motor drive actuators of on-off valves, a damper with 4 freely adjustable limited switches and 2 torque switches shall be provided. If the valve or damper needs to operate in intermediate position, a positioner with a 4-20 mA DC output shall be provided.

All actuators shall be provided with a local indicating pointer and with a handwheel for direct manual operation. The lockable mechanical clutch mechanism will be provided to inhibit motor drive during handwheel operation.

Actuators shall be provided on primary control devices such that all start-up, shutdown and normal operations can be accomplished from the main control room with no need for local manual operator actions.

7.5.11 FURNACE MONITORING TVS

A colour CCTV heavy duty furnace flame monitoring system suitable for high temperature areas and complete with, but not limited to camera and monitors shall be provided. Also, to be included is coal flame, oil flame and igniter flame controllers where cooling air fans for flame monitors and burners are required. These images shall be available at the central control room.

7.6 CONTROL AND INFORMATION SYSTEMS

7.6.1 GENERAL DESIGN CRITERIA

A fully integrated, control and information system shall be provided to secure safe, reliable and efficient operation of the power plant. The control system provides the principal functions in programmable, microprocessor based hardware, as described in the following sections. The primary control is achieved in a distributed control system (DCS), which employs functional distribution and redundancy to achieve a high level of system reliability, in order to achieve all the Performance Guarantees. Some stand-alone systems, such as water treatment, coal handling, sootblowers, ESP or CEMS, may be provided with self-contained controls using a programmable logic controller (PLC) or microprocessor based system. The PLC or microprocessor based system shall be furnished with communication links to the DCS. The Control Room operator shall have the capability to start/stop and monitor the status of the system from the DCS through the communication links. All system parameters and alarms shall be transmitted across the communication links to the DCS system in the Central Control Room.

The system shall include, among others, all instrumentation, automatic controls, manual controls, protective and trip systems, alarm systems, information systems and control room equipment to enable the plant to meet all control, supervisory and operation requirements of the processes and of this specification.

The modulating controls shall be designed to accomplish the process control described herein, utilizing an operating mode and operator interface which is fully automated and eliminates necessity for an operator to provide actions or inputs other than decisions such as, manual/auto, biasing, set point changes, and the like. The system shall not require operator actions to balance, to transfer or perform logic tracking etc within the systems. The operator interface shall provide convenient operator access to system data and to control functions for each control system.

The digital controls shall be designed to accomplish the motor control and valve control activities described herein, utilizing an operating mode and operator interface which includes permissive and guidance messages. The operator interface shall provide convenient operator access to available control functions for each process device.

The protective logic shall be designed to accomplish the protective and safety features described herein. The operator interface shall be designed to alert an operator to protective actions to be conducted for the systems, and to guide operator actions when such actions are permitted or required within the protective logic routines.

The information system shall be an on-line real-time display system to provide the operator, either automatically or on demand, up-to-date information regarding the status and operating condition of the main plant and auxiliary equipment.

The DCS alarms shall alert the operator to abnormal plant conditions through visual and audible annunciators, VDU alarm displays, and/or printed alarm logs. Time tagging of critical alarms shall be accomplished through a sequence-of-events recorder. All the status and events shall be captured and time tagged at the source. Hardwire connection to SOE shall be provided for major equipment and unit tripping signals.

7.6.2 SYSTEM DESIGN RESPONSIBILITY

The Contractor shall retain design responsibility for all aspects of the equipment and systems furnished under the provisions of these Employer’s Requirements.

7.6.3 SYSTEM INTEGRITY

The Contractor's systems and equipment shall be designed such that no single failure of any system component or power source shall interrupt or disrupt any system function, nor shall any single failure cause any controlled equipment to change status except as specifically described in this specification. Any item of system design, application, or construction, which is determined to be not in accordance with these requirements, shall be corrected by the Contractor at no additional cost to the Employer. This requirement shall apply during all stages of design, fabrication, construction, commissioning, initial operation, and during the period of warranty. Exceptions to this requirement are hereby described for the following specific cases, where it does not adversely affect the Plant security, operations, recovery etc:

1. <u>Failure of a single system input transducer:</u>

Failure of a single system input transducer (not a multiple measurement transducer) or of an input module serving only that transducer, a system response to the failure will be allowable. All such failures, however, shall be alarmed.

2. <u>Processor or controller failure:</u>

Processor or controller failure, where a single controller has been specified to serve without a backup, a system response consisting of transfer of function to manual, or a shutdown of running equipment may be allowable. All such failures, however, shall be alarmed.

3. <u>Multiple power source failure, or of controller logic failure:</u>

In cases of multiple power source failure, or of controller logic failure, the DCS shall produce a pre-designed and predictable failure mode.

7.6.4 SYSTEM ACCEPTABILITY

All equipment provided by the Contractor shall be of current design, commercially available from the system or equipment manufacturer, shall be a tested and proven system or equipment, shall carry the OEM warranties and shall have a local Bangladesh representative for sales and technical support assistance. The Contractor shall not propose or provide equipment from any manufacturer that is likely to be superseded or outdated by a later generation of equipment during the period of this Contract. All equipment shall be new, unused, and of the highest quality available from the manufacturer.

7.6.5 SYSTEM FAILURE MODES

The Contractor's control systems shall be designed to react in a predictable manner to certain system failures, as generally described herein. All such failure modes shall be documented by the Contractor, and accepted by the Employer in writing. Any reaction to failure which does not follow the agreed upon pattern shall be deemed a violation of the system integrity criteria described herein. General cases of failure modes are described in the following paragraphs:

1. Upon system logic failure, as detected by system diagnostics, a controller shall transfer to its backup. If the backup does not exist, or is unavailable, the controller outputs shall fail to a predictable status and shall enable any manual shutdown facilities, which are appropriate to provide orderly shutdown of equipment. Generally, outputs shall hold the status existing prior to the failure.
2. Upon system logic power supply failure, or system I/O power supply failure, the controller shall transfer to its backup. If the backup does not exist, or is unavailable, the system outputs shall fail to a de-energized state, which shall be designed to produce minimum disruption of operation.
3. Upon failure of driving power to a controlled device which is running, the system shall react in a predetermined manner, either to command a restart of the equipment upon power resumption, or to cycle the logic to a status requiring equipment shutdown. In either case, the system shall command a start of any backup equipment without waiting for any process deterioration.
4. Upon interruption of a logic sequence caused by failure of controlled equipment, or by equipment not being available to allow the completion of the sequence, the logic system shall automatically reset itself, and shall automatically reset controlled equipment to a safe and predictable condition. Once the sequence has been interrupted, the logic system shall not resume the sequence unless it is reinitiated by operator action.

7.6.6 ELECTRONIC CONTROL SYSTEM FEATURES

The Distributed Control System (DCS) shall integrate the boiler, steam turbine generator, balance-of-plant control, data acquisition, and annunciation functions. The following control system features, among others, shall be included within the DCS:

1. Self-diagnostic capability for all portions of the system.
2. Dual redundant processors, memory, and power supplies.
3. Dual redundant high-speed data highway architecture. Data highway where feasible shall always take different routes around the plant.
4. On-line maintenance capability.
5. Process diagnostics capability.
6. Self-documenting capability or documentation verification capability.

Electronic systems provided with major plant equipment shall either utilize the same control hardware as the balance-of-plant DCS or shall be designed to be easily interfaced with the DCS via data links and hard-wired interfaces.

7.6.7 SIGNAL CONVERTERS

Electric-electric, electric-pneumatic or digital-pneumatic signal converters shall be acceptable. Electric-pneumatic signal converters shall be installed on, or in close proximity to, the final drive element to minimize pneumatic tubing length.

7.6.8 MULTIPLE MEASUREMENTS

Certain measurements shall be provided as dual or triple measurements. Where multiple measurements are necessary for accuracy or redundancy, the Contractor shall provide all signal converters, compensating networks, signal buffers, and other accessories to make a complete measurement system for the specific variable. Utilization and logic associated with multiple measurements shall be as described in the following paragraphs.

7.6.9 DUAL MEASUREMENT SYSTEMS

Dual measurement systems shall be provided for all variables used in process control of the primary steam cycle and for additional critical process auxiliaries. The Contractor shall identify the critical closed loop control function for dual measurement (control and monitoring).

Unless otherwise specified, each dual measurement system shall be provided to meet the following functional specifications. Each system shall have a software selector switch to select the average value or to determine which of the dual measurements shall be used for control and other signal uses. Indication shall be provided for the transmitter selection. Signal comparator logic shall be provided to determine significant (adjustable) deviation of the two signals. Such deviation shall be alarmed and, if operating in the average mode, shall reject dependent control loops to manual.

7.6.10 TRIPLE MEASUREMENT SYSTEMS

Triple measurement systems shall be provided for, but not limited to, the following variables:

1. Deaerator storage tank level.
2. Furnace pressure
3. Condenser hotwell level.
4. Main steam pressure
5. Feedwater flow

Unless otherwise specified, each triple measurement system shall be provided to meet the following functional specifications. The control system shall auctioneer the three signals to determine the median value, which shall be used for all control system and alarm purposes, unless a specific transmitter is selected by the operator. Signal comparator logic shall be provided to determine significant (adjustable) deviation of the signals from the median. When operating in the median select mode, a significant deviation of one signal from the median shall alarm and cause the signal comparator output to revert to the average of the remaining two (2) signals. A significant deviation between the remaining two signals shall be alarmed and cause the loop to reject to manual.

7.6.11 UNIT PROTECTION SYSTEM

The unit protection system shall be designed to enforce procedures to ensure safe plant start-up, to prevent the initiation of events leading to hazardous operating conditions, and to execute emergency shutdown procedures of equipment in the event of major faults. The emergency shutdown operation shall result in the readiness of the equipment for return to service. Overall protection shall be achieved through the various components associated with the trip relay system.

One (1) source of input to the unit protection system shall be the boiler trip system. The boiler system shall be an integral part of its respective system for the steam turbine generator. Both trip systems shall monitor such abnormal conditions as overspeed, abnormal pressures and temperatures, loss of coolant, loss of lubrication, loss of governing fluid, loss of feedwater flow, vibration, differential expansion, other critical variables etc and shall trip their respective systems when the abnormal conditions become critical.

Another source of input shall be the protective relaying systems for the generators, generator transformers, exciters, auxiliary transformers, and the auxiliary electrical system. The generators shall not be tripped directly by the unit protection system but indirectly through the turbine protective system.

7.6.12 UNIT LOAD RUNBACK

Interlocking shall be provided such that if vital equipment should fail, the protective interlock system shall reduce the output to a safe operating level without the need for a complete shutdown of the Power Station.

The unit load runback shall be initiated for at least the following faults:

1. Failure of one of the boiler feedwater pumps.
2. Failure of one of the condensate pumps.
3. Failure of one of the boiler circulating pumps, if applicable.
4. Failure of a coal mill.
5. Failure of a coal feeder (with selectable time delay).
6. Failure of one of the circulating water pumps.
7. Failure of one ID or FD fan.

The Contractor shall demonstrate that the boiler turbine generator shall be capable of automatically coming back to house load operating conditions in the event of a full load (any load up to VWO rating) rejection.

7.6.13 TURBINE WATER INDUCTION PROTECTION SYSTEM

The turbine water induction protection system shall provide the coordinated logic and the means of implementing the protection logic that shall control and prevent water from entering the steam turbine. The control and protection logic shall be implemented in the turbine water induction protection's process controllers.

7.6.14 LOCAL MANUAL CONTROLS

In some cases, small fans and pumps that have no direct impact on power plant generation may be controlled by local control switches. Switches shall be momentary ON-OFF push buttons with shrouds or other suitable means for preventing inadvertent operation.

7.6.15 CONTROL SYSTEM SUMMARY

The following table provides a general summary of the anticipated control platforms and normal operator interface.

Area	Logic Control Platform	Operator Interface
BOP	PLC / DCS	DCS
Turbine		
Turbine and Auxiliary Control	Vendor's Standard	1. DCS – Redundant Link and 2. Integrated in DCS

Area	Logic Control Platform	Operator Interface
Boiler		
Boiler Modulating Controls	Vendor's Standard	DCS
BMS	Vendor's Standard	DCS – Redundant Link
Sootblowers	Vendor's Standard	DCS - Non-redundant Link
AQCS		
FGD	Vendor's Standard	DCS
ESP	Vendor's Standard	1. Local HMI and 2. DCS – Redundant Link or Hardwired
Water		
Steam Cycle Sampling and Analysis	PLC	DCS
Cycle Chemical Feed	DCS	DCS
Water Treatment	PLC	1. Dedicated PLC HMI and 2. DCS – Non-redundant Link
Wastewater Treatment	PLC	1. Dedicated PLC HMI and 2. DCS – Non-redundant Link
Condensate Polishing	PLC	1. Dedicated PLC HMI and 2. DCS – Non-redundant Link
Fire Protection and Alarm	Dedicated Fire Alarm Panel	Dedicated Fire Alarm Panel
Ash		
Bottom	DCS	DCS
Economizer	DCS	DCS
Fly Ash	PLC	1. Dedicated PLC HMI and 2. DCS – Redundant Link
Truck Loading	Hardwired	Local
CEMS	Vendor’s Standard	1. Local and Central Control Room 2. DCS – Non-redundant Link
Coal Handling	PLC	1. Local PLC and 2. DCS – Non-redundant Link

Whether the instruments and sub-systems use hard wire, PLC and/or DCS systems for plant monitoring and control it shall be subject to vendor specific equipment signaling and interface capabilities.
Field device connections to the control system will include, but are not limited to, all transmitters, switches, motor operated valves, damper drives, control valves, switchgear, secondary unit substations, and motor control centers.

Field devices connected to DCS and PLC's will generally be hardwired. Devices should be supplied as HART or equivalent compatible if available.

Specific exceptions to the above may apply due to vendor standard packages or hardware and software availability.

Any proprietary system shall be avoided. Supplier for the PLC shall be selected by the manufacturer and submitted in the Contractor's offer.

7.6.16 PLANT INFORMATION SYSTEM (PIS)

The Plant Information System shall provide real-time event management, retrieval, and deep archiving of volumes of data for the DCS. The Plant Information System brings all operational data into a single system that can deliver it to operators at all levels of the Plant. The system shall keep all the critical operating and information data online and available in a specialized time-series database so it can be recalled when it is needed.

To provide support for the IT infrastructure, the Contractor shall provide an Ethernet Local Area Network (LAN) which typically uses PC based servers or the latest technology for the same applications. The LAN will include as a minimum, a hub layout with cabling, hubs, interfaces to peripheral equipment and hardware to control the data highway. In the rooms routed on the LAN, a minimum of two (2) connection points shall be provided between the rooms.

The system shall be an independent system connected to DCS with security protection to avoid unauthorized usage. The communication shall be one way and shall not affect any of the DCS functions.

A Plant Information System (PIS) shall also be provided to ease the maintenance of the plant. The system will be provided with the same functionality as the operator stations in the CCR (hardware, software, and firmware) but be located in administrative building close to maintenance staff. It will give access to all DCS plant operating data and allow printing of operating and maintenance reports.

The system shall have read-only facility to the DCS.

The following equipment, among others, will be located in administrative buildings:

1. 2 (two) remote DCS operator station (read only)
2. 2 (two) A4 colour printers

3. Networks extension from CCR to administrative building.

The PIS shall provide information related to the following aspects as minimum, in the form of reports and graphics:

1. Operation information
2. Equipment status
3. Plant operation history
4. Plant performance indices
5. Fault cause analysis
6. Equipment maintenance history
7. On job information support
8. Expenditure tracking and forecasting
9. Environmental and hazard management
10. On-line plant DCS logic monitoring
11. Environmental monitoring as in CEMS

All the software graphics and report generation are to configured and tested by the Contractor.

The system shall be based on a client-server architecture. The system shall operate on a commonly used hardware platform and network operating system, preferably Windows based. The system shall be user friendly based on graphical user interface. The system shall be suitable for a wide range of coding systems and in particular KKS.

The system shall be suitably interfaced with plant DCS and suitably located in the following area:

<u>Administration Building</u>

The PIS terminals shall have complete overview of PIS as listed above. Each PIS terminal shall be suitably interfaced to the common station network via standards based communication links and protocols.

7.7 DCS COMPONENT AND SYSTEM REQUIREMENTS

7.7.1 PROCESS CONTROLLERS

Process controllers shall be provided in pairs for redundancy to ensure that no single failure will cause an upset or loss of generation. The back-up process controller shall continuously monitor the status of the primary process controller and automatically assume control by transferring the input-output signals, controller configuration, and control status upon failure of the primary process controller. The bumpless transfer shall take place transparent to the operator and without loss of control and monitoring functions. Such transfer shall be alarmed for operator attention and action.

Each process controller shall have hardware dedicated to the input—output (I/O) requirements. Each process controller shall be able to communicate with any other process controller in the system and with the operator workstations.

The system shall have 20 percent (20%) spare memory capacity in each process controller for configuration expansion, upon project completion.

7.7.2 INPUT/OUTPUT MODULES

Analog inputs and digital inputs shall be powered internally from the DCS or from an outside source. Hardwired analog inputs powered internally shall be current self-limiting and include HART or equivalent capability. DCS powered digital inputs shall be protected by using PTC thermistor (current limiting device).

Hardwired analog outputs shall be HART or equivalent compatible 4-20 mA DC powered internally from the DCS. All analog outputs shall be current self-limiting. Interposing relays (where applicable) shall be provided so that output de-energization always leads to the safe position of the controlled plant/equipment.

The status of equipment that is vital to the operation of the Plant shall be designated as a Sequence of Events (SOE) point and its operating parameters scanned with a time resolution of 1 millisecond. An SOE recording and alarm shall be initiated on a change of state of any SOE designated points. The SOE alarm shall be included in the DCS alarm summary display and print-out with the actual time of occurrence. The SOE recording will be used for post-event analysis.

At the end of the Defects Notification Period (as specified in Section 7), the DCS shall have 10 percent (10%) installed (built-in) spare capacity at all levels, that includes but not limited to inputs-outputs, terminations, interposing relays. In addition, another 10 percent (10%) spare space for installation of future modules and terminations shall be provided. Both types of spares shall be distributed evenly throughout the DCS. This spare capacity shall not preclude adding more processing units, operator workstations, or both on the data highway at a future time.

7.7.3 SYSTEM COMMUNICATIONS

A redundant communication system shall be furnished to permit the transfer of information between the operator workstation, DCS cabinets, and other DCS components. The system shall allow removal of any component without disrupting communication or jeopardizing system integrity. Each DCS drop shall have a dedicated, physically separated, redundant data communication highway connecting all the DCS components of the segment. Each individual drop shall be able to exchange information with the other drops through the redundant data communication highway.

Each data highway shall be capable of handling the initial data requirements plus an incremental 50 percent (50%) data transfer volume without noticeable degradation of the DCS performance due to increased data traffic density.

On failure of one highway, the other shall continue to function without disruption to system operation. Failure of any communication system component shall alarm and display a diagnostic message at the operator workstation, indicating the component that failed. The redundant data highways shall be installed physically separated from each other to preclude physical damage from disabling the entire system.

Third party control systems shall be interfaced with the DCS using data links and/or hardwired interfaces. Third party control systems that have redundant links shall automatically switch over to the backup link upon failure of the primary link. Third party control systems that have a single link shall revert to a fail-safe condition upon loss of the link. An internal DCS alarm and a diagnostic message shall be initiated upon failure of a digital communications link to a third party control system. All associated communications hardware at the DCS end shall reside in the DCS system cabinets.

7.7.4 DCS POWER SUPPLIES

Dual redundant power supplies and distribution shall be furnished for each processor and I/O module. Power conditioning and isolation at each module shall be the DCS supplier's standard. If one power supply fails, the other shall takeover without interruption, and an internal DCS alarm shall be generated. DCS components that do not perform a vital role, such as system printers or engineering work stations, shall be fed from a single, clean, normal source.

Dual redundant power supplies and distribution shall be furnished for each server and operator station. The Contractor shall provide individual static transfer switches associated with each server / operator station, so that each server / operator station can be supplied from any of the redundant power supply sources.

The power supply system shall be sized to provide for the 20 percent (20%) installed and 20 percent (20%) future spare capacity without exceeding 90 percent (90%) of its maximum current rating. Field transmitters shall be powered from the same power source as their input cards; analog outputs shall be powered from the same power source as their output card.

7.7.5 TIME SYNCHRONIZATION

DCS shall synchronize the system clock to within 1 millisecond of a time signal received from a DCS supplier furnished and installed GPS synchronized timing receiver. The system shall use an IRIG-B signal to synchronize the DCS with coordinated Universal Time Code (UTC). The system may also use Network Time Protocol (NTP), Simple Network Management Protocol (SNMP), or TCP/IP. All hardware, software, and cables shall be provided to support a fully functional time synchronization system. The system shall be fully configured at the factory by the DCS supplier.

A master and slave clock system shall be provided.

The GPS synchronized timing receiver shall have capability to add appropriate synchronization connections for extension of additional DCS and control system components in the future.

7.7.6 HARDWARE

The overall proposed DCS architecture is attached as drawing no. 10-PE-PAY-03. The DCS cabinets shall be geographically distributed throughout areas of high I/O concentration. DCS cabinet hardware shall be suitable for the environment it is placed in without requiring environmentally conditioned buildings and enclosures. If not, measures shall be taken to ensure that the correct environment and/or enclosure protection is offered for the DCS equipment within. The proposed DCS functionality is described as below.

The Power Station shall be controlled and monitored from an operator console that shall be located in the Central Control Room. DCS specific console shall contain ten (10) operator workstations, each having one (1) 24 inch colour flat widescreen LED monitor display. Each operator workstation shall have identical capabilities so that each shall be able to perform the tasks of any other operator workstation. Keyboards and pointing devices shall be DCS supplier's standard. Each console shall be ergonomically designed to reduce operator fatigue, protect operator eyesight, and eliminate repetitive strain injuries. Each console shall have bottom entry for cables. Operator workstations shall have password protection with different access levels to ensure system security.

Fully integrated within each console shall be a trip pushbutton panel for equipment requiring hardwired control and indication such as, but not limited to, boiler and turbine master trip switches, generator synchronization controls. The trip pushbutton panel shall be positioned strategically in relationship to the operator workstations so that both shall be within the operator's easy reach.

Two (2) dedicated black & white printer for logs and reports shall he furnished for DCS and available for use by any operator workstation. Two (2) dedicated black & white printer for alarm printouts shall be furnished for DCS. In addition, two (2) A3 sized colour laser printer shall be furnished for printing DCS graphical displays and historical trend data. Alarms will be logged in the software.

Six (6) engineering workstations shall be furnished for DCS, each having one (1) 24 inch colour flat widescreen LED monitor display for each 660MW. Engineering workstations shall be capable of all operator workstation functions, and in addition shall be used for system programming, maintenance, troubleshooting, and other engineering functions such as performance calculations. Two (2) single A3 sized colour laser printer shall be furnished with the engineering workstations. The engineering workstations and associated equipment shall be located in the engineering room.

Four-panel multi-screen display on a high-visibility 4 X 50 inch Digital Light Processing (DLP) large-screen will be equipped for DCS respectively. The Contractor shall provide detailed specifications of the DLP widescreens to be used as the large display, for the Employer’s information. The large screen alarm display shall be driven by the operator workstation or connected on the communication network of the DCS.

Two (2) Unit Shift Supervisor workstation shall be provided for unit plant information system, with a single colour flat 24 inch LED monitor display. The Contractor shall provide detailed specifications of the software and hardware to be used for the data historian workstation, which will be subject to the Employer’s review. Data historian workstation shall be configured for plant data storage and retrieval. Archived data shall be accessible to any operator or engineering workstation. Historical trends shall incorporate associated alarms and events. The data historian workstations shall be located in the station computer room.

Seven (7) Operator / Engineer Station workstations with a minimum 24 inch colour flat screen LED monitor display shall also be provided in the respective subsystem control rooms. The supervisory workstation shall be capable of displaying any screen and carry out any operator or engineering operations, such as parameter settings changes, alarm acknowledgement, control mode selection, or operator control of equipment devices. This workstation shall have security provisions, such as level of password protection, for any control and engineering operations.

7.7.7 SOFTWARE

The system software shall be user friendly, self-documenting and shall require minimal programming expertise to be used. The system shall have a complete library of diagnostics to support the prompt identification of system hardware and software failure(s). Additionally, the system set points, tuning parameters, and control constants shall be fully adjustable while the DCS is online.

The DCS shall be configured with the latest proven version of the software available; first generation software shall not be used in the DCS. The system configuration shall be retained on commercially available magnetic or optical discs and will be installed from the engineering workstations. The engineering workstations shall have the capability to make changes while the unit is on-line. System hardware and software shall include security provisions to prevent unauthorized configuration changes. The system configuration shall be retained in non-volatile memory which shall not be affected by temporary power interruptions.

The Contractor shall guarantee that all operational systems are duly licensed, will comply with specifications and are certified to work with software applied to plant systems. This shall be the latest tested version available (Windows preferred) and shall be covered by the original equipment manufacturers’ warranties.

7.7.8 DCS WORKSTATIONS

The DCS workstations shall be an on-line real-time display system to provide the operator, either automatically or on demand, up-to-date information regarding the status and operating condition of the main plant and auxiliary equipment. The DCS workstations shall act as the information system to the plant operators and consist of a VDU data display, keyboard/ function keyboard and a VDU pointing device.

Any function available at any workstation shall be available at any or all DCS workstations at the operator's designation. The utilization of a workstation shall be easily changeable.

The database and real-time displays shall be updated to ensure that no data displayed is more than two (2) seconds old in real time.

All DCS graphics shall be discussed and accepted during detail engineering & design phase by the Employer.

The Contractor shall also issue a DCS System general philosophy for review and acceptance by the Employer, including at least the following information: operation messages; operation interface; symbols applied; interlock list; system test procedure. This document shall be used as basis for system acceptance and release, i.e. the Engineer’s acceptance for the equipment to be released to the Site, during factory acceptance test (FAT).

7.7.9 WORKSTATION DATA DISPLAY

Light Emitting Diode (LED), widescreen, active matrix displays shall be provided and shall use colour to rapidly draw operator attention to important data. The workstation display shall have the capability to window and display different combinations of graphic pictorials, bar charts, and trend displays in these windows. Typically these window views shall be, among others;

1. Plant system status.
2. Sequence status.
3. Logic data.
4. Alarm messages.
5. Analog value.
6. Historical Trend displays/ bar charts.

Further detailed window views of the above shall be possible through new popup windows giving more detailed information e.g. mode status. Each mimic view shall be capable of being functionally linked to one another.

All window displays shall be updated not more than one (1) second. Response times to an operator command to completely generate or cancel displays shall not exceed one (1) second. Each of the individual composed displays defined in the following paragraphs shall be available for display by operator command using a single stroke call up per display window.

Each operator workstation shall be capable of displaying and storing at least 450 custom graphic displays. Each display in the system shall be in the English language.

The display types listed below shall be implemented as selectable displays on each operator workstation.

7.7.10 PLANT SCHEMATIC DISPLAY

Provision shall be made for displaying process (and if necessary control system) schematics of the Plant areas and Plant components, with fade-in of cyclically updated analog values and control states.

The Plant schematic displays shall be divided into the following display types, among others;

1. Overview display
2. Group and sub-group display
3. Drive unit display
4. Trend display (Real time and historical)
5. Bar chart display
6. X-Y plots/display
7. Operator Guidance messages
8. Process mimic display and graphic symbols
9. Equipment permissive display
10. Disturbance and status messages
11. Alarm display

7.7.11 LOGGING AND LOG TYPES

The DCS shall have a means to produce a variety of logs on the system printers. As a minimum, the following logs shall be available:

1. Change of equipment status.
2. Trip and sequence of events recording including the actual time of event.
3. Post trip event log.
4. Emissions log.
5. Operator's action log for up to eight (8) hours.

The operator shall have the capability to configure custom logs and have them printed on request or automatically.

7.7.12 HISTORICAL DATA STORAGE AND RETRIEVAL, ARCHIVING

The DCS historian shall have the capability for historical storage of the Plant's data and information on permanent storage media for later retrieval and use. The historian shall utilize relational database technology to provide storage of plant information in a format that is accessible to all DCS applications as well as external databases and third-party applications. A relational database management system shall be included to allow data access through standard Open Database Connectivity (ODBC) and Structured Query Language (SQL) queries. All variables, both analog and digital, that are assigned for historical storage shall be stored in a non-volatile short term memory. Data can be retrieved and viewed at any time. The retrieved data shall be available to any of the normal system peripheral devices such as operator work station monitors and printers. The long-term data shall be available for use in trend displays, process control displays, reports, and calculations. The historical storage shall have capacity for a minimum of 180 days of data.

The historian shall provide the following additional features:

1. Any system variable (including, but not limited to I/O point and calculated variable) system message, or file (including, but not limited to alarm list, periodic report and SOE report) shall be available for storage.
2. Ability to execute periodic summary calculations, such as average value, minimum value, maximum value, summation, or run time shall be user selectable on a per point basis.
3. Storage of additional parameters such as point description, engineering units, scaling information and alarm limits shall be user selectable on a per point basis.
4. Storage of control function block parameters (including, but not limited to set point, deviation and block output) shall be user selectable on a per block basis.

After 180 days or sooner, this data shall be downloaded onto long term storage media such as a DVD or equivalent. It shall be possible to reload archived data into the engineer workstation and then view it as required.

Both analog and digital data points archived shall be saved onto the hard disks of the DCS's redundant client-servers acting in "hot-standby". Each server shall utilize a RAID (Redundant Array of Independent Disks) level 5 or better. The Contractor shall provide detailed specifications of the software and hardware to be used for the data historian workstation, which will be subject to the Employer’s review.

7.7.13 PERFORMANCE CALCULATIONS

These calculations shall be performed with the use of the DCS, generally for the purpose of detecting and alarming plant system malfunctions. The program shall be able to be tuned and the calculation formulae shall be able to be changed, if required by the operator.

The calculations shall enable, amongst others, the following to be calculated:

1. Superheat spray outlet approach to saturation temperature.
2. Steam turbine metal temperature differences.
3. Auxiliary power consumption.
4. Auxiliary power deviation from standard.
5. Feedwater leaving deaerator temperatures deviation from standard.

<u>Demand Performance Calculations</u>

These calculations shall be performed with simplified curves on demand to determine the performance of the unit. In general, these calculations shall be performed using methods similar to those described in the appropriate Test Code for the equipment being evaluated.

These calculations shall be performed using averaged data, which is accumulated over a period of time. This time period shall be ten (10) minutes. The system shall then be capable of storing this averaged data for a period of time up to three (3) months and supply automatic backup routines to external media. The system shall include provisions to print the averaged data for review prior to initiation of calculations. The system shall include provisions for substitution of values in the data set, prior to initiation of calculations. At the end of this period, the operator shall be able to input limited fuel analysis data and other manually inserted data into the system and initiate the demand performance calculations.

The following calculations, among others, shall be performed:

1. unit heat rate.
2. unit steam turbine heat rate.

Location of Control Equipment

Control equipment refers to the control devices used to implement the modulating control and motor controls systems.

All other control devices shall be either mounted on a control panel, in a control cabinet, in an instrument enclosure located in various areas of the plant, in other equipment enclosures such as motor control centers (MCC's), or individually mounted near the process connections.

7.7.14 CONTROL AREAS

Control areas include the Central Control Room, the control equipment room(s), the engineering room, and local areas in which local control rooms and local control workstation consoles are located.

7.7.15 CENTRAL CONTROL ROOM

The Central Control Room shall be properly equipped with the latest trend of equipment from appropriate OEM and these shall include, among others:

1. Unit Control Desk
2. Supervisor's Desk
3. Tables for monitors, but not limited to printers, hard copiers and plotters
4. Unit control panels incorporating with, but not limited to hardwired alarm annunciators, recorders, indicators and auto/manual stations.
5. Operator's chairs
6. Control desk storage cupboard.

As mentioned elsewhere in these Employer's Requirements, the Central Control Room shall be adequately sized to cater for similar equipment necessary in the future.

7.7.16 CONTROL EQUIPMENT ROOM(S)

Control equipment rooms for the installation of control equipment, computer cabinets, input/output (I/O) signal terminal cabinets, annunciator I/O cabinets, turbine supervisory cabinets, machinery monitoring cabinets, operator station controllers, and other solid-state electronic equipment shall be provided either in areas adjacent to the process they control, or in a centralized electronic control equipment room.

Associated equipment within the room shall permit hard copy and storage of program changes in electronic or magnetic media storage.

7.7.17 STATION COMPUTER ROOM

The station computer room shall contain the gateways for DCS connection, plant monitoring system (PIS) server, redundant historian server, historian workstation and printers.
In addition, an OPC server shall be provided as a gateway for connection to the Employers data network. It shall access data points plant wide from PIS using client/server technologies and shall provide capability to retrieve, display and store the information from the historian systems. The system shall be furnished with security protection to avoid unauthorized usage. The access data point from OPC server to the Employer’s data network shall be unlimited eg connection to PI server.

7.7.18 LOCAL CONTROL AREAS

Systems that may have "packaged" control devices housed in control rooms, control panels, or cabinets, which are installed locally in the vicinity of the equipment to be controlled shall be reviewed and evaluated for the effects of local environmental conditions, applicable codes and standards, and accessibility requirements. It is anticipated these systems may include, among others, the following:

1. Circulating Water Chemical Feed.
2. Condensate Polishers.
3. ESP.
4. Local Fuel Oil System.
5. Water Treatment.
6. Instrumentation and Service Air.
7. Coal handling.
8. Fly ash handling.
9. Wastewater Treatment

PLC’s may be supplied with stand-alone equipment packages. The project will standardize on one (1) PLC supplier to the maximum extent possible. PLC’s will be redundant unless non-redundancy is required by code or prime contract. PLC’s shall be connected to the plant's DCS through datalinks or hardwired signals. This shall enable the plant control room operators to initiate a start-up or shutdown sequence of the associated systems. Local I/O cabinets shall be provided where appropriate to minimize field wiring. Local control shall be provided for these subsystems through either durable flat PC based LED control panels with membrane keyboard mounted within the local cabinet door or operator workstations depending on the size of the subsystem or as per system requirements.

For systems provided with controls furnished as part of the manufacturer's standard supply, local control areas shall be provided for this equipment. In addition, these local controls shall be capable of interfacing to the data highway by means of serial interface links for transmission of data to the DCS. The operator will be able to initiate start-up and shutdown of these systems through the DCS.

Local fire control panels shall communicate directly with the main fire alarm panel in the Central Control Room per NFPA 72.

7.8 CONTINUOUS EMISSIONS MONITORING SYSTEM (CEMS)

7.8.1 FUNCTIONAL DESCRIPTION

A CEMS shall be provided to measure emissions and produce all required data logging and reporting. The analyzer system shall include extractive analyzers, sample probes, sample conditioning, heated sample lines where required, a fully programmed controller, calibration gas bottles for zero and span, calibration accessories, and mounting hardware for installation to provide a complete and operable system.

The CEMS shall be fully tested on-site, certified and documented per Bangladesh’s environmental standards and norms, World Bank Guidelines, and U.S.A. Environmental Protection Agency (EPA) requirements for CEMS and requirements specified in these Employer’s Requirements.

7.8.2 FLUE GAS ANALYZERS

Extractive systems shall be used to monitor NOx, SO_2, O_2, CO, and CO_2. The analyzers shall be equipped with individual 4-20 mA outputs for each measurement.

In addition, stack gas flow monitoring system shall be furnished as part of CEMS. Stack gas temperature, stack pressure, and atmospheric pressure measurement shall also be provided and recorded.

Double-pass opacity monitors shall be provided. A remote display device shall be located in the analyzer enclosure building.

CEMS shall be complete with all sample port and other measurement port flanges to match the sample and measurement ports provided on the stack.

7.8.3 PROGRAMMABLE CONTROL UNIT

A programmable logic controller type system shall provide signal output, alarms, calibration, calculating and measurement indication for each analyzer. The controller shall be panel or rack mounted and furnished with interconnecting cable to the analyzer. Calibrating shall be provided by periodically introducing zero and span, manually and automatically. All necessary connections, regulators, gauges, solenoid valves, and gas bottles shall be furnished, as required.

The CEMS control and monitoring system shall be furnished with non-redundant data links for interface between the CEMS and DCS.

7.8.4 SAMPLE CONDITIONING

A sample conditioning system shall be furnished to provide a clean dry sample for analysis with the extractive analyzers. The incoming sample, which has been maintained above its dew point in a heated sample line shall be cooled below its dew point and filtered for analysis at the analyzer. A sample pump or eductor with back pressure regulator shall draw the sample into the system. Flow to the analyzers shall be adjusted by setting a sample flowmeter and bypassing the excess as required for reducing response time.

Only suitable alloys or Teflon components shall come into contact with wet, dirty sample gas. A moisture sensor downstream of the drier shall shutoff the sample system to protect the analyzers in the event of a moisture breakthrough.

Probes and sample line not being sampled shall be back flushed periodically with high-pressure air.

7.8.5 DATA ACQUISITION AND HANDLING SYSTEM (DAHS)

A DAHS shall be located in the Central Control Room to retrieve data from the analyzers and store data continuously. The data logging and reporting system hardware shall include, but not be limited to, a computer with keyboard, data storage media, and printer. In addition, another DAHS needs to be provided and located in the analyzer enclosure building.

7.8.6 ANALYZER ENCLOSURE BUILDING

A prefabricated analyzer enclosure building shall be furnished to house the analyzers, sample conditioning systems, and the control units. The building shall be insulated with a HVAC system to maintain interior environment at conditions required for the housed equipment constraints.

The equipment shall be mounted on a rack, completely piped and wired with all field sample tubing and electrical wiring connections terminating at bulkhead tubing fittings and electrical junction boxes.

Utility piping for cooling water, steam, instrument and air vents and drains shall be provided with regulators, gauges, and block valves to permit servicing each system independently.

A rack for supporting span, zero and calibrating gas cylinders shall be furnished, located outside the shelter. Each cylinder shall be provided with a pressure regulator and pressure gauges.

7.9 VIBRATION MONITORING

7.9.1 VIBRATION MONITORING EQUIPMENT

All large rotating machinery driven by medium-voltage motors shall have vibration and thrust monitoring of the motor as well as the driven equipment. The steam turbine and turbine driven feed pumps shall also be provided with vibration monitoring equipment. The application of monitoring equipment shall be subject to the size and type of rotating equipment. The vibration monitoring shall be based on equipment manufacturer's recommendation.

The Contractor shall provide continuous vibration monitoring equipment for the above rotating equipment pump/fan shaft bearings where required and where mechanically feasible to be installed from its construction view. If the motor and pump/fan are not direct-coupled, then the main motor drive bearings shall also be monitored.

The vibration monitoring system shall be provided with vibration monitor, probes, transducers, modules, racks, rack mounted power supplies, cabinets for all major equipment.

The Contractor may furnish the required probe and transducers mounted locally for auxiliary system motor as well as for the driven equipment.

Outputs from the monitors shall be transmitted to the DCS via serial datalink and/or hardwired for displays and alarms.

7.10 OTHER I&C SUPPORTING SYSTEMS

The following I&C sub-systems shall be provided by the Contractor.

7.10.1 CCTV

The Contractor shall set up a complete set of full-digital industrial CCTV including security video monitoring system and production video monitoring system, to reduce number of patrol check personnel and frequency of patrol, enhance monitoring and management of operational equipment by attending staff and realize safety in production for the plant.

Scope of security video monitoring system shall include plant entrance gate and enclosure wall, equipment warehouse and material storage;

Scope of production video monitoring system includes the following areas:

- Dangerous areas of main power house, i.e. turbine oil system, pulverization system, boiler front oil system and burner, cable interlayer;
- Important equipment areas such as high-voltage switchgear, high-/low-voltage distribution room, turbine room, blowing/suction fan, furnace rear dust precipitation, desulfurization and denitration system, coal handling system, ash handling/slag removing system, coal wharf;
- Unattended auxiliary workshop area.
- CCTV for furnace flame monitoring system

Functions of the industrial CCTV shall include: real-time monitoring, dynamic storage, real-time warning, historic picture playback, network transmission, etc.

The industrial CCTV shall have a communication interface with the PIS and the on-site video may be played back from the PIS network.

A total 170 monitoring points will be set up and the monitoring center is in the central control room. The monitoring points will be Employer approved during the detail design stages.

7.10.2 ACCESS CONTROL SYSTEM

Entire plant access control system shall be established for the current project. The application scope of access control system includes:

- important equipment areas in main power house (such as electronic equipment room, high-/low-voltage distribution room, computer room, unattended auxiliary workshop)
- important rooms in production complex building (such as laboratory, information system machine room, etc.)

Access control system shall have the following functions: real-time monitoring, entrance/exit permission management, recording, warning, fire control alarm linkage, etc.

Access control system shall have communication interface for connection with PIS. A total 60 control points, as per detail design drawings, will be set up.

7.10.3 I&C LAB

I&C laboratory shall be set up in general office building. Thermal laboratory appliance and equipment shall be provided according to the requirements for furnishing test apparatus, maintenance device and architectural area of a fossil fuel power plant, i.e. instrument and equipment requirement for a 2 x 660 MW power plant.

Special repair and commissioning equipment required for the automation system is provided together with respective systems.

7.11 NATIONAL LOAD DESPATCH CENTER (NLDC) CONTROL FACILITIES

7.11.1 SCOPE

In order to provide the telecontrol facilities required at the National Load Despatch Centre (NLDC) the following provisions shall be made.

All plant supplied shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical parameters shall be transmitted to the NLDC through the communication Gateway of the DCS system.

All HV breakers, motorized disconnectors, etc. shall be controlled from NLDC through the Gateway of the DCS system using IEC 60870-5-104 protocol. Necessary cabling and interfacing between the Gateway and the communication equipment are to be included in this contract. All testing, commissioning and related works of the interfacing with NLDC shall be done by the Contractor.

7.11.2 400KV SUBSTATION

All equipment in the 400kV Substation shall be monitored and controlled via RTU where the Contractor is required to install new circuit breakers, isolators, earth switches, voltage transformers, current transformers, surge arresters, protection, metering equipment etc. to connect the Plant to the Grid. It also includes the above mentioned equipment installed in the 400kV Substation. The Contractor shall connect the equipment for the NLDC RTU so that the equipment can be monitored and controlled from the NLDC in accordance with the current Bangladesh NLDC practices.

7.11.3 INDICATIONS AND CONTROLS

The following indications, among others, shall be provided:

- 400kV circuit breaker, disconnector and earth switch positions
- Transformer tap change selection on Auto/Manual
- Transformer tap position
- Control switches on Local/Supervisory
- Trip relays operated
- Auto-recloser on/off

The following facilities, among others, can be controlled from the NLDC.

- 400kV circuit-breakers and motorised disconnectors
- Trip relay reset
- Auto-reclose in/out
- Auto transformer tap change raise/lower
- Tap change control remote/supervisory

- Auto/non-auto voltage control

The Contractor shall follow the design philosophy used by NLDC when connecting the 400kV equipment to the Grid, operationally.

7.11.4 LOCAL REMOTE SWITCHES

A local/remote selector switch shall be provided in the control room, adjacent to the CB control switch, for each switchgear group in a bay. A switch group will normally consist of a circuit breaker and associated motorized disconnect switches as defined in the “NLDC SCADA Standard”. The wording on the labels of these switches shall be agreed with the Employer before manufacture.

When the selector switch is in local position, equipment control shall be from the control devices located in the substation control room/ panel room. All command from NLDC shall be inhibited.

When the selector switch is in remote position, equipment control shall be from the NLDC via the communication Gateway system. All commands from the control devices in the control room/panel room shall be inhibited.

A second selector switch shall be provided in the control room, adjacent to the CB control switch of the bay connected to the new power station, to allow control of the bay equipment to be transferred between the substation and the power station. The bay equipment shall normally be controlled from the substation.

7.11.5 ANALOGUE MEASUREMENTS

Analogue measurements may be derived from numerical protection relays or multi-function transducers. The Contractor shall ensure that they are able to communicate/are compatible with the existing NLDC RTU.

Transducers shall be mounted in the RTU marshaling cubical. Transducers that are self-powered from their voltage circuit input are preferred. The devices shall provide an over range output of minimum 110 %.

Under no circumstances shall transducers be connected into CT or VT circuits used for protection. Cabling from CT’s shall terminate at the marshaling cubicle on isolating links of the shorting disconnect type. Cabling from VT’s shall terminate at the marshaling cubicle on fused isolating links. Terminals associated with CT’s and VT’s shall be suitably shrouded.

7.11.6 CONTROL OUTPUTS

Control signals from the RTU are short duration 48V dc pulses. Interposing relays shall be provided in the marshaling cubicle to completely isolate these signals from plant voltages. 48 V control signals shall not be extended beyond the marshaling cubicle. The interposing relays shall be fitted with an LED to provide visual annunciation when the relay is in the "ON" state.

Interposing relays shall be arranged in rows in the cubicle, preferably on DIN type rails and shall be protected by transparent detachable covers. They shall not be capable of manual operation with the covers fitted. All relay coils shall be protected by a suitable back EMF suppression diode.

Interposing relays shall be fitted with suitable number of contacts to allow double pole switching of plant voltages. The relay and relay contacts shall be rated for the voltages applied to them and be suitably rated for the switching duty imposed by the connected load.

Control cabling from the plant shall terminate on isolation type links to allow all plant control circuits to be isolated from interposing relays for testing purpose.

7.11.7 CHECK SYNCHRONIZING RELAY

The Contractor shall provide the check synchronizing to include the 400kV CB to prevent unsafe closing. A voltage selection scheme shall be used to ensure the check synchronizing relay compares the correct voltage signals from VT's depending on the position of disconnect switches.

The Contractor shall supply and install, among others:

- new RTU's and marshaling cubicles to accommodate the above
- Modify the RTU software to accommodate the above
- Modify the database, DCS Gateway software, prepare/modify screen drawings etc. at the power plant control room to enable the power plant switchgear's to be monitored and controlled as referenced above.
- The gateway at the new central control room to provide the necessary IEC-60870-5-104 protocol signals to interface to the NLDC.
- Fibre optic cables between the 400kV Substation and the Plant control building.
- Optical converters at the substation.
- Materials and modifications as necessary to complete the communication circuits between the substation and NLDC communications equipment
- Database/SCADA/EMS software modifications, preparation of screens drawings etc at the power plant to enable the relevant equipment to be monitored and controlled as referenced above

7.11.8 LOAD FLOWS, SYSTEM VOLTAGE AND FREQUENCY

Electrical quantities shall be provided to enable, among others, the following measurements:

- Power flow (MW and MVar) on all 400kV feeder circuits and on the 400kV side of transformers.
- 400kV busbar voltages and frequencies.
- 400kV feeder voltages

7.11.9 ALARMS

Alarm facilities shall be provided to alert the System Control Engineer at NLDC in the event of the following operations, among others:

- Tripping of 400kV circuit-breakers
- Busbar protection operated
- Feeder main 1 protection operated
- Feeder main 2 protection operated
- Feeder back-up protection operated
- Circuit breaker fail protection operated
- Feeder-end protection operated
- Auto-reclose operated
- Transformer protection operated (per transformer)
- Transformer non-trip alarms (per transformer)
- Transformer winding/oil temperature alarm (per transformer)
- Tap change out of step alarm
- Tap change incomplete alarm
- Circuit breaker faulty alarm (e.g. low pressure)
- Protection faulty alarm
- Busbar protection faulty alarm
- Battery fault (per battery)
- Battery charger fail (per battery)
- LV AC System Fail
- Substation common alarm
- Communication equipment alarm urgent
- Communication equipment alarm non-urgent
- Teleprotection channel fail.
- Circuit breaker spring uncharged
- Circuit breaker motor supply trip
- Auto reclose blocked
- DC supply failure

7.11.10 INTERFACES

This contract includes Industrial grade DCS communication Gateway to the NLDC. The Gateway shall have adequate capacity to cater to the future extensions of substation. The cabling between the Gateway and the communication equipment shall be provided under this contract.

7.11.11 COMMUNICATIONS SYSTEMS

Internal and external communications systems shall be provided to transport voice, data, video signals and protection signals.

Single-mode fibre optic communication cables shall be used between rooms and areas of the power station building and to connect with equipment outside the building. Copper communication cables may be used within a cabinet or plant area where electrical isolation is not required.

7.11.12 COMMUNICATION SYSTEM STANDARDS

The communications equipment and installation shall conform to relevant technical requirements of the following standards:

ITU-T	International Telecommunications Union-Telecommunications Standardisation Sector
ITU-R	International Telecommunications Union-Radio Communications Sector
IEC 60794	Optical Fibre Cables
BS 6651	Protection of Structures against Lightning
RFC	Applicable Internet “Requests for Comments (RFC) documents

7.11.13 EXTERNAL DATA COMMUNICATION

A fibre cable loop shall be provided from the Plant to the 400kV Substation and back to the Plant. The cable shall incorporate at least 24 fibres and be terminated at each location in a fibre distribution frame/patch panel provided under the contract.

The DCS communication gateway shall communicate with the SCADA Master station at NLDC to transfer the parameters listed above.

Communication with NLDC master station shall be achieved by provision of communications equipment at the DCS control building. The Contract scope shall include configuring the RTU’s to provide the required signals via an Ethernet interface to transport the data to NLDC.

These fibre optics cables shall carry serial data from the RTU’s and telephone connections as described below.

7.11.14 OPTICAL CABLE AND EQUIPMENT

The fibre and cable specifications shall comply with ITU-T recommendation G.652 and the relevant IEC standards. Each fibre cable shall be supplied with at least 50 % spare cores, minimum four spares.

Single mode outdoor-type optical fibre cable shall be of loose tube, gel filled construction installed in HDPE cable ducts or direct buried in plastic conduit. The cable shall a non-metallic central core sheathed with black polyethylene. An armored layer shall surround the inner sheath made up of corrugated steel or aluminum tape at least 0.2 mm thick followed by an outer polyethylene sheath.

Single mode optical fibre cables shall be designed to optimize transmission of light at the appropriate wavelengths. The core/cladding diameters shall be 9/125µm.

Single-mode indoor optical fibre cable shall be of the tight buffered construction installed in cable ducts or on cable ladder. The cable shall have a non-metallic central core sheathed with black polyethylene. A non-metallic strength layer shall surround the inner sheath followed by an outer polyethylene sheath.

Suitable fibre cable junction boxes, patch panels and patch leads shall be provided. The JB/patch panel shall have a fibre capacity equal to the total number of fibres, (connected and spares), for all cables to be connected. Patch panels shall be designed for 19 inch rack mounting within a standard equipment cabinet.

All unused couplings shall have protective dust covers. The patch area in patch panels shall be accessible behind a door or removable cover. Sufficient factory manufactured patch cords with suitable colour coding shall be provided. Fibre optic connectors shall be standardized for ease of maintenance.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 8 – CHEMICAL

CONTENTS

8 CHEMICAL ENGINEERING

This section discusses the design criteria which shall be used for all chemical engineering related work; including water treatment, wastewater treatment and disposal, condensate polishing, electro chlorination, cycle chemical feed, and steam cycle sampling and analysis.

8.1 DESIGN CODES AND STANDARDS

The design and specifications of all work shall comply with all applicable Laws and codes. A summary of the major international codes and industry standards to be used in design and construction is provided below. In case of conflict between them, Bangladesh legislation, regulations, and codes are mandatory and represent the required minimum; compliance with more stringent standards is acceptable Contractor may adopt alternative standards not covered by the list presented below, provided the Contractor has requested and demonstrated, to the Employer’s satisfaction, and Employer has accepted each such alternative standard as being equivalent to the listed standard.

1. Storage and handling of all chemicals shall be in accordance with International standards and local regulations.
2. Deluge showers and eyewashes shall be provided in areas in which exposure to potentially injurious materials may occur, in accordance with International standards and local regulations.
3. Potable water quality shall be in accordance with the World Health Organization standards and National Sanitation Foundation International (NSF) standards.
4. Sewage treatment system design shall be in accordance with all applicable local regulations.
5. The design and materials for use and installation in hazardous areas shall be in accordance with International and local standards.
6. Pressure vessels shall be in accordance with ASME Boiler and Pressure Vessel Codes Section VIII, Division I.
7. Water heater tanks shall be in accordance with ASME Boiler and Pressure Vessel Code.
8. Structural skids shall be in accordance with ANSI/AWS D1.1.
9. Tank and pipe rubber lining installation shall be in accordance with ASTM D3488 Practices for Installation of Vulcanized Rubber Tank Linings and Pipe Linings.
10. Fiberglass reinforced plastic tanks shall be in accordance with ASME/ANSI RTP-1.
11. Tank steel sidewall for solids contact unit, and sludge thicker, and gravity filter shall be in accordance with ANSI/AWWA D100.
12. Pump Shafting Diameter and Straightness shall be in accordance with ANSI/AWWA E101.
13. Antifriction type bearings for sludge service shall be in accordance with AFBMA B-10 - minimum rating of 30,000 hours.
14. Gravity filter media materials shall be in accordance with AWWA B100.
15. Gravity filter gradation sizes shall be in accordance with ASTM E11.
16. Oxygen feed equipment shall be in accordance with the following standards:

i. Gas cylinder/container connections: ANSI B57.1 (Compressed Gas Association, Inc.: Pamphlet V-1, Compressed Gas Cylinder Valve Outlet and Inlet Connections).
ii. Oxygen feed system design: CGA G-4.4.
iii. Guide for designing oxygen systems for oxygen service: ASTM G 88

Other recognized standards shall be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

The codes and industry standards used for design, fabrication, and construction shall be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

Unless otherwise indicated, metallic piping shall be utilized to the maximum extent possible unless otherwise specified. Non-metallic piping may be used for chemical feed piping, seawater, and underground piping.

8.2 CHEMISTRY OF POWER PLANT

Facilities and chemicals of the chemical water treatment system should be subject to safety design in accordance with the General Rule for Classification and Hazard Communication of Chemicals, Rule for Storage of Chemical Dangers and Technical Code for Designing Chemistry of Fossil Fuel Power Plants.

When arranging for high-temperature and high-pressure steam/water sampling piping, avoid crossing such crowded areas as control room, and take heat preservation measures when crossing places where people stop or pass through.

In the hydrogen station, rooms with explosion danger should be arranged in a centralized manner. Rooms with explosion danger should not directly connect with rooms without explosion room.

In the hydrogen supply station, hydrogen tank should be provided with a pressure meter and a safety-relief device

A hydrogen vent pipe should be arranged at the top of the hydrogen tank.

Walls and floors of the laboratory should be subject to anti-corrosive treatment and provided with such safety protection and emergency treatment facilities as flushing facilities.

Such buildings and rooms for storing and using chemicals as acid/base storage room (warehouse), meter room and acid and base unloading pump room should be provided with such safety protection and emergency treatment facilities as water flushing and drainage facilities.

8.3 DESIGN WATER QUALITY

The quality of water to be used as the basis for design of water treatment facilities is as follows.

The fresh water source for boiler make-up water treatment system is the river water from Andhar manik.

The boiler make-up water treatment system is designed temporarily on the basis of this water quality. The Bidder shall check the water quality report in rainy season so as to confirm the accuracy of the system as necessary and ensure the reliability of system selection.

River Water

River water shall be supplied by the Contractor for once through condenser cooling water and electro chlorination feed. A portion of the condenser effluent water will be used in the FGD absorber for SO_2 removal. The river water analysis is provided in Attachment E1 of Section 5.

Potable & Service Water System

Potable and service Water receives water from the Service/Fire Water Storage Tanks.

Demineralized Water

A demineralized water treatment system shall be supplied to produce makeup to the steam cycle and the closed cycle cooling water system. In addition, demineralized water shall be used to supply various high quality water users during unit startup and normal operation such as laboratory and for condensate polisher and demineralizer regeneration.

Water used for cycle makeup shall be of the highest quality practical to support boiler and steam purity requirements. Minimum quality requirements for cycle makeup water shall be the more stringent of the requirements set by the boiler and steam turbine manufacturers and as follows:

Constituent	Maximum Concentration
Silica (as SiO_2)	0.01 mg/L
Sodium (as such)	0.003 mg/L
Chloride (as such)	0.003 mg/L
Sulfate (as such)	0.003 mg/L
Total Organic Carbon (TOC)	0.3 mg/L
Specific Conductivity	0.1 μmho/cm

The cycle makeup treatment system shall have a minimum design capacity based on a total makeup rate of 5 percent (5%) of the full-load MCR boiler steaming rate. The cycle makeup treatment system capacity shall allow for the water requirements for condensate polisher regeneration, ion exchange regeneration, and any other demineralized water users.

8.4 CHEMICAL STORAGE

Storage Capacity

Chemical storage tanks, unless otherwise indicated, shall be sized to store a minimum of 15 days of storage or 1.5 times the normal bulk shipment, whichever is larger. Some chemicals may be delivered in total containers or semi bulk containers suitable for off-loading and feeding chemical. These containers shall be sized as required to meet standard size requirements.

Containment

Chemical storage tanks containing corrosive or environmentally hazardous fluids shall be located within containment areas. Separate containment areas shall be provided for incompatible chemicals. Containment curbs or walls shall be designed to contain 110 percent (110%) of the volume of single largest tank within the containment plus sufficient freeboard for the design rain event (for outdoor storage). Containment areas shall slope to a recessed sump. A floor drain routed to the chemical waste sump shall be provided in the sump. A locked closed isolation valve shall be provided on the floor drain piping and shall be accessible from outside the containment curb.

Closed Drains

Where required, drainage piping shall utilize closed drains to reduce exposure to noxious or toxic vapors. All open floor drains shall be provided with traps.

Coatings

Chemical storage tanks shall be constructed from materials suitable for the chemical being stored without degradation of the tank or chemical being stored. All interior tank surfaces exposed to the chemical that are constructed from incompatible materials shall be provided with a suitable protective coating or lining.

In general, chemical containment areas shall be concrete. Chemical containment areas containing chemicals that could damage the concrete shall be coated with an appropriate protective coating in accordance with Coating System Data Sheets in Attachment B2 of Section 5 - Employer’s Requirements or shall be constructed from an alternative material compatible with the chemical being stored. All surfaces within the containment area and below the top of the containment wall, including but not limited to skid bases, tank supports shall be constructed from compatible materials or coated with an appropriate protective coating.

8.5 WASTEWATER TREATMENT

The extent of wastewater treatment provided by the Contractor shall be as required to meet the International and local standard, whichever is more conservative. The wastewater treatment scheme described in System Description, the process flow diagrams shall be submitted by the Bidder, and System Definitions in Attachment C of these Employer's Requirements shall be the minimum functionality required for this Project. Additional wastewater treatment systems shall be provided as necessary to meet the discharge regulations.

Potentially oily plant and equipment drains shall be treated for oil and grease reduction, and then routed to the wastewater treatment system as required to meet discharge requirements.

Plant chemical wastes, including chemical containment drains shall be treated for pH adjustment in the neutralization tanks. Neutralized chemical wastes shall be routed to the wastewater treatment system as required to meet discharge regulations.

Sanitary (domestic) wastewater shall be collected and treated in a packaged sewage treatment plant. Industrial wastewater associated with power production, material handling, or water/wastewater treatment processes at the site shall not be treated in the sewage treatment plant. The sewage treatment plant shall have a capacity based on 170 plant shift personnel at a minimum of $0.2m^3$/day per capita. Provisions shall be made for collection and disposal of solid waste generated by the sewage treatment plant.

Coal pile storm water and coal dust suppression runoff shall be collected in the coal pile runoff pond. Decanted water from the coal pile runoff pond shall be used for coal pile dust suppression or transferred to the wastewater treatment system.

8.5.1 LOCATION OF THE EQUIPMENT

Generally, water treatment equipment shall be located in a building. Equipment designed for outdoor installation shall be designed for a temperate coastal environment. Except for larger tanks and clarifiers, all water treatment equipment installed outdoors shall be covered with a sunshade. Equipment that is not suitable for outdoor installation shall be installed inside of a building or enclosure.

8.6 WATER MASS BALANCE

The water mass balance shall be revised and finalized by the Contractor. The Contractor shall also create all additional water mass balances based on other operating conditions that are required to properly determine the water usage and treatment capacity of the water/wastewater treatment systems. Any required changes in the water mass balance to account for actual equipment water demand, wastewater production, or water/wastewater treatment shall be reflected in the revised water balance. The Contractor shall also make any necessary additions or changes to the water/wastewater treatment systems to meet the demands of the equipment and/or wastewater discharge limitations.

8.7 CHEMICAL DOSING SYSTEM

To decrease corrosion on the thermodynamic system and increase the pH value of feed water, the condensation water and feed water after polishing adopts the ammonification and oxygenation treatment.

In order to inhibit corrosion and scaling on the closed-circuit cooling water system, it is planned to adopt the inhibitor (e.g. hydrazine) treatment.

The chemical dosing system is planned to be arranged on the ground floor of the main building, convenient for signal connection with the steam and water sampling and operation management.

8.8 CHEMICAL LABORATORY AND TESTING INSTRUMENTS

This project is equipped with water analysis instrument and equipment, coal analysis instrument and equipment, oil analysis instrument and equipment and necessary operating and testing equipments, testing desk and table, medical cupboard and laboratory according to the standard for 660MW ultra-supercritical power unit.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 9 – BULK MATERIAL HANDLING

CONTENTS

9 BULK MATERIAL HANDLING

9.1 GENERAL

This specification covers the design, manufacturing, supply, erection, commissioning and handing over of the complete coal, high speed diesel (HSD), ash handling and gypsum handling systems, comprising in each case the unloading or loading, transport, and storage and removal systems for the entire specified power plant. The configuration shall cater for all units, with number of units and capacities as specified in sub-clause 9.2 and other parts of the Specification. If not mentioned otherwise, the given numbers of equipment is for 2 x 660MW.

It is to be emphasized, that this specification does not enumerate or describe all the materials and equipment to be supplied and all the services to be performed. However, the fuel and ash supply and storage systems shall be complete in every respect and shall ensure safe and reliable operation of the Plant. This means, all material and equipment shall be provided as required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship. Refer drawings 10-PM-PAY-02 for general layout (overall), 10-PM-PAY-19 for coal handling plant, 10-PM-PAY-09 for fly ash handling system and 10-PM-PAY-08 for slag disposal system diagram, in Attachment B4 of Section 5. Also refer Attachment C of Section 5 for more details.

9.2 SCOPE OF SUPPLIES AND SERVICES

9.2.1 COAL HANDLING SYSTEM (CHS)

An appropriate coal handling system including a coal control building shall be provided. The control and regulation of the CHS should be based on the DCS system.

The coal handling systems shall be complete in every aspect, including at least:

- six (6) grab-type ship unloaders of 6 x 500 t/h capacity to unload the coal supplied from bulk-cargo vessels/barges berthed at the jetty constructed under this Contract
- mobile equipment: six (6) light wheel loaders for cleaning-up operation in the holds of the coal vessels to perform the ship unloading trimming works
- all fully enclosed/covered redundant belt conveyors, conveyor bridges and transferring towers needed to supply the coal to the coal yard and to the station coal bunkers of the unit
- three (3) radial type stacker & reclaimers of 1750 t/h capacity, each, for round coal storages for storing and blending the coal, fully equipped with water spray for dust suppression
- hoppers
- the project has 3 round fully covered coal yards, 120 meters in diameter, each round coal yard have one set of circular stacker reclaimer, which can be stored in the coal

yard, and coal yard can be taken to the main plant in raw coal bunker. Stacker, reclaimer capacity is 1750t/h; 3 round coal yards storage capacity of 54 x10^4 t, for 2 x 660MW units for 40 days operation.

- Three (3) transfer towers T1, T2 and T3
- water spray system for the coal stock yard for dust suppression
- full roof coverage of each coal stock yard to prevent dust emissions and to protect against rain
- eight (8) magnetic iron separator stations, four (4) separators shall be installed in the coal receiving system, one in each line, and four (4) shall be installed one in the bunker feeding system, upstream of the coal crushers
- two (2) metal detectors, for C-7A and C-7B belt conveyors
- at least ten (10) coal weighing stations, two (2) for the coal received at the jetty, two (2) for the coal transported to the coal bunkers at the units, six (6) for the coal in & out the NO.1 to NO.3 round coal yards.
- four (4) fully automatic coal sampling stations, two (2) for the coal received at the jetty and two (2) for the coal fed to the station coal bunkers
- one (1) crusher building including two (2) crushers of an adequate type, including roller screens
- twenty-two (22) plough unloaders for filling of unit coal bunkers.
- one (1) Coal Handling Control Building
- mobile equipment: three (3) TY220 type bulldozers and three (3) ZL50 type loaders for moving and compacting coal on the coal yard
- all auxiliary devices for the trouble-free and safe operation of the coal handling system such as: spray water system (complete for all areas), firefighting system (complete for all areas), access systems in accordance with valid fire protection rules, mobile vacuum cleaning system, dust collection system for crusher building, transfer towers and bunker area
- ventilation systems for all underground tunnels/installations, if any and for each coal yard
- sump pumps for dewatering all underground tunnels/installations, if any
- the complete power supply, electrical distribution boards, earthing, etc.
- lightning protection for each of the equipment and towers and coal yards
- communication system: wireless, fiber-optic as back-up

9.2.2 LIMESTONE HANDLING SYSTEM

An appropriate limestone handling system shall be provided. The limestone handling systems shall be complete in every aspect, including at least:

- limestone transportation from the jetty to the transfer tower-2 shall use the same coal transfer facility from tower-2 to the lime stone shed the lime stone will be transported by belt conveyor.

- one (1) slewing and luffing stacker, for longitudinal limestone storages for storing coarse limestone, fully equipped with water spray for dust suppression
- one (1) closed limestone stock yard, consisting of 1 longitudinal limestone storage, with a minimum capacity of ninety (90) days of total supply (BMCR operation with high sulphur coal), including dewatering system and limestone runoff pond
- water spray system for the limestone stock yard for dust suppression
- mobile equipment: two (2) front end loaders for limestone supply to the two (2) limestone hoppers
- all belt conveyors needed to supply the limestone to the limestone yard
- all auxiliary devices for the trouble-free and safe operation of the lime-stone handling system such as: spray water system (complete for all areas), firefighting system (complete for all areas), access systems in accordance with valid fire protection rules
- sump pumps for dewatering all underground tunnels/installations, if any
- the complete power supply, electrical distribution boards, earthing, etc.
- lightning protection for each of the equipment.
- full roof coverage of the limestone stock yard to prevent dust emissions and to protect against rain.

9.2.3 HIGH SPEED DIESEL (HSD) SYSTEM

For the start-up, low-load and shut-down firing of the boiler, one complete HSD supply and storage system shall be supplied. HSD shall also be employed for the emergency Diesel generators and the emergency Diesel firefighting pump and the coal yard bulldozers. HSD shall also be used for the auxiliary boiler.

The HSD system shall include at least:

- unloading stations (number of unloading pumps to be defined by Con-tractor, minimum 4) for road truck supply for parallel unloading, quick coupling flanges, valves, redundant suction filters and pumps
- two (2) HSD fixed roof storage tank(s) of a total capacity of at least 2 x 500 m3, single wall tanks complete with retention basin for a collection capacity consistent with DOE’s or DOSH’s requirements, incl. overflow level indicators and instrumentation
- two (2) HSD inter tank transfer pumps with dedicated piping and fittings
- two (2) forwarding pumps, with filters. The capacity of each pump shall be 10% higher than the needed high speed diesel flow to reach 25% BMCR. One common stand-by pump with the same capacity shall be installed.
- all piping to forward the HSD to the burners of the boiler. This includes recirculation lines, safety valves, pressure controllers, headers valves, check valves, etc.
- two (2) transfer pumps for additional users, each with 100% capacity, e.g. for emergency diesel generators, auxiliary boiler, emergency diesel fire fighting pump

- fire protection devices, where needed according to valid fire protection rules
- separate metering stations with totalizers, on the supply line, for start-up firing line for each boiler, on the auxiliary consumers and on the auxiliary boiler
- two (2) slop oil collecting systems, one for each boiler, with redundant pumps
- the control and regulation of the HSD-system shall be based on the DCS system.

9.2.4 ASH AND GYPSUM HANDLING SYSTEM

The Ash Handling System (ASH) shall be designed with the capacity to collect all the ash and slag produced when the worst coal is burned in the boiler. The control and regulation of the AHS should be based on the DCS system.

For the handling of the bottom and fly ash, the following shall be supplied at least (as an example):

- two (2) wet bottom ash removal systems, one for each boiler, where each includes at least:
    - transition hopper with hydraulically operated isolation flaps below the boiler with dedicated hydraulic equipment
    - mechanical expansion joint
    - heat resistant extractor with cleaning devices
    - post cooler
    - adequate crusher system (pre-crusher and main crusher)
    - one main crusher as cold standby
    - emergency cooling system to lower ash temperature (as required)
    - temperature monitoring system
    - supporting structures including stairs, walkways, etc.
- one (1) bottom ash silo near the boilers with bottom ash extraction facilities to trucks by vibro feeders which allow regulated feeding
- two (2) collecting and transportation system for the fly ash, one for each boiler, from the electrostatic precipitators and economizers using positive pressure pneumatic conveyors with all required compressors, tanks and piping, and transporting the fly ash to the fly ash silos, which are located near the ESP
- three (3) fly ash silos, with fluidization system, dedusting system and fly ash extraction facilities to dry ash trucks and to wetted dust dumpers
- one (1) gypsum silo with gypsum extraction facilities to trucks
- one (2) submerged scraper conveyor from the boiler for bottom ash to the slag silos
- one (1) ash/slag storage yard and FDG gypsum to be classified, compacted and stored separately.
- two (2) complete water return systems with pumps from the overflow pond of the ash yard back to the HCSD systems near the storage silos

- dust suppression system for ash yard, as required to ensure IFC guideline requirements.

9.3 BULK MATERIAL HANDLING DESIGN CRITERIA

This subsection describes general design criteria for components of bulk material handling systems. The coal handling system shall be furnished according to the General Layout overall drawing number 10-PM-PAY-02 and Coal Handling Plant diagram number 10-PM-PAY-19 in Attachment B of these Employer's Requirements. The ash handling system shall be furnished according to the Fly Ash Handling System diagram number 10-PM-PAY-09, the Slag Disposal System diagram number 10-PM-PAY-08 in Attachment B4 of these Employer's Requirements.

All equipment in coal and ash handling systems shall meet the requirements of applicable Laws and codes specified herein. In this section detailed technical requirements are mentioned for the fuel and ash handling system.

9.3.1 DESIGN CODES AND STANDARDS

Design and specification of all work shall comply with all applicable Laws and codes. A summary of the major international codes and industry standards to be used in design and construction is provided in sub-clause 3.2.2 of Chapter 3, Section 5.

9.3.2 COAL RECEIVING AND TRANSPORT SYSTEM

Major components of the coal handling system shall include a receiving conveyor system comprising of standard belt conveyors, a stacking and reclaim facility comprising of traveling bucket-wheel type stacker-reclaimers, coal yard conveyors, and enclosed silo fill conveyors. A dual conveyor system shall be utilized to ensure continuous plant operations. Please refer to the relevant documents in the System Definitions in Attachment C of Section 5 for additional requirements relating to the Coal Handling System.

The Coal Storage system shall be fully covered round Coal Yard, as detailed herein. The Project shall have three round coal yards of 120 meters in diameter. Each yard shall have one set of circular Stacker Reclaimer which can be stored in the Coal Yard. Stacker Reclaimer capacity is 1750t/hr. The three coal yards storage capacity is 54×10^4 t, for 2 x 660MW units 40 days requirement. The coal yards shall have three coal transporters, three wheel loaders with necessary spares for auxiliary operations and coal yard conveyors. The required arrangement is shown in Coal Handling Plan drawing number 10-PM-PAY-19. Water soaking shall be considered for the Coal Conveyor System.

9.3.2.1 GENERAL REQUIREMENTS

The conveyors into and out of the round coal yards shall be arranged in one way all the rest shall adopt double way arrangement, one for operation and the other for standby. Bunker Bay Belt conveyor C-9A/B parameters, band width B=1600mm, band speed 2m/sec, output 1750t/hr. The rest Belt Conveyor parameters Band Width B=1400mm, band speed 2.8m/sec output 1750t/hr. The Coal Loading margin shall be designed for two times coal consumption of the 2 x 660MW boilers meeting the output requirement of the Coal Conveying System. There shall be 3 transfer towers T1, T2 and T3, as noted in the coal handling plan diagram number 10-PM-PAY-19.

In the T2 Transfer Tower the coal is conveyed by C-7A/B Conveyor to the Coal Crusher or by C-3A/B conveyor to the Coal Yard. The Coal Loading to bunker directly from wharf conveyor shall be possible, in the T2 Transfer Tower to avoid double handling.

Coal Handling System shall have electrical three devices and four devices by switch to have cross operation. In T3 transfer tower provision shall be provided to send and receive coals to future similar 3 coal yards for future 2 x 660MW in a similar way.

9.3.2.2 COAL HANDLING SYSTEM

Coal and limestone arrive via bulk-cargo vessels/barges with capacities between 2,000 DWT and 8,000 DWT at the unloading facility jetty. Coal shall be unloaded from the ships by six (6) grab-type unloaders. The unloaders shall be operated dust-free and be suitable to operate during rough weather conditions.

At least one of the unloaders shall be connected to unload limestone from bulk cargo vessels to dedicated limestone conveyor belt system.

The unloaders deposit coal via hoppers onto the coal jetty conveyor belts. From the coal jetty, the coal is moved via the receiving conveyor belts to the coal storage yard.

The coal is reclaimed with portal scraper reclaimers onto the reclaiming coal conveyor belts, which transfer the coal to the boiler bunkers.

Blending shall be either achieved on the coal yard itself, if vessels from different location will arrive in a staggered mode. The stacking equipment shall be able to use following stacking methods: Chevron, Strata (preferred), Windrow, cone shell.

In addition blending shall also be achieved by parallel operation of two portal scraper reclaimers. The blended coal is transported via belt conveyors to the crusher building and from there to the coal bunkers, if coal is sent directly to boiler. If seen advantageous, the crusher station may also be implemented upstream of the coal yard.

An automatic sampling system for both the coal received from the vessels as well as of the coal being fed to the coal bunkers shall be foreseen.

A fully covered coal yard shall be offered (refer drawing no. 10-PC-PAY-04 and 10-PC-PAY-05).

The operational requirements are as follows:

- The coal handling system shall be designed with sufficient redundancy that the failure of any individual component shall not disrupt delivery from the jetty to the stockyard or feeding of coal to the station coal bunkers.
- The conveying and crushing system shall have 100% redundancy.
- The system shall be capable of offloading ships, feeding coal to the station coal bunkers and stocking out to the stockpile simultaneously.
- The system must be designed for minimum life cycle costs, operation with the minimum level of manpower and minimum manual intervention. Local and semi-automatic control shall be provided for all equipment. The layout shall be as simple as practicable to minimize the number of conveyors, conveyor transfer points, diversion chutes and change in direction of the coal flow.

The unloading station shall also be used for unloading of limestone.

9.3.2.3 DESIGN BASIS FOR COAL HANDLING SYSTEM

- The coal handling plant (CHP) shall be sized for 100% plant load factor (PLF) and performance fuel NCV at BMCR.
- Peak daily coal requirement shall be met by 12 hours net operating hours of CHP.
- The rated capacity shall consider 10% margin over above mentioned requirements.
- Equipment design capacity shall consider 10% margin over rated capacity.
- The mechanical, electrical and structural / civil system shall be designed for round the clock operation with both the streams operating simultaneously.
- For all volumetric capacity calculations, the bulk density of coal shall be taken as 800 kg/m3.
- For all load, stress and torque calculations, the bulk density of coal shall be taken as 1100 kg/m3.
- The whole range of coal moisture content and HGI shall be considered.
- For the belt conveyor maximum 80% fill factor shall be considered.
- All capacities given in this specification and in the Technical Schedules are nominal capacities. The maximum equipment capacities must have a margin of +20%.

9.3.2.4 PARTICLE SIZE DISTRIBUTION AND COAL CONDITION

The following particle size distribution of the coals shall be applied to the system design:

- Over 50 mm: 5%, maximum 10% (maximum 100 mm)
- Under 2 mm: 30%, maximum 40%

Considering the fact that the coal delivered to the site may:

- be raw coal from open cast mines or beneficiated coal
- have a high clay content, contain fines, have a high moisture content, be sticky and difficult to handle
- contain rock, tramp metals, plastic sheets and other contaminants
- may be very dry, free flowing and dusty.

The system shall be designed to handle the whole range and condition of coal that may be delivered to the site in a safe, reliable, economic and environmentally acceptable manner.

Oversize material and any metal contaminants must be safely detected and removed automatically from the coal handling system.

9.3.2.5 OPERATION HOURS

The coal handling system shall be designed under the following conditions:

- Unloading operation from vessels: 24 hours/day
- Discharging operation to bunkers: 12 hours/day.

The complete coal handling system shall be possible to be operable for 24 hours/day. The design of the coal handling system therefore has to take the night noise limitations into account.

9.3.2.6 WEATHER CONDITIONS

The coal handling system shall be designed to be able to convey in any weather conditions. With the expected rain conditions at site, the coal handling system shall be designed to deliver the required loading with the worst coal in terms of moisture content and mill primary air flow.

The coal handling facilities shall be also designed to be able to operate under the following wind conditions:

- Unloading operation on jetty: max. 16 m/sec
- Stacking and reclaiming operation at coal storage yard: max. 16 m/sec.

The complete coal handling system structures, including stackers, reclaimers, coal yard roof and ship unloaders must be designed to withstand the highest wind speeds, as defined in Chapter 4 of Section 5.

Design quality and standards

The coal handling system and auxiliaries shall be of standard proven design. The coal handling system shall be designed, manufactured and tested based on the ISO standards and CEMA Belt Book where applicable or equivalent codes, in particular:

ISO 5048 Continuous mechanical handling equipment
Belt conveyors with carrying idlers

ISO	5049	Mobile equipment for continuous handling of bulk materials
CEMA		Belt conveyors for bulk materials.

The system shall be designed for ease of operation, maintenance, inspection and cleaning, as well as to prevent the undesirable effects of dust and water.

Communication System
The communication system shall follow the requirements of Chapter 7 of Section 5.

9.3.2.7 COAL UNLOADERS

The six (6) coal unloaders located on the jetty shall be of grab type and shall be of proven design, with extensive track record and experience, applying all modern practices for easy and safe operation and rapid unloading with additional emphasis on accessibility for ease of maintenance.

The coal unloading system shall be capable of unloading all typical bulk-vessels/barges with capacities between 2,000 and 8,000 DWT.

The unloaders shall be able to simultaneously and independently discharge coal via their own hopper and via vibro feeders onto jetty conveyors. Anti-collision control devices shall be installed for the unloaders.

The unloading equipment shall be designed such, that the unloading (excluding berthing and unberthing) of the coal supply ships can be achieved in the following maximum time with one unloader in operation:

- 2,000 DWT ships: 2.5 hours
- 8,000 DWT ships: 9 hours

At minimum, the unloaders shall have a nominal capacity of either 6 x 500t/h, but the above stated unloading times have to be met as well.

Six (6) grab-type unloaders are only permitted when very good references are available.

The unloaders shall be operable under the following operation mode:

- manual operation from the operator
- auto/semi-auto operational mode.

The Contractor shall provide six (6) wheel loaders for cleaning-up operation in the holds of the coal vessels.

Appropriate fittings shall also be included to facilitate lifting of the equipment by the unloaders from the jetty into the holds and vice versa.

9.3.2.8 GRAB-TYPE UNLOADERS

The rigidity of the equipment structure and the resistance to deformation shall be compatible with the function of the mechanism.

The gantry crane travel system shall consist of an arrangement of bogies with a driven and a non-driven wheel. The drive systems shall each be protected by rigid, heavy duty crash guards. Suitable overload and slack cable protection devices shall be provided. The construction shall make sure that the gantry corner weight is equally distributed to all wheels. Jacking support points shall be provided under the gantry frame to allow replacement of any wheels and pins. Shock absorbers and bumpers shall be installed on the ends of each bogie.

Sufficient and adequate lighting shall be provided to ensure safe and efficient bulk unloading operations in all weather conditions at all times of day, including highly efficient floodlights along boom girder and the hopper area.

To ensure safe operations and travel on the unloading jetty, the grab unloader shall be equipped with amber strobe warning lights as well as audio warning units at the corners of the gantry bogies.

Power back up shall be provided to cater the event that during storm and a power failure the grab-type unloader shall be parked in save position. Spilling of coal into the river or any other unsafe operating condition shall be prevented.

A storm anchorage system shall be provided for the crane.

The winding drum mechanisms of the main hoist shall include hoisting, grab opening/closing, trolley towing and shall be mechanically independent and electronically synchronized in such a manner that operations are safe in every possible operation mode.

The trolley holds the load on the grab transmitted by the hoists and grab opening/closing ropes. The trolley is towed by the winding drum mechanisms on the rail mounted on top of the main and boom girders.

The trolley shall be easily accessible from the machinery-house while in parking position. This implies that shall be possible to lift or lower to ground every piece of the trolley, including wheel assemblies and sheaves assemblies, without difficulty by using the maintenance crane of machinery house.

The grab shall be suitably designed for the above mentioned vessel sizes as well as time efficient unloading. Furthermore, it shall accommodate lifting lugs to handle bulldozers and other mobile equipment.

A passenger hoist to boom level shall be provided.

The machinery house and electrical room shall be located on top of the main girder as a single unit. It shall provide a weatherproof casing to the hoist travel bases as well as the electrical power distribution equipment. In the machinery house, an overhead travelling service crane shall be provided, capable of lifting the largest as well as the heaviest equipment included in the machinery house. The crane shall be able to service all parts and lower them to jetty level for servicing.

The electric drive control panels and PLC are to be located in an air-conditioned electrical room inside the machinery house. Visual observation of the mechanical equipment from the electrical room shall be possible via suitably large safety glass windows for ease of maintenance and operations.

Walkways shall be provided for maintenance access to all points requiring attention.

Anemometers shall be provided on the top of coal unloader to indicate the wind velocity at the operator’s cabin. When the anemometer indicates winds above allowed maximum value, the grabber shall be parked in a safe condition. The Bidder shall provide value for the maximum wind speed the grabber can be operated.

The gantry structures shall be of heavy-duty construction. Platforms, stairway and ladders shall be provided to all areas needing for operation, inspection and maintenance.

All control functions of the unloader operation shall be carried out in the operator’s cabin. Each signed cabin as follows:

The cabin shall be totally enclosed with glazed design giving all round vision to the operator and shall be air-conditioned. The seat for the operator shall be adjustable to enable him to suit different operations. Hinged windows shall be provided where necessary to allow the windows to be cleaned. Electrically operated windscreen washers and wipers shall be provided where essential.

The whole operator’s cabin shall be and able to withstand the maximum storm wind condition. Access to the cabin shall be convenient and safe.

The operator cabin shall be of rigid construction and be thermally and acoustically insulated. It shall be comfort and performance. Special attention shall be paid to the isolation of the operator from shocks and vibrations associated with the operation of the equipment.

Intercommunication system between the cabin and the foreman and cable between the cabin and the Coal Handling Control Room shall be provided. Loudspeaker to talk to the ground level or the hold bottom shall be provided. A clock and a manual chemical extinguisher shall be provided. A TV monitor, which shows the digging place, shall be provided.

A computerized system shall be included to provide continuous data monitoring and diagnostics for operation and maintenance purposes with the necessary sensors and transducers. The systems data shall be presented in an ergonomical way through a HMI (Human Machine Interface) in the operator cabin. The HMI shall allow the operator to control all machine functions in manual mode as well as operate the unloading automatically or semi-automatically (only start and end movements of the trajectory are manually controlled). The system shall include among others: bucket trajectory control, automatic grab closing, grab fill control, grab load monitor and adjusting system, vessel height monitoring.

Water spraying system shall be equipped on all coal transfer points from the digging device to the jetty conveyors so that dust emission can be reduced to a practicably minimum level. Dust suppression devices shall be provided for the receiver hoppers.

9.3.2.9 COAL CONVEYING

9.3.2.9.1 BELT CONVEYORS

The coal conveyors from the coal unloaders to the coal yard shall have at minimum 2 x 1,750 t/h. It shall be ensured that two unloaders can discharge simultaneously onto one single belt conveyors.

The complete coal handling system from the coal yard onwards shall be designed to meet the one day coal requirements of two units with worst coal (lowest NCV) firing at BMCR condition at 12 hours effective operating time. The minimum conveying capacity for the coal handling system from the coal yard to the boiler bunkers shall be at least 2 x 1,750 t/hr nominal capacity.

The maximum incline of conveyors shall not exceed 16 degrees.

The maximum speed of the conveyor belt shall not exceed 3.5 m/s. The jetty conveyor may be designed for maximum conveyor speed of 4 m/s, if sufficient references are available.

All belts must be capable to start fully loaded.

All conveyors shall be provided with an emergency trip wire system and shall be provided with misalignment switches to offer protection from belt damage.

All conveyors shall be provided with a belt speed detector on the return belt, to detect belt slip or severance to stop the drive before further damage to the belt system occurs.

The belt type shall be either synthetic fabric such as nylon-nylon/polyester-polyamide or steel cord belt (preferred for conveyors of more than 800 m length). Belt types shall be with rubber covers of adequate flexibility for the troughing angle. For all the conveyors the number of plies, cover thickness, factors of safety, etc. shall be as per recommendation of the belt manufacturer, but not inferior to the figures as given blow:

- Minimum number of plies: 4
- Cover thickness (top / bottom)
  for N-N belt 5 mm/2 mm
  for steel cord belt 8 mm/6 mm
- Factor of safety
  for N-N belt 10
  for steel cord belt 7
- Working tension 80% of allowable tension

Steel cord belt shall be provided with rip-protection. The bidder shall provide proven experience for the rip-protection.

Heat resistant conveyor belts according EN 12882 class 4 or fire retardant according to ISO 340 shall be provided for all conveyors. All splices are to be hot vulcanized.

Drum friction and electrical surface resistance shall be tested and conform to Canadian standard CAN / CSA M-422-M87.

All outdoor belt conveyors except noted below shall be fully enclosed. If full enclosure is technically not possible (e.g. for the jetty conveyor) a dust and weather-proof conveyor cover shall be applied. All outdoor conveyor covers shall be of galvanized steel and shall comply with BS 1449. The sheets shall be 0.7 mm thick. Both sides shall be coated to a minimum thickness of 200 microns on each side. Inspection doors including door support shall be provided in the conveyors. For conveyor from transfer Tower-T1 to transfer Tower-T2 a dust and weather proof conveyor cover shall be applied.

All conveyors shall be fitted with internal and external belt cleaners. The belt cleaner shall be fitted with hard, durable materials for the blade to prevent damages to the belt.

Areas not subject to wear but subject to build-up of fine sticky coal shall be lined with HDPE plastic Solidur 10100 or similar to ensure that coal build-up does not occur.

Dual side-by-side conveyors shall be supplied with a 1100 mm clear central main walkway and 800 mm clear side auxiliary walkways.

Checkered plate shall be installed across the full width of all walkways and minimum 3mm thick seal plate shall be installed for the remaining width of the structure. The checkered plate and seal plate shall prevent equipment from falling and allow safe access to the far side of the conveyor for maintenance. The minimum height of the conveyor crossing over any road shall be 8 meters and in case of the main access road 8 meters.

All transfer points shall be located in a totally enclosed transfer house or tower, and shall offer protection to the drive assembly of the conveyor and associated plant. Each junction tower shall be equipped with an access area, a minimum of 1.5 meter wide around the drive and pulley locations, to facilitate the routine maintenance of the equipment.

9.3.2.9.2 CHUTES

The Contractor shall supply all the necessary chutes for feeding the coal onto the conveyors.

The design of the chutes shall be suitable for the trajectory of the coal as it leaves the conveyor, so that minimum wear takes place and no spillage occurs. The size and shape of the chutes shall ensure free flow of coal at the transfer point, without plugging even under extreme moisture.

Chutes shall be fabricated from wear resistant steel plates, Hardox 400, 400HBN or higher quality. The material selection shall assist the free flow of coal. The thickness of the chutes shall be 20mm for the three sides where coal slides/impacts the chute and 10mm for the chute wall that is not subject to abrasion. The chutes shall include external integral stiffeners and shall be provided with support brackets to attach chutes to adjoining structures. Chutes and supports shall be designed to withstand the load imposed by a totally plugged condition and also designed so that the load is shared by the floor(s) the chute passes through.

Chutes shall be provided with permanent lifting lugs and shall be designed to allow removal of parts or the entire chute without removing other equipment such as conveyor pulleys, crushers, etc.

Suitable access doors to allow ease of maintenance to items such as detectors, bearings, liners and belt cleaners shall be provided for all chutes.

Chutes shall be provided with 12 mm thick abrasion resistant wear plates at impact points and bolted with countersunk screws.

Chutes, which feed onto conveyors, shall be supplied with skirt boards. A suitable soft rubber dust curtain shall be provided on all entries into convey-or head chutes and also at the end of each covered skirt plate area.

A suitable arrangement, i.e. tilt-switch or better, according to experience of Contractor, shall be provided to indicate a blocked chute.

9.3.2.9.3 BELT CONVEYOR DRIVES

The drive system for the various conveyor systems shall consist of drive motors, fluid couplings, gear reduction, low speed flexible couplings and pulleys. Hydraulic drives or controlled start transmission (CST) drives may also be considered.

Rating of all drive motors shall not be less than 120% of the power required at drive motor output shaft at specified design capacity. The motor rating shall be at 50°C ambient temperature.

For replacement of spare parts all components must be easily accessible.

Near the drive unit a local control cubicle (on/off) with key-operated-switch shall be foreseen.

9.3.2.9.4 GEARBOX

The gearbox shall be designed for continuous operating and at least 80.000 operating hours. All gearboxes shall be of bevel-helical gearbox type and equipped with splash lubrication. The gearbox must be equipped with outside oil level indicator.

For replacement of oil the gearbox shall be located such that full size oil containment can be placed below the gearbox. The oil screw cap shall be easy accessible.

9.3.2.9.5 CLUTCH

Between motor and gearbox a fluid coupling/fluid clutch shall be installed. The clutch shall be connected directly to the motor and allow easy inspection of the oil level without the need for tools.

It shall be possible to repair the clutch without disassembly of the motor or gearbox.

Adjustment of the start-up delay time shall be possible. The construction of the bearings shall allow long lifetime.

The replacement of the clutch shall be possible without prior emptying of the oil and without disassembly of the clutch. The clutch design shall ensure that after re-assembly the system motor –clutch –gearbox is not necessary to re-adjust.

The maximum start-up torque shall be limited to 1.5 times the nominal torque.

Contact free thermal limit switch for surface temperature of the fluid clutch shall be provided.

9.3.2.9.6 BRAKES

Belt conveyors shall be equipped with wheel-disc brakes which shall be installed between clutch and gearbox. The brakes shall be designed for the full capacity.

9.3.2.9.7 PULLEYS

All pulleys shall be welded construction and balanced after machining. Pulley diameters shall follow DIN 22 101.

The drive and tensioning pulleys shall be equipped with rough surface. Adequate support and / or lifting hoists shall be foreseen, also for taking the load of the belt.

For interchangeability reasons, the belt pulleys for the different conveyors shall be preferably identical, as far as practical.

9.3.2.9.8 PULLEY BEARINGS

Bearing with permanent lubrication (grease box) shall be installed. The bearing house shall be of split type with removable cover.

The design lifetime of the bearing shall not be less than 80.000 operating hours.

9.3.2.9.9 BELT CLEANING

Downstream of the discharge belt cleaning by scrapers shall be installed.

For reversible conveyors two belt cleaners shall be installed suitable for reversible operation. Limit switches for each belt cleaner are required.

The coal attrition shall be directed to the downstream chute.

Belt cleaners shall be easy accessible and easy replaceable.

An inspection opening shall be installed for checking of each belt cleaner.

9.3.2.9.10 ROLLERS/IDLERS

Only rollers/idlers that follow DIN 15 207 part 1 shall be used. They shall be of low-noise type.

The calculated life time of the bearings shall be minimum 80.000 operating hours.

The roller arrangement and the trough shape of the conveyors shall follow DIN 22 107. For the upper belt 3 identical rollers shall be used.

The distance between rollers shall be selected such to ensure deflection of maximum 2%, preferably less than 1%.

9.3.2.9.11 BELT TENSIONING/TAKE-UP

For short conveyors length (up to approx. 50 m length) an adjustable spindle-type belt tensioning system shall be provided. For long belt conveyors a weight tensioning system shall be provided, complete with all necessary take-up equipment as: bend pulleys, take-up pulley, supporting/sliding assembly, wire ropes with turn-buckle arrangement for suspending the take-up weight sliding assembly close to the ground, counter weights and other accessories.

9.3.2.9.12 BELT WEIGHERS

Ten (10) automatic belt weighing stations consisting each of two (2) belt weighers of load cell type shall be provided on the belts from the jetty to the coal yard and two (2) belt weighers of load cell type shall be provided on the bunker feeding conveyors six(6) for the coal in & out the No.1 to No.3, coal yards.

Each weigher shall be provided with indicating and continuous integrating mechanism arranged for easy observation. The accuracy of the weighing system shall be within ± 0.25% at 20 to 120% of total belt conveyor capacity.

The coal flow rate shall be transmitted to the Coal Handling Control Room and/or the integrating figures to the coal sampling systems for their operation.

Integrating data per bunker shall also be transmitted to the Coal Handling Control Room.

Belt weighers to comply with relevant ISO standards or comparable, including but not limited to DIN EN 61326, IEC 1000-4 (3/4/5/6), DIN VDE 0843.

9.3.2.9.13 MAGNETIC SEPARATOR AND MAGNETIC DETECTOR

In the import and export of round coal yard before and behind the coal crusher room three grade iron removers shall be arranged. The iron removers shall be arranged at T-2 Transfer Tower, T-3 Transfer Tower and Coal Crusher Room. The metal detectors shall be arranged in the middle of the C-7A/B conveyor before the coal crusher room one for each belt. For convenient equipment installation and maintenance electric block or lifter shall be arranged at the heads of each band conveyor and the upside of other equipment. Chain block or lifting ring shall be arranged at the upside of some light equipment and band conveyor tail.

9.3.2.10 COAL SAMPLING EQUIPMENT

Four (4) automatic coal sampling systems shall be provided on the receiving conveyors to sample the coal from the vessels and on the bunker feeding conveyors.

Sampling shall be in accordance with ISO standards or equivalent. The coal sampling units shall be suitable to provide samples that follow ASTM-D-2234. The automatic sampling equipment shall be complete with all necessary samplers, belt conveyors, belt feeders, chutes, crushers, dividers and turntables. The different equipment selected for the coal sampling units shall be such that there shall be no loss of fines and moisture from the samples.

The first sampling equipment acts as primary sampler, which determines the quality of the coal received from the coal vessels. The primary sampler shall be operated automatically by interlocking with the conveyor scale. The primary sampler has to sample from entire width of the conveyor. Four (4), one for each line, spoon type sampler shall be provided.

The equipment shall have a maximum sampling capacity to cater to a consignment at once. The final sample shall be automatically filled in a can of 15 kg capacity on the turntable and the rejected portion of the sampled coal shall be returned to the main conveyor lines respectively.

The second system, the secondary sampling system, samples the coal stream, which is supplied to the bunkers. This automatic sampling equipment shall be complete with all necessary samplers, belt conveyors, scales, crushers and turntables. The equipment shall have the maximum sampling capacity of the maximum coal consumption for the unit and have the function for managing the samples.

The equipment shall be completed with a bucket elevator, belt conveyors, a scale, dividers, a drying tumbler, an auto packer, feeders, crushers and a turntable. The samples shall be treated to a size under 0.25 mm for the analysis.

Stainless steel shall be used in the fabrication of all moving parts.

9.3.2.11 SCREENING AND CRUSHING EQUIPMENT

The screening and crushing of the received coal shall occur in the Crusher House.

Two (2) roller screens shall be provided on the coal belt conveyors from the jetty to the coal yard. The roller screens shall remove rock and contamination in excess of 100 mm from the coal stream. The roller screen bars shall be manufactured from a cast manganese alloy. Alternatively perforated deck may be provided.

The removed rock and contamination shall be fed to a disposal container, which shall be of mobile type with wheels for easy removal and transfer to dumping area.

Eight (8) magnetic separators shall separate ferrous materials, such as tramp iron, bolts, nuts etc. The system shall be capable of separating tramp iron pieces, starting from 0.05 kg up to 50 kg of individual mass. Four (4) separators shall be installed in the coal receiving system, one in each line, and four (4) shall be installed one in the bunker feeding system, upstream of the coal crushers.

Two (2) roller screens shall be provided on the coal belt conveyors from the coal yard to the boiler bunkers. The roller screens shall separate coal particles larger than 30mm size and feed this oversize material to the coal crusher. The fine fraction shall bypass the coal crusher. The roller screen bars shall be manufactured from a cast manganese alloy.

Two (2) crushers shall be supplied, which each shall be designed to crush the oversize fraction of the coal that is screened off. The coal crushers shall be sized to provide the desired coal size for the coal mills, to be determined by the Contractor. The comb vibrating screws and the ring hammer coal crusher are arranged one for each way.

Provision shall be made to seal the inlet and outlet opening of the crushers to prevent the emission of dust during operation. The crusher shall be constructed to allow disassembly inspection and replacement of worn out parts. The construction of the crushing equipment shall be rugged and extra heavy-duty casings shall be provided. Shafts shall be generously designed in cross sectional area and fitted between heavy-duty roller bearings.

Since the screens and crushers cause large noise and vibration, special care shall be considered for sound insulation.

An overhead crane with sufficient and adequate capacity shall be provided in the screen-crusher house for maintenance purposes. Rope lengths shall be sufficient to reach the ground floor. The layout in the crusher house shall be so designed that adequate maintenance access to all equipment can be possible by means of the crane.

A dust collecting system using bag filters shall be provided in the crusher house for belt conveyors, screens, samplers, sample preparation equipment and crushers. Collected dust shall be returned to a suitable point on the coal stream. Filtrated air through the bag filter shall be exhausted outside of the house.

9.3.2.12 COAL YARD EQUIPMENT

The coal yard equipment and mainly the conveyor belts and the stacking and reclaiming machines have to be designed considering the following operation philosophy:

- The coal yard shall have sufficient storage capacity for forty (40) days of operation (total storage) at full load (i.e. 100% BMCR with the worst coal), of which up to a maximum of 5% may be passive (i.e. only accessible via bulldozer).

- The coal yard equipment shall have the capacity to stack coal at the same rate that the ship unloaders and conveyor system can supply it, sufficient capacity to reclaim at the same rate that the conveyor system can supply it to the station coal bunkers for all bunkers at 100% BMCR with worst coal.

- Stacking shall be performed at the capacity of the unloading devices (min. 1,750 t/h). Redundancy of the same capacity shall be considered for the stacking purpose and in function of the proposed number of stockpiles.

- The reclaiming operation shall be performed at the minimum capacity of the station coal bunkers supply system (min 2 x 1,750 t/hr each). Redundancy of the same capacity shall be considered for the reclaiming purpose.

- The discharging conveyors shall be redundant. Each line shall have a capacity of 2 x 100 % BMCR capacity with worst coal (min.1,750 t/hr each).

- Three (3) heavy-duty bulldozers (Caterpillar D9 or equivalent) operated with HSD shall also be provided to allow further moving of coal on the coal yard.

- Sufficient redundancy is to be incorporated into the design to ensure that no failure in any part of the system shall cause the loss of coal supply to the station coal bunkers for 100% BMCR with the worst coal.

The Contractor shall state in his proposal the coal handling system, including the type and number of the stacking/reclaiming machines according to the above philosophy.

In the stacking operation, coal brought to the machines by the yard conveyors shall be received on the machines through the trippers and shall be stacked on the yard through boom conveyors.

In the reclaiming operation, coal on the stockpile shall be reclaimed by the portal scraper reclaimers, and then transferred to the yard conveyors through hoppers.

The reclaimer shall have in-machine coal hoppers and constant feeders to adjust the discharging coal flow for the coal blending operation.

The stacking and reclaiming equipment shall be operable under the following operation modes:

- Manual operation from the operator
- semi-automatic operation from the Coal Control Room.

Anemometers shall be provided on the roofs of operator's cabins to indicate the wind velocity at the control panels. Access to and on the machines shall be by means of walkways, stairways and ladders. However, ladders will only be used if it is difficult to install stairs.

Anti-friction bearings shall be used in such parts that continuously rotate at high speed as pulleys, gear reducers for belt conveyors and travelling units and high speed rotating parts of other gear reducers.

The conveyor pulley shall be, in principle, of shaft rotating type.

The driving pulley shall be herringbone grooved rubber lined, and the driven pulley of the boom top shall be crowned to avoid misalignment of conveyor belt.

The coal yard machines shall have mainframe substructures supported on rail-mounted bogies. The substructures shall also support the boom gantries and counterweights on roller paths or large diameter slew bearings.

The stacking and reclaiming equipment shall be operable semi-automatically from the Coal Handling Control Room. Semi-automatic meaning, that the task to be provided (stacking or reclaiming at a certain rate at a certain site with a certain feed rate) shall be established from the Coal Handling Control Room, and then be performed without human interference.

Nevertheless, a manual operation shall also be possible, from a local operator’s cabin. The cabins shall be arranged in the center of the machine and be equipped with a camera (controllable angle, tilt, zoom) at the boom end. The cabins shall be resiliently mounted, sound and dustproof and air-conditioned.

The coal yard machines shall be capable of travelling in either direction between the coal stockpiles running on heavy-duty rail track, which must be permanently secured on foundations. Integrally mounted rail clamps de-signed to operate on the rail track, shall be provided on the stacker and reclaimer bogies. Both, manual and hydraulically operated rail clamps shall be provided on both sides of the rail. These clamps shall be capable of retaining the structure in a wind velocity of 35 m/s, which is defined as the instantaneous gust velocity at the anemometer.

The coal yard machines shall be capable of operating in wind speeds up to 16 m/s at which speed the rail clamp shall be automatically applied.

The Contractor shall provide such rail securing and splicing details as required to permit freedom of movement of the clamps and their application at any point along the runway rails. In addition the Contractor shall provide machine tie-down systems at the ends of the tracks where the yard machines can be physically held down to restraints in the event of winds in excess of 35 m/s.

Rail cleaners shall be provided on the both ends of the machines for protection of the travelling wheels.

All coal yard machines shall be designed to operate in conjunction with the coal yard conveyors and travel the full length of the coal storage yard. Three (3) meters distance shall be provided between the coal piles and surface of coal yard machines to be provided for the use of bulldozers.

Each coal yard machine shall comprise of a travelling portal frame straddled over the yard conveyor, a slewing and luffing belt conveyor with a stacking chute attached on its end, and a trailed tripper for stacking and shall be of counter-balanced type utilizing link mechanism.

All necessary facilities including foundations and track rails shall be provided and installed.

Necessary interlocks shall be provided to prevent collision between the yard machines and any adjacent coal plant structures especially the adjacent yard machine.

Rotation of the superstructure supporting the gantry and boom or conveyor boom shall be achieved by a minimum of two slew drive assemblies consisting of an electric motor driving through torque limiting coupling, brake and gear reducer.

The coal yard machine boom limit shall be 0.3 meters above the ground level of the coal stockpiles. The boom lengths shall be designed to be capable of stacking the coal to the stockpiles. Indicating equipment shall be provided in the operator's cabins.

The discharge chutes shall rotate with the boom and direct material from the boom conveyors into the in-machine hoppers when reclaiming. Impact table skirt-board sections shall be located at the bottom of the discharge chutes to receive reclaimed material into the in-machine hoppers. Plugged chute devices shall be located at the transfer points to shut down conveyors loading into the blockage.

9.3.2.13 PORTAL SCRAPER RECLAIMER

Each reclaimer shall consist of a portal structure mounted on end carriage beams and bogies running on rails on either side of the stockpile. A scraper conveyor consisting of chain driven scraper bars is mounted from the portal frame and covers the width of the stockpile.

The chain conveyor shall include a mechanism for raising and lowering the scraper conveyor. The raising and lowering mechanism shall include appropriate safety devices and interlocks.

The reclaimer shall be capable of remote automatic operation without an operator on board and also manual operation from a cab mounted on the reclaimer. The reclaimer local control cab shall be air conditioned.

The reclaimer shall send basic data such as position, mode of operation and fault alarms to the coal plant control room.

The following modes of operation shall be provided:

- automatic reclaiming,
- automatic relocation to the parking position,
- manual movement to any position,
- manual reclaiming.

The reclaimers shall be designed to operate in a dusty environment and shall be capable of handling wet coal and dry dusty coal with a high fines fraction. Each reclaimer shall be capable of reclaiming up to 1750 tonnes per hour. The portal structure shall be designed to a recognized international structural steel design code. The reclaimer shall be fitted with rail clamps to prevent movement under the highest wind loading.

The reclaimer shall have a variable speed long travel, with higher speeds used for reclaimer relocation. The reclaimer frame shall be fitted with dropping stops to limit the drop of a bogey to 20mm in the event of a wheel failure.

The reclaimers shall be designed for ease of operation, inspection and maintenance and for access for adjustment and component replacement. The reclaimers shall be designed to accommodate rail installation tolerances. The reclaimers shall use standard components to the greatest degree possible including (wherever possible) with stacker components.

The reclaimers shall be designed so that all routine maintenance can take place between reclaiming operations. All platforms ladders and walkways required for maintenance of scraper, raising/lowering mechanism, all movement systems, cable reel and electrical equipment shall be included in the scope of supply.

Bearings shall be protected from dust, spillage and wash water. Hydraulic cylinder seals shall be suitable for the operating environment.

The reclaimer shall be fitted with energy absorbing impact buffers. The reclaimer shall have an anti-collision system installed.

An automatic fire detection and fire extinguishing system shall be provided for the electrical equipment enclosure. The fire extinguishing system shall comply with the relevant local legislation and NFPA codes for such systems.

The scraper blades shall be carried by two drive chains which shall be supported by guides. The roller shall be designed to accept side thrust due to scraper movement. The chains shall be heavy duty chains. The chain drive shall be an electric motor with a fluid coupling. All surfaces in contact with coal during the reclaiming process shall be lined with erosion resistant material.

Transfer chutes shall be designed to transfer reclaimed coal from the scraper onto the conveying belt without spillage.

During the design phase the Contractor shall demonstrate allowances for fault conditions as detailed below:

- overloaded scraper,
- stalled scraper,
- scraper collision with stockpile while travelling,
- blocked reclaimer discharge chute,
- failure of travel or movement limit switches.

During the design phase the Contractor shall provide the following:

- details of the reclaimer wheel loading and rail loading capacity,
- details of the reclaimer drive and drive control,
- details of the automatic lubrication system,
- details for the fire protection and detection system.

9.3.2.14 DUST SUPPRESSION SYSTEMS

A water spray system shall be supplied to suppress the coal dust. The dust suppression system shall be provided wherever dust formation may occur, including at minimum but not limited to the ship unloading discharge hoppers, the coal belts, the transfer towers, the stacker conveyor discharge points, the reclaimer, along the complete length of the coal yard and for the coal bunker feed points.

Spray nozzles shall be installed along the length of the both sides of stock-piles. The spray nozzles shall cover all the area of the coal stockpiles, including the stockpile faces.

The water spray system shall be piped and divided into groups in order to facilitate sequential or progressive step spraying from the coal handling control room.

The sprays shall form a mist suitable to settle fine dust particles, which become airborne during strong winds. The mist spray shall be able to cover the whole area and reach the maximum height of the coal piles.

The system shall be complete with all the necessary components including vessels, pumps, piping, valves, anemometers and all control and instrumentation.

At all transfer points, points dust suppression shall be installed, e.g. as dry fog dust suppression systems.

9.3.2.15 ON-MACHINE WATER SPRAY SYSTEM

The entire yard machines shall be supplied with self-contained dust suppression systems of the atomized water sprays type at all transfer points and the bottoms of booms for coal piles.

The spray nozzles shall be supplied with water from tanks located on the yard machines, and filled with water by a snap-on hose connection from points located on the pipe work of domestic water lines installed along the rails.

The sprays for the atomized mist shall consume a minimal amount of water, while offering a width of spray suitable to settle the airborne dust particles.

Connections from the above water supply system shall be provided and fitted with purge jets to clean chutes and hoppers.

The systems shall be complete with all the necessary components and shall include but not be limited to storage tanks, pipe work, valves, pumps, controls and instrumentation.

9.3.2.16 COAL HANDLING CONTROL SYSTEM

A comprehensive and efficient system of control and instrumentation (DCS based control system) for all of the equipment included in this specification shall be provided to give:

- remote sequential and remote individual start and stop control and necessary monitoring system for the coal handling conveyor system under VDU operation system. VDU controller shall have hot stand-by redundancy
- local control for conveyor system
- automatic/manual control for the reclaimers
- coal yard management computer system with uninterruptible power supply (UPS).

The main functions of the coal yard management computer to be installed in the coal handling center shall be:

- data acquisition related to coal movements, coal handling equipment and ambient conditions
- stock inventory control of the coals in the yard
- anti-collision calculations for stackers, reclaimers and other machinery, with initiation of alarm and stop commands to the machines.

The mode of operation of the coal handling system shall be operable with the following operation modes, as selected by the operator in the coal handling control room:

- remote sequential operation mode
- remote individual operation mode
- local operation mode.

9.3.2.17 COAL HANDLING CONTROL ROOM

The coal handling control room shall be located in one ancillary building. The rooms shall be air-conditioned. In the coal handling control room the following systems, desks and panels shall be installed:

- four (4) interchangeable VDU operation systems each with redundant controllers. Each controller shall support all four VDUs.
- two (2) Large Video Screen-70” size 65
- two (2) yard management computers
- back-up panel (Large screen display)
- control desk
- printers, hardcopier with console
- fire alarm monitoring panel.

These electronic devices shall be of the same technical characteristics than the one installed in the Central Control Room (CCR) of the unit. A mini-mum amount of important alarms and information about the status of the coal system shall be sent to the CCR.

9.3.2.18 BULLDOZERS

Three (3) heavy-duty bulldozers shall be provided which shall be suitable for moving coal on the coal yard for blending and redistribution purposes. The bulldozers shall be capable of moving onto the coal piles as proposed by the Contractor, and shall be capable of moving the coal with a shovel of minimum dimensions 4 x 2 m (Caterpillar Type D9 or equivalent). The bulldozers shall be capable of operating with the HSD.

9.3.2.19 COVERED COAL YARD

The Bidder shall offer a coverage of the coal yard for the respective coal piles. The Contractor shall propose a system suitable to cover the complete coal yard. Refer drawing no. 10-PC-PAY-04 and 10-PC-PAY-05.

The cover shall be suitable to protect the environment from dust pollution from the coal yard during dry season and to protect the coal from heavy rainfalls during monsoon, such that the moisture of the coal reclaimed from the coal yard differs by less than 10 % (relatively) from the moisture of the same coal stacked as it was stacked onto the coal yard. The coal yard coverage may in no way inhibit the normal operation of the coal yard, and the coal stored in the covered portion may be both stacked and reclaimed at will at any time. Retaining wall shall be arranged around the coal yard dust suppression sprinkler system.

9.3.2.20 COAL SILOS

There shall be minimum six coal silos for each boiler. Five coal silos shall have a total useable storage capacity to 12 hours at the maximum burn rate of worst coal at BMCR. Mass flow design shall be based on a dedicated silo per pulverizer. A passive bin vent filter system shall be utilized to filter displaced air from the silos. A stainless steel liner shall be used on the wear surfaces of the sloped and vertical portions of the silos. The contractor shall furnish continuous non-contract level measurement of the amount of coal in each silo. High level tilt switches shall also be provided by the Contractor. The silo shall be equipped with bunker grating. The bunker grating blade shall be made to be easily replaced for maintenance purpose.

Coal silo valley angle shall be 70°. Coal silos shall be provided with a manually actuated eco-friendly inerting system sized for 3 times the volume of a single silo.

Electric two sides flow discharge shall be used for Coal Unloading at the Silos.

9.3.2.21 COAL YARD RUNOFF POND

The Coal Storage Pile and Coal Yard Runoff Pond shall be provided. The Coal Yard shall be contoured to be a relative high pointed and drained to a perimeter ditch. Runoff shall be directed to a Coal Pile Runoff Pond. Runoff shall be collected in the Runoff Pond to allow suspended solids to settle. Decanted runoff shall be discharged to the Waste Water Treatment System.

The Coal Pile and Coal Pile Runoff Pond shall be lined. The Pond shall be sized to contain a minimum free water volume equal to the sum of the maximum dry weather flows from dust suppression systems, rainfall directly on the Runoff Pond from a 25 years / 24 hour event, Storm Water Runoff from a 25 year / 24 hour event over the lined area of the fully developed coal pile and sediment expected to be accumulated in the Runoff Pond during a 10 year period. The washing sewage can be recycled after treatment.

9.3.3 LIMESTONE SYSTEM

Generally the same special technical requirements shall apply for the limestone system as for the coal handling system.

9.3.3.1 LIMESTONE YARD EQUIPMENT

The limestone yard equipment and mainly the conveyor belts and the stacking-reclaiming machines have to be designed considering the following operation philosophy:

- The limestone yard shall have sufficient storage capacity for ninety (90) days of operation (total storage) at full load (i.e. 100% BMCR with high sulphur coal).
- The limestone yard equipment shall have the capacity to stack limestone at the same rate that the ship unloaders and pipe conveyor system can supply it. If the capacity is lower than the nominated capacity of the ship unloaders, adequately sized buffer hoppers must be provided.
- The reclaiming operation shall be performed by mobile front end loaders into the limestone unloading hopper of the limestone milling system. N+1 redundancy shall be considered for reclaiming.
- Six (6) plough unloader for the limestone yard.
- One (1) TY220 type bulldozer and one(1) ZL50 type loader for limestone yard.

9.3.4 HIGH SPEED DIESEL (HSD) SYSTEM

The HSD supply and storage system shall comply with the regulations set forth by the local authorities, and the applicable national and international regulations, standards, codes, guidelines etc. as specified in Chapter 3 of Section 5 and the technical requirements as defined in sub-clause 1.9.2, Chapter 1 of Section 5.

Capacity of HSD storage tank is base on the conventional diesel lighting-up system of boiler, if other lighting-up system is supplied, the contractor can adopt reasonable capacity of HSD storage tank.

9.3.4.1 UNLOADING STATION

A sufficient number of unloading stations (minimum 4) shall be supplied, for unloading the HSD coming by truck. At least n+1 redundancy shall be provided for the unloading stations.

The road truck unloading stations shall be positioned in the vicinity of the storage tank. The unloading stations shall include pumps complete with inlet duplex-filters for each pump, etc. Each pump shall have a capacity of 50 m^3/h of HSD. Simultaneous unloading of road tankers at the unloading stations shall be possible.

Both the unloading system and the fuel oil pressurizing system shall be controlled through a dedicated PLC, as described in Chapter 7 of Section 5.

Oil sampling points shall be provided at each fuel entry point.

9.3.4.2 HSD PUMPS

HSD pumps for unloading and the HSD forwarding and transfer pumps shall be screw pumps (self-venting) or centrifugal pumps, following API 676.

Each pump shall be complete in all respects and each shall be capable of supplying HSD at the required pressure on a continuous basis. Each pump shall include a margin of 10% in the pumping capacity to enable the pumps to continuously operate from min. to max. consumption with recirculation flow. The boiler shall be able to operate with 25% BMCR on HSD only; the HSD system shall be able to supply the HSD for one boiler at 25% BMCR and another boiler’s lighting.

The pumps shall be designed to operate satisfactorily in parallel with each other.

Grease-lubricated anti-friction bearings shall be provided for the pumps. Antifriction guide bearings shall be ball bearings designed for the rated life of the unit under the design operating conditions.

The pump casings shall be of cast iron with the shaft and impeller manufactured from stainless steel. The pump shafts shall be fitted with renewable sleeves of stainless steel or other approved material.

Each pump shall be designed to permit removal of the rotating parts such that the casings can remain connected to the suction and discharge pipe work. Each pump/motor unit shall be provided with a common base plate of cast iron or fabricated steel construction.

A spacer coupling shall be used unless otherwise specified. The spacer length shall permit the removal of the coupling, bearings, seal and/or rotor without disturbing the suction and discharge piping.

Pumps shall be equipped with mechanical seals. Drainage facilities shall be provided on the pump casing and/or adjacent pipe work to facilitate dismantling of the pumps.

9.3.4.3 STRAINERS AND FILTERS

A duplex suction strainer/filter with manual change-over facilities shall be provided for each fuel oil pump. The strainer/filter shall be located on the suction side of the pumps and shall be complete with all necessary fittings. The strainer/filter screens shall be mesh 20 or above, and manufactured from stainless steel. Strainer/filters change-over shall not interrupt the supply of fuel and it shall be possible to clean or renew the stand by filter element whilst the system is running.

Differential pressure gauges and transmitters shall be provided for each strainer/filter and shall be connected to the DCS.

9.3.4.4 FUEL OIL STORAGE TANK

Two (2) fixed roof storage tanks with a total net capacity of 2 x 500m^3 shall be supplied. The storage tanks shall, where possible, be located in the open above ground.

The fuel oil storage shall be designed, fabricated and erection according to EN 14015 and EN 1993 shall be taken into account. Comparable international standards which have the same or higher requirements are also acceptable, like API 650.

Venting systems of the fuel oil tanks shall follow the requirements of API 2000.

A single wall tank with catchment is acceptable, it shall meets the required safety standard. The catchment pit shall be provided with a capacity at least 10 % greater than that of the tank.

Fuel oil storage tank shall be of the flat-bottom type with self-supporting fixed cone roof.

Shell manholes are to be equipped with swiveling mountings. A safety device preventing unintentional closure of the cover shall also be provided.

The tank shall have a permanently installed roof and shell sprinkling system for fire protection. Care must be taken to ensure that both roof and shell of the tank are adequately cooled on all sides.

The HSD tank and auxiliaries shall be corrosion protected.

A shell spiral staircase is to be led to the floor of the catchment pit.

The tanks shall have a permanently installed top and side spray installation for fire protection as well as permanently installed foam system. The scope of supply for the tanks includes the foam inlet branches and all mountings for the foam tubes, etc., at the tanks.

A water supply is to be provided for the complete sprinkling (roof and shell) of the tanks. Care must be taken to ensure that both roof and shell of the tank are adequately cooled on all sides.

The tanks are to be equipped with devices for local level indication, this unit also being suitable for remote transmission. Ultrasonic/Radar type level transmitters shall be used. The device must also be equipped with at least tree (3) adjustable limit contacts to initiate alarms or signals at given levels (low, high and very high).

In addition, the tank must be provided with overfilling protection which must respond when the maximum permissible level is exceeded by giving an alarm and closing the motorized gate valves in the filling lines so that no further oil can enter the tank.

The third limit contact (maximum) of the level indicator is also to be linked to the overfilling protection so that the tank will be protected against overfilling by two (2) independent devices.

9.3.4.5 PIPING AND VALVES

Piping shall be based on the standard API 5L Grade B.

Pipe work design within the bund area shall make due allowance for any tank settlement which may take place.

Interconnection pipe work shall be designed to take into account movement of the pump sets during all modes of operation, including start-up and shut-down. With the exception of those items, which require flange joints to facilitate removal, all interconnection piping throughout the installation shall be welded.

Valves shall have forged or cast steel bodies.

9.3.4.6 FITTINGS

Fittings for oil services shall be butt welded fittings, conforming to ANSI B16.9 and material according to ASTM-A-234. Fittings of 50mm and below shall be socket welded conforming to ANSI B16.11 and material according to ASTM-A-105.

9.3.4.7 ELECTRICAL, CONTROL AND MONITORING

All equipment shall be designed to comply with the hazardous area requirements of IEC 60079 where the source of hazard is as defined in IEC 60079.

Where necessary, provision shall be made to prevent damage to bearings by shaft currents. Bearings and their associated connections shall be insulated from the bedplate or foundation and an earth-bonding link provided at the driving end. The link shall be removable for the purpose of testing bearing insulation.

All the equipment shall be grounded. The frame of each main item of electrical equipment including pumps skid shall have earthing terminal of appropriate design in at least two positions.

Control and monitoring (DCS based), interlock and protection systems must to be provided as required for safe and reliable operation and satisfactory supervision of fuel oil supply and storage system.

9.3.4.8 FUEL OIL METERING

The function of fuel oil metering is to measure and record the total fuel oil quantity delivered and used by the Plant as well as the consumption of each fuel oil consumer. The minimum number of metering points to be supplied is three (3). One (1) metering device shall be installed for each of the HSD unloading stations. One (1) metering device shall be installed for the HSD supply to the unit

Metering stations shall be provided with isolating valves and a full flow bypass to facilitate maintenance. They shall be capable of passing the maximum fuel oil flow without restriction.

The number and installation of the metering devices shall be such that a balance per each consumer and additionally of the Plant is possible. The metering devices shall be accurate to within at least ±1 % overall. However, the final number and type of metering devices, their accuracy and signal interface requirements shall be according to the Employer’s Requirements and the requirements of the metering code.

9.3.5 ASH HANDLING SYSTEM

The ash handling system shall be capable to handle the ash produced under all operating conditions, including a continuous operation with worst coal (worst coal being defined here as the coal leading to the highest bottom and / or fly ash amounts). This shall include any peaks due to the removal of slag from the boiler tubes. The system shall also be able to extract a 12 hours backlog of ash within a further 24 hours period with the unit operating on 100% BMCR throughout and burning worst coal. The system shall be fully automatic with facilities for remote and local manual intervention by the operator. Materials in contact with water and ash shall be resistant to corrosion and abrasion respectively.

9.3.5.1 FLY ASH SYSTEM

Please refer to the relevant documents in the Fly Ash System Definitions in Attachment C of these Employer’s Requirements for a description of the system operation. Refer drawing no. 10-PM-PAY-09 for fly ash handling system diagram.

In the ash handling system the fly ash delivery system shall be designed in the unit of 1 x 660MW power unit, conveying it into the ash silo for storage by positive pressure dense phase pneumatic conveying system. The fly ash storage system is designed in the unit of 2 x 660MW power units. From the ash silo transportation shall be by truck to the ash storage yard or to the comprehensive utilization site. The design output of the conveying system shall be not less than 150% ash discharge of the design coal combustion at BMCR. The fly ash handling system shall include but not be limited to the following:

- Two (2) collecting systems for the fly ash, one for each boiler, electrostatic precipitator using air blower / compressor as carrying fluid and transporting the fly ash to the fly ash silos
- Two (2) 100% duty aeration blowers for boiler, airheater and ESP hoppers including aeration pads for each hopper.
- Three (3) fly ash silos, two for coarse ash and one for fine ash, each reinforced concrete structure silo with minimum 1000m^3 nett storage capacity and active storage capacity of 800m^3. Also the coarse ash silo could contain combustion for 48 hours of the two boilers design condition at BMCR.
- Four (4) 100% duty aeration blowers (3 runs 1 standby) and three (3) heaters for ash silos.
- Three (3) 100% duty dedusting system with vent filter and exhaust fan
- Three (3) dry ash unloading device by wetting the dry ash and then to be transported outward by wetted dust dumper.
- All necessary piping and valves.

The positive pressure pneumatic conveying system is preferred for the fly ash delivery system of this project, which is briefly described below:

An ash transporting pump is installed under each economizer hopper and electric precipitator ash hopper of each boiler. The transporting pump has the necessary instruments such as pneumatic feed valve, air inlet component, air inlet control mechanism, charge level indicator and pressure transmitter. The manual slide plate gate is equipped between the ash hopper outlet and the inlet valve of the vessel transporter for storage vessel transporter. In order to improve the ash flow in the ash hopper, a set of electric precipitator ash hopper fluidizing blower is equipped, which includes fluidizing blower, electric heater, fluidizing plate, etc. The fluidizing blower is arranged in the compressor room.

A coarse ash delivery pipe is equipped for economizer and no. 1 and 2 electric fields of the electric precipitator of each boiler to deliver the fly ash to the coarse ash silo for storage; a fine ash delivery pipe is shared by the fly ash of the storage pump under the ash buckets of no. 3 and 4 electric fields to deliver the ash to the fine ash silo. And meanwhile, the pneumatic pipe changeover valve is equipped at the ash delivery pipe at the top of the ash silo, through which, the coarse ash in the coarse ash delivery pipe could be changed over to any coarse ash silo or the fine ash in the fine ash delivery pipe could be changed over between the coarse and fine ash silos.

Three silos, one for fine ash and two for coarse ash will be constructed of concrete with flat bottoms and a porous fabric fluidizing system with two discharge points. Standard silo roof mounted accessories shall be provided by the Contractor include bin vents, pressure / vacuum relief assemblies, roof manway access hatches, side access hatches and all other roof mounted equipment.

Fluidizing air shall be provided for each fly ash silo by redundant fluidizing blowers. Fluidizing air for the ESP hoppers shall be provided by redundant fluidizing blowers.

Two ash conditioners shall be provided with the fly ash silo. Additionally, one telescoping dry discharge spout shall be provided with the fly ash silo. Pipe, hose, elbows, fittings, valves, supports and connection materials shall be provided as required for a complete operating conveying, storage and discharging system.

The pneumatic conveying systems shall be designed for continuous operation.

The system design shall allow any ESP hopper to be unloaded to the fly ash silo.

Fly ash conveying system operation shall be fully automated and controlled by a PLC with local control provided as required for proper operation and control of the system.

Please refer to the relevant documents in the Systems Definition in Attachment C of these Employer’s Requirements for Fly Ash system in reference to this Section. The fly ash handling system shall include a pressure system to transport collected fly ash from the boiler air heater hoppers and particulate control system hoppers to a fly ash storage silo. The capacity of the fly ash transport system shall be based on a fly ash production equal to a minimum of 90 percent (90%) of the total maximum ash production. The fly ash handling system shall include the air lock vessels and valves to allow the system to sequentially convey ash from the collection hoppers. The piping system shall be designed for abrasive fly ash service including hardened cast iron fittings designed for pneumatic conveying systems.

The silo storage volume shall be elevated to allow load-out of ash into the Employer's trucks through a dry unloading telescoping discharge chute or a wet ash conditioner. The fly ash silo shall be equipped with a fluidizing system, including a redundant blowers and electric heaters to facilitate silo discharge. The fly ash silo shall be equipped with a vent filter to discharge all air entering the silo from the conveying system or air displaced by the material. The filter shall be of the bag type with pulse cleaning. The ash silo shall also be equipped with an additional 300 mm ash outlet opening for future use. The opening will be supplied with a bolt on blind flange.

The primary disposal method is by way of discharge of saleable ash into an ash transport truck. The secondary disposal method will be to discharge conditioned ash into an open bed truck for transport to the ash yard. The water source for the wet ash conditioners shall be recycled wastewater from the wastewater collection sump. The dry telescoping spout shall include a vent fan that will draw air from an annulus area in the chute and discharge the dust/air back into the silo. A local control station(s) shall be provided at ground level to operate the ash unloading equipment.

9.3.5.1.1 TRANSPORT COMPRESSORS

The Plant compressors shall supply required compressed air of quantity and quality continuously. Refer Chapter 15 of Section 5.

9.3.5.1.2 PRESSURE FEEDERS AND VALVES

A pressure feeder with inlet and outlet valves shall be furnished at each ESP hopper outlet.

The valves shall operate on load control and shall be designed for handling abrasive material. Each pressure feeder shall be complete with supports necessary to support the feeder from the fabric filter hopper to prevent overstressing the hopper discharge flanges.

A fly ash fluidizing feeder of the porous plate type shall be incorporated in the inlet and outlet valve assemblies of each pressure feeder. If required in the Contractor’s design, each pressure feeder shall vent to the associated ESP hopper. The pressure feeders shall be insulated and/or heated as required to keep the ash flowing freely.

Air lock vessels for pressure conveying shall be of the Contractor’s proven design. All air lock assemblies shall meet all applicable requirements of ASME Section VIII- Boiler and Pressure Vessel Code and shall be provided with a code stamp, if required. Each air lock vessel shall be provided with two view ports to observe ash flow during routine operations.

The pressure feeders shall have manholes and poke holes for observation and rodding of plugged hoppers.

9.3.5.1.3 FLY ASH ESP HOPPER FLUIDIZING EQUIPMENT

Porous stone air diffuser assemblies, to fluidize the fly ash and provide free-flowing ash from the ESP hoppers shall be furnished for each hopper if required in the Contractor’s design to flow ash into the feeders. The fluidizing air equipment shall be sized to allow continual simultaneous fluidizing of all hoppers. The fluidizer material shall be silicon carbide.

9.3.5.1.4 FLY ASH TRANSPORT PIPING AND VALVES

Fly ash transport piping and fittings shall be designed to minimize potential ash fallout and pluggage. All fly ash transport straight pipes shall be carbon steel. All elbows and all the pipes after the last elbows into the fly ash silo shall be lined internally using the fused cast basalt material to prevent erosion. Fittings shall be replaceable insert ceramic wear back type with BHN of 400 to 450. Fly ash transport elbows shall be long radius.

Access covers shall be provided on each fly ash feeder valve to allow for rodding of potential pluggage. Type 321 stainless steel expansion joints shall be provided in the fly ash system as required to prevent overstressing any system component due to thermal expansion or contraction and to allow for movement of ash piping, ESP and fly ash silo interface connections.

Fly ash valves shall be slide-knife gate or rotary type designed to provide a complete leak tight shutoff to allow for maintenance of any downstream equipment.

9.3.5.1.5 FLY ASH SILO

The three silos shall be sized as stated in sub-clause 9.3.5.1. The active silo volume shall be the overall silo volume, minus an inactive volume two (2) m in height at the top of the silo.

The silo shall be constructed of reinforced concrete. The roof of the silo shall be weather tight and shall be sloped to drain water. Handrail and kick plate shall be provided around the top of the silo. The fly ash silo, fly ash discharge equipment, floor, unloading deck, and entire structure shall be completely supported by a concrete foundation. A truck drive through clearance shall be provided below the discharge equipment.

The silos shall be provided with open air radar type level transmitters and an operator accessible local indicator. A radio frequency probe or vibrating rod type level switch shall also be provided for a high level alarm to the control system.

Flanged piping nozzles shall be provided for the conveying line inlets.

Two discharge outlets, one set of dry ash unloading device with the output of 100 t/h and one set of wet type unloading device with the output of 100 t/h are equipped at the bottom of each ash silo. The dry ash unloading device is used for the dry ash tank car to load and transport outward the dry ash for comprehensive utilization; the wet type unloading device makes the dry ash into ash wetting then to be transported outward by wetted dust dumper for comprehensive utilization or to the ash yard for storage.

9.3.5.1.6 SILO FLUIDIZING EQUIPMENT

Porous fabric ash fluidizers shall be provided for each fly ash silo to maintain the ash in a fluid condition so that it will flow from the silo. The fly ash silo fluidizing air system shall be provided.

9.3.5.1.7 SILO VENT FILTER

An air pulse, self-cleaning, bag type vent filter shall be provided for the fly ash silo. Air jet cleaning of filter bags shall be continuous while the dust collector is in operation. Bags and bag cleaning system shall be of a type having a minimum of 3 year average bag life before replacement in similar service. One (1) spare bag shall be provided for each 10 bags furnished.

Each blow pipe shall have a positive means of alignment and coupling. Interstitial or rising velocities shall be limited to 2 m/s. Interstitial velocity shall be calculated by taking the total collector flow rate divided by the following: (the collector cross-sectional area, minus inlet plenum or baffle area for high inlet, minus the cross-sectional area of the bags) times 60.

9.3.5.1.8 SILO VENT FILTER FAN

Each fly ash silo bin vent filter shall be equipped with a vent fan to prevent the fly ash silo from becoming pressurized.

9.3.5.1.9 SEGREGATING VALVES

Isolation valves shall be furnished on each branch line in the pneumatic ash conveying system. These valves shall be of the slide gate (or knife gate) type. The valves shall be self cleaning, non-clog type, with knife capable of retracting out of the material flow path. The valves shall be of dust-tight construction and shall be furnished with automatic and manual override operation. Limit switches and/or process switches shall be provided so the control system can determine the position of each of these valves.

9.3.5.1.10 VACUUM/PRESSURE RELIEF DEVICE

A vacuum/pressure relief device shall be provided to protect the silo. The vacuum/pressure relief device shall be located on top of the silo roof. The relief device shall not provide normal venting, but shall provide emergency venting in the event of high positive or negative pressures.

9.3.5.1.11 TELESCOPING DRY UNLOADING CHUTE

A motor-operated telescoping discharge chute shall be furnished for dry ash discharge from the silo. The chute shall be constructed of carbon steel with abrasion-resistant alloy steel for ash contact surfaces.

The dry unloading chute shall capture fugitive dust produced as a result of its operation and return the captured dust to the silo. A concentric piping vent with vent fan shall be provided for the chute. The vent lines shall be piped back to the inlet of the silo.

9.3.5.1.12 FLY ASH CONDITIONERS

Each fly ash conditioning unit shall be provided with a non-stick liner attached to the barrel and agitators (pins or paddles). The Contractor shall provide the longest wear material available. Dry ash flow control valves shall be provided to meter the ash from the discharge of the silo and shall be capable of the desired discharge rate with varying ratios of fly ash and various silo levels. Water flow control valves shall be provided to meter the quantity of water being mixed with the ash. The system shall include a means to wash down the interior of the conditioner with water after conditioning operations are complete. The local control system for the conditioner shall have the capability to adjust ash or water flow rates as required to maintain a damp earth discharge consistency.

9.3.5.2 BOTTOM ASH SYSTEM

Refer to the bottom ash and combustion waste disposal handling System Definitions in Attachment C of these Employer’s Requirements for a description of the system operation. Refer drawing no. 10-PM-PAY-08, slag disposal diagram.

9.3.5.3 BOTTOM ASH SUBMERGED SCRAPER CONVEYOR (SSC) SYSTEM

The submerged scraper conveyor system shall be designed for continuous removal of bottom ash from under each boiler. The system shall include a mechanical submerged flight chain conveyor, access provisions, continuous chain wash, and all necessary valves, piping, controls, and instruments.

The system shall be designed to minimize the water used for makeup and continuous chain washing.

The submerged scraper conveyor assembly shall be capable of temporarily accumulating and storing ash deposited therein at boiler MCR (BMCR) burning the design fuel for a period of 8 hours. The operation of the conveyor shall normally be continuous, but may be periodically shut down for maintenance without the need for a boiler shutdown or load reduction. The SSC maximum output shall be 40t/hr.

Please refer to the relevant documents in the Systems Definitions in Attachment C of these Employer’s Requirements on Bottom Ash for reference.

Bottom ash from the bottom of the boiler combustion chamber shall be discharged to a submerged drag chain scraper conveyor (SSC) that shall dewater the ash and discharge it through a grinder and elevated directly to abrasion resistant alloy steel silo which could contain the slag discharge of the check coal combustion for 40 hours at BMCR condition. The primary disposal method will be by way of discharge of saleable ash into an ash transport truck to ash storage yard.

Recycled water from the wastewater collection sump shall be the source of water to the SSC.

The silo storage volume shall be elevated to allow load-out of ash into the Employer's trucks through a dry unloading telescoping discharge chute or a wet ash conditioner. The bottom ash silo shall be equipped with air cannons, liners, drains and other discharge aids as required to facilitate consistent discharge of wet bottom ash. The bottom ash silo shall be equipped with a vent filter to discharge air displaced by the material. The filter shall be of the bag type with pulse cleaning. The ash silo shall also be equipped with an additional 300 mm ash outlet opening for future use. The opening will be supplied with a bolt on blind flange.

The water source for the wet ash conditioners shall be recycled wastewater from the wastewater collection sump. The dry telescoping spout shall include a vent fan that will draw air from an annulus area in the chute and discharge the dust/air back into the silo. A local control station(s) shall be provided at ground level to operate the ash unloading equipment.

9.3.5.4 TRANSITION CHUTE/SEAL ARRANGEMENT

Mechanical Seal

Mechanical expansion joint shall provide the sealed connection between the boiler throat and the bottom ash transition chute, whilst allowing for boiler expansion.

The joint itself shall be composed of several layers of special fabric and ceramic materials in order to obtain high thermal insulation and mechanical strength combined with a great flexibility.

If required a protection shield (refractory lined and insulated) shall be provided to protect the joint from the boiler radiation and to prevent contact with ash.

Material thickness and external structural stiffening shall be sufficient to withstand the direct impact of furnace slag and meet furnace pressure design criteria. The inside of the transition chute shall be free of structural members or other obstructions that could cause bridging. Breaker bars installed across the inside of the transition chute shall not be permitted.

9.3.5.5 UPPER TROUGH

The upper trough housing material thickness and external stiffening shall be sufficient to withstand direct impact of furnace slag. The inside of the upper trough shall be free from structural members or other obstructions that could cause bridging. Breaker bars installed across the upper trough will not be permitted.

The upper trough shall be designed with an active ash collection width that is wider than the boiler throat. The trough shall be capable of storing up to the specified storage amounts of bottom ash without exceeding normal water level. The upper trough bottom and dewatering slope shall be lined with a replaceable, abrasion-resistant wear plate, which covers the entire bottom of the trough and dewatering slope. As an alternative, the incline ramp dewatering portion of the conveyor may be lined for the full width with basalt. These abrasion-resistant wear surfaces shall have a minimum hardness of 360 BHN. These wear-resistant plates shall be installed on a bias of not less than 10 degrees to ensure smooth passage of the flights from one wear plate section to the next. All welds shall be ground smooth to eliminate the possibility of flight hang-up. The depth of the water in each upper trough shall be such that makeup and chain wash water is accommodated without spillage.

Provisions shall be made to protect the chain the entire length of the trough from falling ash and slag.

An overflow shall be provided on the upper trough to limit the normal operating water level. The overflow shall be provided with an inverted serrated weir that will limit carry-over of floating solids or clinkers into the Plant drain systems.

The inclined ramp portion of the submerged scraper conveyor trough shall be in accordance with Contractor standards. The length of each sloped portion shall be sufficient to dewater the ash to the anticipated percent moisture content at both normal and maximum conveyor speeds. If other ashes are discharged into the upper trough of the SSC, a cover shall be provided to prevent any splashing outside the upper trough of the SSC.

9.3.5.6 LOWER TROUGH

Each lower submerged scraper conveyor trough shall be a dry region for the return of the conveyor flights. Each trough shall be designed to allow for visual inspection of the entire length of return chain and flights through access panels. Each lower trough shall have provisions for draining any accumulated water through a drain connection(s).

The lower trough shall be lined with basalt tiles or abrasion-resistant plates. The abrasion-resistant steel liners shall have a minimum hardness of 360 Bhn. The rails shall be configured to evenly distribute any wear over the entire surface of the flight liner in contact with them.

9.3.5.7 SUPPORTS AND WHEEL ASSEMBLIES

The complete submerged scraper conveyor trough assembly shall be self-supported and mounted on roll-out wheel assemblies. The wheels shall be cast steel railroad type wheels mounted in structural steel carriage ways and furnished with bearings. Towing lugs shall be fitted along the conveyor assembly for moving the conveyor into the maintenance position. Double flanged wheels shall be furnished, or at the Contractor's option, two double flanged wheel assemblies, and flat roller assemblies for the remainder.

The conveyor trough assembly shall be designed to unbolt and detach quickly from a self-supporting side panel section. The design shall permit rolling the conveyor to one side of the boiler transition chute and thus allow full access to the furnace through the transition chute and boiler throat. The upper trough shall be able to clear the boiler seal transition chute arrangement while the boiler is in the hot position.

9.3.5.8 FLIGHTS AND CHAIN ATTACHMENTS

The flights shall have wear plates the full width of the flights. The wear plates on each flight shall have a minimum BHN of 360. The flights shall be oriented on the chain so that a flat face is forward, i.e., in the normal direction of motion.

Flights shall be fitted with chain attachments. The chain attachments shall be of the same materials as the chain, hardened, easily removed from the chain, and not fail due to loosening or fatigue. The flight attachment shall be designed to provide a non-rigid connection of the flight to the chain, shall introduce no bending moment into the chain, and shall not interfere with proper meshing of the chain links into the sprockets and idlers.

The flight connectors shall be sized to withstand the stresses imposed by the maximum load on the flights.

The flights shall be designed so that the chain shall not be dragged along the bottom of the trough, but held in suspension by the flight connectors.

9.3.5.9 FLIGHT CHAINS

The flights shall be moved by double-strand, matched, abrasion-resistant chains. Allowable chain pull at peak operating conditions shall not exceed 1/7 of the chain breaking strength as rated by its manufacturer, and the allowable chain pull at storage pullout shall not exceed chain manufacturer's recommendations for maximum chain pull allowable on an infrequent basis. The chain shall be furnished in matched pairs with connecting links. The chains shall be "ship" type, not "mine" type, and links shall be resistance welded, close tolerance alloy steel wire. The chain links shall be case hardened to a minimum depth of 0.09 of the wire diameter (d) to a nominal hardness of 750 Vickers.

Chain link connectors shall be hardened and of the same metallurgy as the chain.

Piping and spray nozzles for water to clean the chains before contact with the drive sprockets shall be provided.

9.3.5.10 SPROCKETS AND IDLERS

Sprocket drive teeth shall be bolted in position for easy removal and replacement, and shall be made of the same material as the chain. All idler surfaces in contact with the chain shall be smooth and free of pockets that could accumulate ash and cause wear. Idler contact surfaces shall be hardened to a minimum BHN of 450. Idlers shall be provided at all locations where the chain changes direction.

Idler assemblies submerged in the upper trough shall be independent cantilevered type mounted to an externally removable support plate. Antifriction, self-aligning bearings, internally mounted to the idler, shall be protected against water intrusion by double row lip seals, and shall be externally greaseable to provide both a seal and lubrication.

Idler assemblies located in the ash path shall be furnished with idler groove cleaners.

9.3.5.11 CHAIN TENSIONERS

An automatic hydraulic operated chain tensioning device shall be furnished for each chain and located at the tension end of the submerged scraper conveyor. The device shall allow vertical travel and shall be equipped with limit switches to alarm on insufficient and excessive chain tensions. Each chain shall be independently adjustable, allowing for individual take-up adjustment for each chain. A zero speed switch shall be provided on each chain tensioner idler wheel.

9.3.5.12 SHAFTS AND BEARINGS

Bearings on the drive and all other continuous or through-shafts shall be rolling element, self-aligning, extra heavy-duty type. Externally mounted, heavy-duty spherical roller type bearings in pillow blocks are preferred. Regreaseable lubrication with drain plugs and seals with lubrication fittings shall be provided. Lubrication fittings shall be located so that they are easily accessible for greasing operations. Water flushed bearings will not be acceptable.

Shafts shall be solid alloy steel. Bearing and sprocket mount areas shall be machined and shoulders provided for positive positioning of sprockets. Idler and sprocket hubs shall be shrink fit or supplied with compression hubs to prevent "walking" along the shaft. Set screws alone do not meet this requirement and shall be deemed unacceptable.

9.3.5.13 SUBMERGED SCRAPER CONVEYOR DRIVE AND MOTOR

The submerged scraper conveyor shall be furnished with a hydraulic drive and gear reducer, coupled to the conveyor headshaft through a roller chain and sprocket assembly. The forward output speed shall be infinitely variable throughout the required speed range. The drive system shall allow for inching or jogging in both the forward and the reverse direction.

9.3.5.14 BOTTOM ASH CRUSHER

The bottom ash crusher (2 x 100% capacity 30t/hr) shall be of a size suitable for handling the required quantities of ash and shall be capable of reducing clinkers to a maximum size suitable for belt conveying.

The crusher tooth material shall be suitable for the temperature and abrasive service, and shall be material used successfully before in similar service.

9.3.5.15 ACCESS PROVISIONS

Access provisions shall be provided for the submerged scraper conveyor, which shall provide easy access to the head and tail section, economizer seal box and instrumentation. The access shall be supported from the submerged scraper conveyor.

9.3.5.16 CLOSED LOOP ASH WATER COOLING SYSTEM

A complete closed-loop water recirculation system shall be provided to maintain the appropriate water temperature and water level in the upper trough of the conveyor. The system shall be designed for the maximum total ash rate expected.

9.3.5.17 OVERFLOW WATER SETTLING/SURGE TANK

Overflow water from the submerged drag chain conveyor shall be collected in a single settling/surge tank. The tank shall be divided into a "dirty" and a "clean" section by internal baffles (underflow/overflow) designed to promote particle settling. The "dirty" section shall receive overflow water from the submerged drag chain conveyor. The tank shall have a sloped tank bottom with agitation nozzles to direct accumulated sludge toward the sludge removal connection. The settling or "dirty" portion of the tank shall be designed to remove particles larger than 44 microns with a specific gravity of 2.5 during normal continuous operating conditions.

9.3.5.18 LOW-PRESSURE ASH WATER PUMPS

Each low-pressure pump shall be sized to provide sufficient flow for the following applications: (i) for maximum submerged drag chain conveyor upper trough heat rejection, as required by the process and design conditions and (ii) for motive water supply to the pulverizer rejects sluicing system.

9.3.5.19 ASH WATER HEAT EXCHANGERS

Parallel-plate type heat exchangers shall process overflow water discharged from either of the low-pressure ash water pumps. The closed cycle cooling water system shall be used as the cooling water source. The heat exchanger design shall minimize the potential for ash build up.

9.3.5.20 SLUDGE RETURN PUMP

The pump shall be a horizontal centrifugal slurry pump, supported on an independent base at grade elevation.

9.3.5.21 LOCAL CONTROL INSTRUMENTATION

The temperature of the water in the upper trough of the submerged drag chain conveyor shall be continuously monitored. Whenever the temperature increases to a value greater than the design value, the SSC control system shall generate a high temperature alarm. This condition shall also initiate a position change (further opening) of the recirculated cooling water valve. If the upper trough water temperature increases to a value greater than the maximum limit, the SSC control system shall add makeup water directly into the upper trough to maintain a temperature less than the stipulated maximum. Similarly, activation of low level probes within the upper trough shall signal the control system to add makeup water to maintain an adequate seal with the furnace.

Additional process control instrumentation shall include, but not be limited to, the following:

1. Level control for overflow water settling/surge tank.
2. Continuous pressure monitoring of low-pressure ash water pump discharge.
3. Heat exchanger inlet / outlet fluid temperatures.
4. Differential pressure of ash water across heat exchangers.
5. Position indication for control valves.

9.3.5.22 BOTTOM ASH SILO

The bottom ash silo one for each boiler shall have a net storage capacity of slag for 40 hours BMCR burning the design basis fuel or 100m3 effective storage capacity whichever is larger. The net storage capacity shall be based on the active silo volume. The active silo volume shall be the overall cylindrical silo volume, minus an inactive volume two (2) m in height at the top of the silo, and minus the volume of the silo below a 20 degree angle of repose (from horizontal) from the silo floor center point to the silo sidewall.

The silo will be constructed of abrasion resistant alloy steel. The roof of the silo will be weather tight and shall be sloped to drain water. Handrail and kick plate shall be provided around the top of the silo. The bottom ash silo, bottom ash discharge equipment, floor, unloading deck, and entire structure shall be completely supported by a concrete foundation. A truck drive through clearance shall be provided below the discharge equipment. Vibrating system for silo and discharge equipment for truck loading shall be provided.

The silo shall be provided with open air radar type level transmitters and an operator accessible local indicator. A radio frequency probe or vibrating rod type level switch shall also be provided for a high level alarm to the control system.

Flanged piping nozzles of the Contractor’s design shall be provided for the conveying line inlets. All necessary flexible connections and supports shall be provided as required for proper installation and operation of equipment.

9.3.5.23 BOTTOM ASH SILO DISCHARGE EQUIPMENT

The Contractor shall design the bottom of the bottom ash silo to discharge bottom ash under all conditions. The system shall include silo discharge equipment such as air cannons to facilitate ash discharge from the silo.

9.3.5.24 SILO VENT FILTER

An air pulse, self-cleaning, bag type vent filter shall be provided for the bottom ash silo. Air jet cleaning of filter bags shall be continuous while the dust collector is in operation. Bags and bag cleaning system shall be of a type having a minimum of 3 year average bag life before replacement in similar service. One (1) spare bag shall be provided for each 10 bags furnished.

Each blow pipe shall have a positive means of alignment and coupling. Interstitial or rising velocities shall be limited to 2 m/s. Interstitial velocity shall be calculated by taking the total collector air flow divided by the following: (the collector cross-sectional area, minus inlet plenum or baffle area for high inlet, minus the cross-sectional area of the bags) times 60.

9.3.5.25 SILO VENT FILTER FAN

Each bottom ash silo bin vent filter shall be equipped with a vent fan to prevent the bottom ash silo from becoming pressurized.

9.3.5.26 SEGREGATING VALVES

Isolation valves shall be furnished on each branch line in the pneumatic ash conveying system. These valves shall be of the slide gate (or knife gate) type. The valves shall be self cleaning, non-clog type, with knife capable of retracting out of the material flow path. The valves shall be of dust-tight construction and shall be furnished with all necessary appurtenances for proper installation and automatic and manual override operation. Limit switches shall be provided so the control system can determine the position of each of these valves.

9.3.5.27 VACUUM/PRESSURE RELIEF DEVICE

A vacuum/pressure relief device shall be provided to protect the bottom ash silo. The vacuum/pressure relief device shall be located on top of the silo roof. The relief device shall not provide normal venting, but shall provide emergency venting in the event of high positive or negative pressures.

9.3.5.28 TELESCOPING DRY UNLOADING CHUTE

A motor-operated telescoping discharge chute shall be provided for dry ash discharge from the silo. The chute shall be constructed of carbon steel with abrasion-resistant alloy steel for ash contact surfaces.

The dry unloading chute shall capture fugitive dust produced as a result of its operation and return the captured dust to the silo. A concentric piping vent with vent fan shall be provided for the chute. The vent lines shall be piped back to the inlet of the silo.

9.3.5.29 BOTTOM ASH CONDITIONERS

Each bottom ash conditioning unit shall be of a dual shaft paddle type design. Bottom ash flow control valves shall be provided to meter the ash from the discharge of the silo and shall be capable of the desired discharge rate with varying ratios of bottom ash for various silo levels. The system shall include a means to washdown the interior of the conditioner with water after conditioning operations are complete. The local control system for the conditioner shall have the capability to adjust ash or water flow rates as required to maintain a damp earth discharge consistency.

9.3.5.30 ASH POND / ASH YARD

Specification of ash pond is given in Chapter 4 of Section 5. Refer drawing no. 10-PM-PAYRA-18 in Attachment B4 of Section 5.

Simple separation levee is made in the ash yard with compacted ash to divide the yard into ash area, slag area and gypsum area for separate storage and comprehensive utilization. Ash pile roller compaction is done in sequence.

To allow operation of ash yard as designed, compaction machinery shall include two (2) bulldozers for leveling of damped ash; two (2) vibrorollers and two (2) hand vibrorollers for layered roller compaction; two (2) wheel loaders; two (2) sprinkling cars for dust prevention in working zone of ash yard, cleaning of ash transportation road and dust prevention; three (3) mobile submersible sewage pumps for remove water log in working zone.

9.3.6 MILL REJECTS SYSTEM

The mill rejects from the coal pulverizers for each boiler is continuously delivered into the mill rejects hopper beside each coal pulverizer for storage. When a mill rejects hopper is filled the mill rejects is discharged into the tipcart and poured into the dumper and transported outward to the specified area at ash storage yard for storage. Refer Attachment C for more details.

9.3.7 GYPSUM STORAGE

The gypsum storage shall be designed as a silo with a storage capacity of 24 hours operation of two boilers at BMCR and worst coal (highest sulphur). The silo material shall be abrasion resistant alloy steel. The silo shall be located near the FGD.

The gypsum coming from via the pipe conveyor shall be conveyed to the silo filling conveyor and then discharged through a telescopic chute onto the (screw) conveyor which is spreading/leveling the gypsum on top of the stored material over the entire cross-section of the silo. This shall be performed by slewing and luffing the steel structure which supports the spreading conveyor. All these movements shall be controlled in order to achieve an even filling over the entire surface. After each complete rotation of the steel structure, it shall be hoisted with a certain adjustable step.

Emptying the silo, i.e. unloading of the silo shall be arranged by the same device. The (screw) conveyor shall transport the gypsum by rotating in the opposite direction. The conveyor reclaims the gypsum, conveys it to the center column of the silo and presses it through the openings between the discs of the central column into the interior.

The gypsum leaving the gypsum dewatering process shall be conveyed with a reversible belt conveyor to the loading facilities for truck. The conveyor shall be equipped with all necessary gypsum specific cleaning devices for reliable operation.

It shall be possible to store and transport gypsum out of the gypsum silos at the same time (in a parallel operation situation).

Air ventilation in the roof shall ensure the exhaust of vapors.

Measures shall be taken to avoid any blocking of the silo outlet.

Care and respective measures shall be taken to avoid problems with I&C and electrical equipment inside the silo due to the high dust and humidity atmosphere.

In the bottom of the silo a drainage system shall ensure the collection and discharge of condensation water and water of post-dehydration of gypsum.

The gypsum silos shall be equipped with all necessary devices for feeding a belt conveyor and/or loading in trucks and ships.

Adequate access by stair ways and platforms shall be provided to all instrumentation equipment. Equipment lifting devices shall be provided for the silo.

Safety of personnel and plant shall be addressed in the design and the intended operational procedures of the gypsum handling plant with close attention to guarding, anti-run back, braking and trip systems. Safety requirements for materials handling plant according to International Standards shall be applied.

Careful consideration shall be given by the Contractor to the maintainability of the Plant.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 10 – STEAM TURBINE

CONTENTS

10 STEAM TURBINE

10.1 STEAM TURBINE SYSTEM

Refer drawing no. 10-PM-PAY-03; Principle Power System Drawing in Attachment B4 of Section 5.

The steam turbine shall be an Ultra Supercritical single-shaft, tandem compound, 3000 RPM, single-reheat condensing turbine suitable for indoor installation. The steam cycle arrangement for the Power Station, including turbine generator parameters, shall be selected by the Contractor to achieve the Guaranteed Dependable at rated main steam flow, pressure, and temperature conditions.

The following are the indicative steam turbine parameters at rated load 660MW (TMCR) However, these parameters are to be determined by the Bidder.

Main steam flow (t/h)	1868.00
Main steam temperature before main steam stop valve (°C)	600
Main steam pressure before main steam valves (MPa)	26.25
Reheat steam flow (t/h)	1582.00
Reheat temperature before reheat steam valve (°C)	600
Rated mean backpressure (kPa)	8 (To be determined)
Number of Feed Water Heating System	To be determined by the Bidder
Feed temperature (°C)	298.2
Heat rate at TMCR (KJ/kWh)	7522
Rated speed (r/min)	3000

The steam turbine shall have an additional 3 percent (3%) (minimum) flow margin above TMCR point with valves wide open (VWO). The turbine generator and the rest of the plant shall be capable of continuous long term operation at VWO, normal pressure conditions. The cycle conditions, including the number of feedwater heaters, approaches, terminal temperature differences, heater drain arrangement, backpressure, last stage blade selection, and other steam cycle parameters shall be optimized by the Contractor based on rates as measures of the relative value of capital cost and operating cost.

The Employer’s preferences on the cycle arrangement for Feed Water System is as set out in Table 10.1-1 below.

The steam turbine shall be a tandem compound reheat machine consisting of a high-pressure turbine (HP turbine) and intermediate-pressure turbine (IP turbine) casing and flow low-pressure turbine (LP turbine) casings exhausting downward into the surface condenser.

The turbine casings shall be horizontally split along the turbine rotor centerline.

The turbine rotors shall be statically and dynamically balanced. A complete system of valving to protect the turbine from overspeeding shall be furnished.

Table 10.1-1
Feed Water System Arrangement

Boiler Feed Pump Parameter	
Number of BFPs	Two (2) 50 percent capacity)*, One (1) 25 percent capacity for startup and backup capability
BFP Drive	Two (2) Steam turbine for 50 percent capacity pumps, electric motor for 25 percent capacity pump
Feedwater Control	Variable speed
*Each steam turbine driven BFP shall be capable of providing a minimum of 70 percent rated flow with only one pump in operation.	

The design features to reduce and control thermal stresses in the turbine shall include:

1. Full arc admission capability at startup using control valve configuration only, not the turbine stop valves.
2. Sliding throttle pressure operation from minimum load to 100 % TMCR- pressure condition and then fix pressure to VWO (103 % TMCR) condition.
3. A rotor stress monitoring system to assist in startup by monitoring and presenting rotor stresses in terms of cycle life expenditure during steam-to-metal temperature matching, acceleration, and loading.

The turbine blading and the turbine generator control system shall be designed to allow for low-frequency and high-frequency operation commensurate with the Grid Code requirement. Startup and initial loading of the turbine shall be controlled by the turbine control and instrumentation system by either automatic or fully manual means with operator guidance that follows the Original Equipment Manufacturer's “OEM” recommended procedures.

All protective tripping functions shall be implemented using redundant sensors, so that the failure of one device does not make the turbine system inoperable.

Self-diagnostics shall be provided to identify devices that are out of normal operating range. The self-diagnostic system shall alarm the out-of-range devices so that they can be identified for repair.

Functional constraints applicable to the steam turbine generator shall be identified by the turbine manufacturer for such conditions as startup and loading procedure, speed, condenser pressure, throttle and reheat temperature and pressure, and steam quality. The turbine manufacturer shall provide startup and operation curves for starting the turbine in the cold, warm, and hot conditions. The major technical conditions of steam turbine are summarized as follows.

1) Longitudinal arrangement of turbo-unit: from the steam turbine to the generator, the lubricating oil system on the right
2) Rated speed: 3000r/min; the turbo-unit should realize continuous and steady operation in the cycle of 48.5~51.0Hz.
3) Direction of rotation (from the steam turbine to the generator): clockwise or counterclockwise
4) Unit power: The steam turbine should ensure the power unit has the power of 660MW at the working condition of turbine rated load (TRL) with the mean back pressure of 11.8kPa(a) (indicative); the steam turbine should ensure the power unit reaches the maximum continuous power value at the working condition of TMCR.
5) The net heat rate of turbo-unit at the working condition of turbine heat acceptance should not exceed 7522kJ/kWh (indicative) with the positive deviation of zero. The thermodynamic performance acceptance of turbine should be measured and calculated as per ASME PTC6.
6) While the steam turbine run at all working conditions of steady operation (rated speed), the relative vibration value of double-amplitude (in horizontal and vertical directions) measured at any journal should not be greater than 0.05mm; the vibration limit value of the bearing bracket should not be greater than 0.025mm; the allowable relative vibration value of double-amplitude measured at any journal should not be greater than 0.15mm when the rotor system allowable value passes through critical speed; and the vibration value of the bearing bracket should not be greater than 0.075mm.
7) The power unit should have certain variable load with the load change as follows: 50 to 100%TMCR, not less than 5% TMCR/ min; 30 to 50%TMCR, not less than 3% TMCR/ min; below 30% TMCR, not less than 2% TMCR/ min; at the load stage, 10% TMCR/min.
8) The max noise value measured at the supposed plane 1.0m to the turbine casing and 1.2m above the turbine operating floor should not be greater than 85dB(A); for the other auxiliary machines, the max noise value should not be greater than 85dB(A).
9) The turbo-unit should ensure the rated power output when the high pressure heaters all shut down and all the other conditions are identical with the working condition of THA, except that some reheating systems could not work properly and the air inflow is different.
10) The steam turbine has base load as well as the ability of variable load operation at 35% to 100% TMCR load.
11) The steam turbine should run in the mode of constant-variable-constant pressure or constant-variable pressure.

12) The steam turbine has strong load adaptability; the power unit with the RB (runback) function can bear the abrupt change of 50% rated load and remain steady operation and, at the abrupt change of 100% load, the power unit should ensure the turbine safe.

13) The steam turbine should allow no-load running and the allowable continuous running duration should meet the requirement for generator testing.

14) The digital electro-hydraulic control system (DEH), emergency trip system (ETS) and turbine supervisory instrument (TSI) are supplied by the turbine manufacturer. DEH and ETS software and hardware should be integrated with the power unit DCS to the greatest extent, or else, should reserve the bidirectional redundancy communication interface with the power unit. The selection and configuration of instrument control equipments supplied by the turbine manufacturer, such as the instruments and actuators, should meet the integrated automation level of the whole plant and the interface requirements.

15) The turbine lube oil system shall include, as a minimum: one shaft driven main oil pump and one AC oil pump, DC emergency oil pump, two full-capacity duplex lube oil coolers, one vapor extractor mounted on the reservoir, an oil reservoir (clean lube oil tank), a lube oil conditioner, and a dirty lube oil tank.

16) One main lube oil pump shall be turbine shaft driven, with a back-up full flow AC motor driven pump. All other pumps required for system operation shall also be provided. All motor driven lube oil pumps shall be mounted on the lube oil reservoir. Each oil pump suction and oil return line shall be provided with a strainer.

17) There shall be no emergency stop push button on the emergency oil pump for the turbine.

18) All lube oil piping shall be 18-8 stainless steel and guarded. The guard pipe may be carbon steel. Lube oil piping shall be routed in a manner to avoid crossing or being located directly above any steam piping, sloped to avoid air pockets and allow gravity drainage where possible, and within the confines of the turbine foundation where possible. Redundant pressure transmitters shall be provided for automatic sequential starting of the motor driven oil pumps. Individual pump discharge pressure transmitters shall be provided to indicate operation of each individual oil pump. Provisions shall be included for testing of the AC bearing oil pump(s) and DC emergency oil pump auto-start from the control room. Pressure transmitters shall also be provided for the common lube oil supply header and the individual lube oil supply to each bearing.

19) A turbine lube oil purification system, including a circulating pump, pressure particulate filter, and coalescing water removal filter shall be provided. This system shall remove particulate matter down to 10 microns or less and shall remove any free water in the oil being processed. The system shall be

designed to treat at least 20 percent of the lube oil system capacity per hour.

20) The turbine lube oil system shall also be furnished with a clean and a dirty lube oil tanks, each with a working capacity equal to the total turbine lube oil reservoir capacity and a level transmitter for control room level indication.

21) The turbine exhaust hood water spray system shall be a complete system and shall be the supplier's standard for protection against high exhaust hood temperature.

22) The gland seal system and gland condenser shall be the turbine supplier's standard. Seal steam shall be provided from the Auxiliary Steam System, with bypass valves provided around the seal steam feed valve and unloading valve.

23) Drains shall be provided in the auxiliary steam supply piping to prevent water entering the seal steam piping. The seal steam feed valve and unloading valve shall be regulated automatically to control seal steam pressure.

24) The system leakoff drain piping and outer shaft packing annulus of the turbine shall be maintained under vacuum by the shell-and-tube gland steam condenser and two times 100 percent (2 x 100%) capacity motor-driven steam packing exhauster blowers. The LP turbine shall be suitably protected from hot seal steam.

25) Main stop valve and control valve leakage systems shall be the manufacturer's standard. Leakoff from these valves shall also be directed to the gland steam condenser, along with turbine leakoff, in continuously sloping piping from the turbine to the gland steam condenser.

26) The turbine shall be designed to allow RH and LH valve testing (100 percent (100%) stroking) during operation of the main steam and reheat steam stop, control, and intercept valves without tripping. The valves shall be equipped with coarse and fine strainers. The stop valves shall be designed to permit them to be opened against full steam pressure.

27) The LP blading shall be designed to withstand deterioration from erosion by water. Combinations of rotating and stationary blades shall be of proven reliability. Evidence of previous satisfactory use and exact similarity shall be provided to the Employer; otherwise, the results of testing/calculations showing the dynamic natural frequencies (in Campbell diagrams) shall be made available to the Employer.

    The turbine supplier shall perform a resonant vibration study on turbine blades and diaphragms where failures have occurred over the frequency range required by the grid. The turbine supplier shall provide Campbell diagrams for blades located in stages where there have been failures.

28) The turbine shall be provided with atmospheric rupture diaphragms in the exhaust hood.

29) The steam turbine and generator shall be provided with turbine supervisory instrumentation, including x and y bearing vibration monitoring with phase angle for alarm, trip, and trending.

30) The equipment and components of the turbine (and generator) shall be factory tested in accordance with the supplier's standard methods and procedures. The Employer shall have the option of witnessing any manufacturing cycle, ready for shipment, and tests.
31) The turbine and generator shall be designed to withstand the stresses caused by an overspeed of 20 percent (20%) above normal synchronous speed without reducing the life of the machine.
32) The turbine generator shall be equipped with a microprocessor based digital EHC governing system. It shall be the supplier's standard system. There shall be a provision to test the redundant Auto Stop (Trip) Coils on-line. The EHC governing system shall have two (2) x 100 percent hydraulic pumps. The hydraulic fluid shall be a known environmentally safe fluid.

The generator excitation system shall include a Power System Stabilizer (PSS) that the Contractor shall test and tune to the electric transmission system.

Major equipment arranged in order from the fixed end to expansion end in turbine house 0.0 m floor includes closed-circuit cooling water heat exchanger, host machine lubrication oil device (including main tank, oil cooler, jacking oil pump, etc.), vacuum pump, small turbine packaging oil tank and its oil purification device, condenser and drain water expander, condensing water pump and its frequency converter, generator sealing oil device, excitation transformer, electrical water filter, condensate polishing unit, etc. Reheating cold section pipe is arranged below the intermediate floor in front of unit head.

10.2 STEAM TURBINE BY-PASS

The turbine 60% capacity bypass system of this project shall consider the startup function as well as any emergency load fluctuations. To simplify the startup bypass, the turbine works should specify the bypass capacity, parameters, control mode and matching with operation of the power unit according to the startup mode of the turbine.

The turbine bypass systems shall be designed to handle the difference between the generated and consume steam flows during upset or transient conditions. The turbine bypass system shall be designed to meet the requirement of minimum house load operation for a minimum of two (2) hours and full load rejection.

The bypass system shall have two stages (HP from main steam to cold reheat, LP from hot reheat to condenser).

The steam turbine bypass shall be designated to withstand full load rejection (100% TMCR) without the need of safety valves lifting.

The spray water for de-superheating shall be supplied from the feed water pump or condensate extraction pump discharge and routed through the spray water control valves.

The turbine by-pass control and isolating function valves shall be of superior design of the pressure-reducing and de-superheating type, specifically developed for turbine by-passing duty. All the by-pass control valves shall be of ANSI/FCI 70-2 CV seat leakage class B according to EN12266/1. The contractor shall provide isolating valve for turbine bypass valves as an option.

The design pressure and temperature of the piping systems shall be suitable for the purpose, as determined by the heat balance and after due consideration of all possible operating conditions. The selection of pipe material shall be compatible with design pressure and temperature of the system.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 11 – BOILER

CONTENTS

11 BOILER

11.1 MAJOR TECHNICAL CONDITIONS

Refer drawing no. 10-PM-PAY-04, Principle Combustion System and Typical Power Plant Arrangement drawings no. 10-PM-PAY-05 and 10-PM-PAY-06.

The major technical conditions of the Boiler for this project are summarized as follows:

1) The boiler shall be of advanced design and shall be based on ultra-supercritical once-through boiler of sliding-pressure operation, single reheat, tangential coal firing, balanced draft, outdoor arrangement, wet ash extraction, all-steel suspension structures.
2) The boiler shall be designed, constructed and performance tested in accordance with, amongst others, ASME Boiler and Pressure Vessel Code, ASME B31.1 and NFPA Regulations.
3) The Bidder must provide evidence that the proposed Boiler is based on proven technology with similar design and material.
4) The boiler shall be designed to burn any coals listed in Attachment B3 of these Employer’s Requirements, either alone or in combination, using the manufacturer's standard low NO_x burners and over-fire air arrangement. Combustion air shall be provided by primary air fans and forced draft fans. The boiler shall be top supported and shall be a two-pass design to be determined by the Contractor.
5) The boiler and auxiliaries shall be designed for safe and reliable operation from startup to the boiler maximum continuous rating (BMCR) of the unit. The unit shall be capable of stable firing without the use of supplemental fuel, from 30 percent (30%) load to BMCR. The startup fuel shall be HSD fuel. The Power Station shall be designed for continuous safe operation in a controlled, stable manner to facilitate plant operation from minimum load without HSD fuel support to BMCR. The maximum continuous rating of the boiler shall correspond to 105% of MCR.
6) The main steam and reheat steam pressures and temperatures should completely meet the parameters of steam turbine. The boiler maximum continuous rating (B-MCR) corresponds to the working condition of steam turbine VWO (valves wide open), which is determined in the public bidding.

   Following are the Boiler parameters at BMCR and BNCR load: (Indicative only). However, these parameters are to be determined by the Bidder.

		BMCR	BNCR
1.0	Main steam flow (t/h)	1962.00	1868.00
2.0	Superhater outlet pressure (MPa)	27.56	27.00
3.0	Superhater outlet temperature (ºC)	605.00	605.00
4.0	Reheater Steam Flow (t/h)	1657.30	1582.00
5.0	Reheater inlet pressure (MPa)	5.90	5.70
6.0	Reheater outlet pressure (MPa)	5.75	5.60
7.0	Reheater inlet temperature (ºC)	368.30	365.00

		BMCR	BNCR
8.0	Reheater outlet temperature (ºC)	602.00	602.00
9.0	Feedwater temperature (ºC)	298.00	296.00
10.0	Outlet flue gas temperature (ºC)	127.00	126.00
11.0	Boiler efficiency (low heat value) (%)	> 93.9%	94%

7) The minimum once-through load of the Boiler should not be more than 30% BMCR.
8) The High Speed Diesel oil ignition is adopted with the high-energy spark ignition device reserved. With no oil supporting, the minimum load for steady combustion should not be more than 30% BMCR (design coal and worst coal) and the boiler should maintain long-term steady operation.
9) The Boiler main steam temperature shall be controlled by a combination of burner tilting, and desuperheating spray water, depending on the manufacturer's standards. If temperature control for the main steam is provided by desuperheating spray, the desuperheaters shall be located between the primary and secondary superheaters and the secondary and tertiary superheaters.
10) The reheat steam temperature shall be controlled by tilting burners. The secondary method of hot reheat steam temperature control shall be with desuperheating water spray.
11) The use of TP347H shall not be allowed for the finishing superheater or reheater tubing. The use of TP347 HFG, 304H, NF709, or HR3C shall be acceptable for the finishing superheat sections with internal shot peening for exfoliation resistance enhancement. The superheater and reheater layout shall provide sufficient mixing of flows to ensure uniform temperature at all loads, and shall provide for thermal expansion of headers, tubes, and supports. All sections shall be accessible for cleaning, inspection, maintenance and removal of assemblies. The furnace walls shall use a membrane configuration with vertical (rifled) tubing.
12) The design, fabrication and erection of the boiler shall be subject to survey by an independent inspecting authority (the third party inspecting authority). The cost for the engagement of this inspecting authority shall be covered by the contractor.
13) The boiler shall be designed to operate satisfactorily over the full load range with the coal properties shown in Attachment B3 of Section 5. The boiler manufacturer shall design the boiler and the related auxiliaries to operate reliably with high moisture coal (up to 30 percent moisture by weight, as received) over the full load range of operation. The coal moisture content shall be considered in selecting the pulverizer design. In addition, the boiler related fans (including seal air fans) shall handle the additional moisture. The air heater design shall account for the need to provide hot primary air to the pulverizers to dry the high moisture coal
14) The furnace shall be sized to ensure complete combustion of the fuel within the furnace proper without flame impingement on waterfall, superheater, or reheater elements. A division wall shall not be used in the furnace. All radiant waterwall surfaces shall be installed in the walls, roof, or floor of the furnace without the use of water-cooled surfaces projecting into the furnace. Steam-cooled platens projecting into the furnace shall be widely spaced and designed for ease of cleaning during operation. Adequate space will be provided for full sootblower coverage of all sides of the furnace. Sufficient space for maintenance of sootblowers shall be provided.

15) The boiler heat input per plan area, burner zone heat, heat available to the furnace per square meter of effective projected radiant surface, maximum gas temperature entering close spaced platens, and maximum gas velocity shall be selected by the contractor to ensure stable and reliable operation with respect to slagging, fouling and erosion of the boiler over the range of fuels proposed at Boiler Maximum Continuous Rating (BMCR), with carbon in the fly ash being no more than 5 percent (5%) for non-Indonesian coals, and no more than 3% for Indonesian coals with ash content greater than 2% on as received basis. The furnace exit gas temperature shall be less than the minimum initial deformation ash fusion temperature in a reducing environment for any fuel throughout the load range.

16) The Contractor shall provide an acoustic tube leak detection system complete with, amongst others, detectors, electronics and control room indicators. Amongst other special tools which may be specifically required for the Plant and equipment maintenance, the Contractor shall provide a power operated cradle for furnace maintenance. The design of the maintenance cradle is such that the parts can pass through the furnace inspection/man hole and be fully assembled for use inside the furnace. Furnace materials in the high heat zones shall be appropriate for the predicted duty intended service.

17) A circulation analysis shall be developed to ensure proper design of waterwall tubing, headers, downcomers and feeder/releaser tubes. Results of the circulation analysis shall be shared with the Employer.

18) The pipes of superheater and reheater requires high heat resistance, i.e. high creeping strength and endurace strength at high temperature, and should have fine high-temperature corrosion resistance on the fume side, fly ash erosion performance and high-temperature oxidation resistance on the steam side, which should be selected by the manufacturer based on the conditions and characteristics of the project.

19) Superheater and reheater tubes shall be seamless. The economizer shall be of the non-steaming type and the economizer tubes shall be seamless and shall be bare, not finned. The Contractor shall demonstrate during detailed design that the furnace material selection is appropriate for the predicted duty and intended service, taking into consideration the heat flux and potential of flow assisted corrosion (FAC).

20) The boiler system (including the furnace, and all flues and ductwork from the air inlet to the stack) shall be designed for protection against negative and positive pressure per NFPA 85 requirements. The planned operation of the unit is base loaded operation at full load. However, the fatigue analysis of the boiler pressure parts and other related equipment shall be based on operation of a cycling unit (full load for 10 to 16 hours per day and reduced load corresponding to minimum load without the use of supplementary fuel the remainder of the day).

21) A boiler filling system shall be provided.

22) Vessels in once-through boilers which have the function of separating water and steam during startup and low load operation, shall be designed so that the separating ability of the vessel and internal components is adequate at all loads from ignition to complete once through operation with no water emitted to the super heaters.

23) Boiler water recirculating pump (BWCP) is to be provided. The pump shall be sized to adequately handle the maximum required flow during start-up and circulation, considering the prevailing conditions of pressure and temperature in normal and all

possible transient conditions. The pump shall be installed in such a way as to have adequate access for maintenance, repair, removal and adjustment.

24) The Contractor shall install a minimum of 8 oxygen probes in the boiler backpass flue gas space in equal areas between the economizer and air heater.

25) The Contractor shall provide the system for short and long term preservation of the boiler and associated plant and equipment. The Contractor shall ensure that the wet storage regime is compatible with his installed dosing equipment.

26) Infrared (IR) temperature probes shall be provided to measure the temperature of flue gas at the furnace exit.

27) A complete soot blower system shall be furnished to effectively remove all ash, in its various forms, from the heat transfer surfaces of the complete boiler unit. Soot blowers shall be electric motor driven units. A means of manually rotating and retracting the soot blowers shall be provided. All elements shall be constructed of seamless tubing with one end closed. A soot blowing system for removal of ash deposits shall be provided with programmable type controls incorporating variable group selection of individual or groups of blowers as well as heat flux sensors for furnace tube temperature monitoring. The soot blowing steam header shall be equipped with an automatic drain to remove condensate. The soot blowing medium shall be steam for convective and superheat surface and furnace walls. Each soot blower shall be equipped with isolation valves to enable maintenance while the system is online.

28) The quantities of boiler auxiliaries shall be at least as listed in Table 11.1-1. The type of air heater and boiler auxiliary equipment shall be dependent upon vendor selection and associated OEM standards. Air pre-heater design and material selection shall be apropriate to mitigate acid dew-point corrosion issue.

Table 11.1-1
Boiler Auxiliaries

Component	
Primary Air Fan	2 x 50%
Forced Draft Fan	2 x 50%
Air Heater	2 x 50%
ID Fan	2 x 50%
FGD Booster Fan (if required)	1 x 100%

29) Furnace design pressure shall be ± 533 mm w.g

30) The combustion BNCR technology of low NOx is used with the boiler load at the working condition as follows: the NOx emission per hour at the air pre-heater outlet should not exceed 350mg/Nm^3 (converted to the oxygen content of 6%, dry state)

31) The boiler should have reliable measures to prevent the waterwall, burner nozzle and radiation superheater from coking.

32) The boiler has base load as well as the ability of variable load operation at 30% to 100% TMCR load.

33) The boiler has strong load adaptability; the power unit with the RB (runback) function can bear the abrupt change of 50% rated load and remain steady operation and at the abrupt change of 100% load, the power unit should ensure the boiler safe.
34) The boiler should run in the mode of constant-variable-constant pressure or constant-variable pressure and could meet the steam turbine determined in operation mode and startup curve.
35) When the high pressure heater is removed, the boiler should meet the feed steam parameter of the steam turbine at rated load.
36) The coal-pulverizing system uses the direct-firing pulverizing system of medium-speed cold primary air fan. At the load of 90% BMCR, while using the design coal, the ensured thermal efficiency should be greater than 94% (low heat value). The acceptance test for boiler thermal efficiency should be measured and calculated as per ASME PTC4.1.
37) The boiler has no air heater but with the secondary air hot air recirculation system. The tail heating surface of the boiler should be designed with effective and reliable measures to prevent low-temperature erosion.
38) Life requirements of the boiler: The main pressure parts should have the designed life not less than 30 years; the heated elements of air pre-heater should have the service life greater than 50,000 hours; the nozzle of spray type desuperheater should have the service life greater than 80,000 hours.
39) The rotary tri-sectional air preheater is used with the dry process electrostatic coating for the ceramic elements of heat transfer at the cooling stage; the air leakage rate of air pre-heater in the acceptance test should be less than 6% and 6.5% within one year and after one year respectively after the boiler put into service.
40) The flame check and cooling air instrument control system and the boiler pipe leakage detection device should be purchased separately and the soot blowing should be included in the scope of DCS monitoring. The selection and configuration of FSSS (Furnace Safety Supervision System) cast house instrument control equipments, instruments and actuators supplied by the boiler manufacturer should meet the integrated automation level of the whole plant and the interface requirements.
41) The design pressure of the furnace is temporarily determined as ±6.5kPa and the furnace transient design pressure is ±9.8kPa.
42) All combustion air ductwork shall be designed for minus 203 mm w.g. and a positive pressure equivalent to the maximum transient pressure that can be developed at any location during operation (including a Master Fuel Trip) plus a margin. All flue gas ductwork up to the inlet of the ID fan shall be designed for plus 203 mm w.g. and a negative pressure equivalent to a worst transient negative pressure that can be developed at any location during operation (including a Master Fuel Trip) plus a margin. In no case shall the design pressure be less than that required by NFPA 85.
43) The coal-pulverizing system uses the direct-firing pulverizing system of medium-speed cold primary air fan. At the load of 90% BMCR~BMCR, while using the design coal, the ensured thermal efficiency should be greater than 94% (low heat value). The acceptance test for boiler thermal efficiency should be measured and calculated as per ASME PTC 4.1

44) The flame check and cooling air instrument control system and the boiler pipe leakage detection device should be purchased separately and the soot blowing should be included in the scope of DCS monitoring. The selection and configuration of FSSS (Furnace Safety Supervision System) cast house instrument control equipments, instruments and actuators supplied by the boiler manufacturer should meet the integrated automation level of the whole plant and the interface requirements. The design pressure of the furnace is temporarily determined as ±6.5kPA and the furnace transient design pressure is ±9.8kPA

45) An 813 mm wide by 1397 mm high water cooled access door shall be provided on each side of the lower furnace. 457 mm wide by 610 mm high refractory lined access doors shall be provided to permit access to superheater, reheater, between the arch tubes and casing, between economiser banks, and in any other areas requiring access. All doors shall be hinged and pressure tight. Sight holes shall be provided to give a clear view of each burner row and side, front and rear walls in the vicinity of burners, as well as the ash hopper slopes. Any other area requiring inspection during operation shall be similarly fitted. These holes shall be situated not higher than 1.5 m from the adjacent floor or gallery levels with easy access without building of scaffolding.

46) Life requirements of the boiler: The main pressure parts should have the designed life not less than 30 years; the heated elements of air pre-heater should have the service life greater than 50,000 hours; the nozzle of spray type desuperheater should have the service life greater than 80,000 hours.

11.2 MAIN STEAM, REHEAT STEAM AND BYPASS SYSTEMS

The main steam and high and low temperature steam systems adopt the unit system, the main steam pipe and reheat steam pipe leading out from the both sides of the outlet header of superheater and reheater respectively and the four branch pipes combined into two tubes and connected in front of the boiler to the steam turbine in parallel and then in two tubes to the main steam stop valve and reheat stop valve on left and right sides of the high pressure cylinder and the intermediate pressure cylinder. The cold reheat steam pipe leads out from the two air outlets of the high pressure cylinder and are combined into a main tube at the handpiece and then divides into two branch pipes in front of the boiler and connected respectively into the inlet header of the reheaters. In this way, it could reduce the deviation of steam temperature and pressure caused by heat deviation and piping layout difference on both sides of the boiler, contribute to safe operation of the boiler and save the pipe investment by selecting proper pipe specification.

The superheater has temporary blind at the outlet pipe for hydraulic test; the reheater has the isolating device at the inlet and outlet pipes for hydraulic test; and the side pipe system allows the isolation hydraulic test.

The power unit has the 2-stage serial turbine bypass system with the temporary design capacity of 60% and the final capacity to be determined on the basis of types, structure, performance and startup mode of the steam turbine and boiler. The capacity should meet the requirement for unit startup and provide station service when the unit is isolated plant.

11.3 AUXILIARY STEAM SYSTEM

The following should be considered for the startup steam:

1) Shaft seal steam at startup;
2) Steam required for condensation water preheating and voltage regulation in the deaerator;
3) Steam used for Fuel oil steam atomization;
4) Other steam volume.

The above steam is supplied by the Startup oil fired boiler with the capacity of 1*35t/h, 1.3MPa and 350º C. However, the boiler parameters are to be determined by the bidder.

11.4 AIR HEATERS

Each boiler is equipped with two trisector rotary air heaters of 50% capacity. The air heater(s) shall be of vertical shaft consists of corrugated metal heat transfer elements. Elements shall be designed for ease of replacement, and supported from a steel center shaft. The shaft shall be mounted in oil-cooled and lubricated bearings designed for the imposed radial and thrust loads. Seals shall be provided to prevent gas and air leakage around the rotor.

The air heater shall be designed with appropriate materials to resist Acid dew point corrosion where necessary, including Corten basket materials.

The regenerative air heaters shall be provided with room in the casing for up to 30 cm of additional basket depth. Connections for the fire protection spray water shall be provided in the air heater. The air heater shall be designed to minimize the potential for acid condensation and shall include a steam soot lower and a water wash manifold.

Airflow ports shall be supplied on the air heater primary and secondary air discharge ducts for manual flow traverse testing.

The contractor shall provide air preheat coils if necessary to keep the air heater gas outlet temperature above the dew point, in accordance with the air heater Supplier's recommendation.

11.5 HOPPERS

The design of the duct system shall include ash hoppers for the collection and removal of ash at the air heater gas outlet and electrostatic precipitator.

Hoppers shall be sized for no less than 12 hour ash accumulation when burning the typical design fuel without undue draft losses or efficiency losses. The hoppers shall be provided with flanged outlets for installation of collection equipment. The slope of the hopper sides shall not be less than 60 degrees referenced to a horizontal plane. Connections shall be provided on each hopper for installation of level detection devices.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 12 – PULVERIZERS, COAL SILOS AND FIRING EQUIPMENT

CONTENTS

12 PULVERIZERS, COAL SILOS AND FIRING EQUIPMENT

12.1 FUEL ANALYSIS

Indo 12 brown coal is used for the design coal; Indo 6 brown coal is used for the check coal/worst coal, Refer Attachment B3 for the coal analysis data.

The High Speed Diesel Oil (HSD) is used for the Boiler with the high-energy spark ignition. HSD oil is used for the ignition and combustion supporting.

12.2 COAL-PULVERIZING SYSTEM

The design coal for this project is brown coal with, which catches fire and burns out easily, clinkers easily and has weak wearability. Therefore, it uses the positive pressure direct-firing pulverizing system of medium-speed cold primary air fan. This system is simple in structure, compact in layout and quick to start and stop, enjoys variable load shaving performance, low electricity consumption in operation and good explosion protection. Six number of vertical spindle type pulverizers shall be selected such that the boiler can achieve BMCR with check/worst coal specified in Attachment B3 of these Employer’s Requirements with one pulverizer out of service and the pulverizers in work (85% capacity) condition. Feeder and pulverizer combinations shall be identical size assemblies. The pulverizers shall be designed to meet BMCR when firing coal with moisture content up to 29.50% percent by weight, HGI of 48 and GCV of 17,408 MJ/kg (LHV, as received basis) and worn pulverizers with one pulverizer out of service. The boiler is equipped with six steel silos of corrosion resistant stainless steel plate lining. The coal storage of five silos could meet 12 hours combustion of the worst coal at BMCR load.

Each boiler has medium-speed vertical spindle pulverizers, six electronic weighting belt coal feeders and two axial primary air fans per boiler. The seal air for the coal pulverizers comes from the cold primary air pipe with two centrifugal seal air fans, one for service and one for backup. Among them, the gross output of five coal pulverizers, based on the design coal, could meet the requirement of maximum continuous rating with 10% allowance left. The coal feeder output is considered as 120% of the maximum design output of the coal pulverizers.

Each pulverizer lube oil system shall include electric motor driven oil pumps, electric motors, motor starters, reservoir heaters, water-cooled heat exchangers, filters, thermometers, pressure gauges, temperature and pressure switches for alarm and control, piping, and other accessories.

Each coal silo outlet shall be equipped with a manually operated outlet gate fabricated of carbon steel. The manual silo outlet valve shall include a chain wheel operator. The gravimetric coal feeders shall include, but not limited to variable speed drive, weighting device, stainless steel downspout, sealing arrangement, coal flow monitors. Each coal silo shall discharge onto a heavy-duty variable speed gravimetric coal feeder, which shall regulate coal feed to the boiler system. Coal chutes and hoppers will be lined to minimize wet coal pluggage issues. Coal silos shall be provided with a manually-actuated eco-friendly inerting system, sized for 3 times the volume of a single silo. The boiler coal silos shall provide a total of 12 hours storage when operating at BMCR conditions and burning the worst case coal.

Pulverizers shall be provided with a manually-actuated steam or eco-friendly inerting system and connections for fire protection spray water. Coal silos and pulverizers shall be equipped with carbon monoxide detection, which alarms into the main fire protection panel.

A Mill Reject Handling System complete, but not limited to hoppers, seal box, discharge gate, conveying system, disposal system shall be provided.

12.3 AIR-FLUE GAS SYSTEM

The air-flue gas system uses balanced draft, meeting the requirements for blowing the exhaust flue gas while burning the design coal from the startup to the maximum continuous rating (BMCR) and meeting the requirements for burning the check/worst coal.

12.3.1 AIR SYSTEM

Each boiler is equipped with two primary air fan and two forced draft fan as stated in Section 5, Chapter 13.

Each boiler is equipped with two tri-sector rotary air heaters as stated in Section 5, Chapter 11. The hot and cold air duct thickness of 5mm carbon steel. The system shall be designed as per applicable codes.

All combustion air ductwork shall be designed for minus 203 mm w.g and a positive pressure equivalent to the maximum transient pressure that can be developed at any location during operation (including a Master Fuel Trip) plus a margin

12.3.2 FLUE GAS SYSTEM

This system is to extract the flue gas from the furnace and discharge into the atmosphere through air heater, electrostatic precipitator, desulfuration absorption tower and chimney. This project has desulfuration bypass for the flue gas. When the desulfuration system breaks down, the flue gas is discharged directly through the chimney. This project has desulfuration bypass for the flue gas. When the desulfuration system breaks down, the flue gas is discharged directly through the chimney. Behind the precipitator electro static, there shall be two radial ID fans as stated in Section 5, Chapter 13. According to the environmental requirements, the electrostatic precipitator efficiency of this project should be $\geq$ 99%, with the double chamber electrostatic precipitator used, two for each boiler (Refer Section 5, Chapter 22).

All flue gas ductwork up to the inlet of the ID fan shall be designed for plus 203 mm w.g and a negative pressure equivalent to a worst transient negative perssure that can be developed at any location during operation (including a Master Fuel Trip) plus a margin

To meet the requirement of one boiler working and the other for chimney and desulfuration flue repair and maintenance, a reinforced concrete outer cylinder with double steel inner flue is advised to be shared by the two boilers of the project. The steel inner core of chimney of Ø7.2m in diameter and 275m in height.

12.4 FUEL OIL SYSTEM

This project uses HSD for the oil ignition and combustion supporting, arranged with 2 x 500m^3 oil tanks and corresponding unloading pump and oil feed pump, as stated in Section 5 Chapter 9

The scheme of main burner with the function of HSD oil ignition is adopted, with the high-energy spark ignition device for backup.

12.5 FIRING EQUIPMENT

Coal pipe orifices shall be provided for burner balancing. Coal pipes shall be ceramic lined at all elbows. The coal pipe sections from the top of the pulverizer to the inlet of the pulverizer discharge valves shall be ceramic lined. The coal pipes and classifier material coatings shall be designed for the most abrasive coal.

Low NOx burners and Overfire Air Systems shall be provided that will allow the boiler to meet the required NOx emissions throughout the expected operating range and firing the range of fuels specified.

Burners shall be mounted in cased insulated wind boxes. All coal gate drives, damper drives, and register drives required for pulverizer and burner control, remote light-off, and load modulation shall be furnished. All wind box dampers required for pulverizer and burner control and remote light-off shall be furnished.

Burner design shall provide accurate fuel-air ratio control through mixing of fuel and air at all ratings. Burner design shall prevent flame impingement on furnace tubes at any time. Adequate burner cooling air shall be provided when the burner is out of service during boiler operation.

The burner management system (BMS) shall be incorporated into the plant DCS.

12.6 DAMPERS

Adequate numbers of lower dampers and guillotine gates for 100% isolation of all fans, air heaters, ESP, pulverizers and FGD shall be arranged for on load maintenance. All lower dampers shaft shall be stainless steel with self lubricating sleeve bearings. The seals material for the gates and dampers shall be haste alloy or equivalent. The components shall be sized to shut off torque of the actuators. Pneumatic actuators shall be selected for quick closing.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 13 – PA, FD, ID, SEAL AIR AND SCANNER AIR FANS

Contents

13 PA, FD, ID, SEAL AIR AND SCANNER AIR FANS

Forced draft fans and primary air fans shall be furnished to provide combustion air to the boiler.

2 x 50% Primary Air fans shall draw air from the atmosphere or the air heater and provide air to convey pulverized coal from the pulverizer through the coal pipes to the burners. The primary air fans shall be motor driven, axial fans with airfoil or backward curved blades and shall be equipped with inlet silencers, inlet guide vane control, and a lubricating oil unit for each fan. The forced flow lubricating oil system shall include dual, full capacity oil filters and pumps. The motors shall be directly connected to the fan shafts with flexible couplings and shall operate at not more than 1400 RPM. Fan flow rate shall be controlled using variable inlet vanes. The fan rotors shall be statically and dynamically balanced. The fans shall be designed for test block conditions with 30 percent (30%) flow margin and a 15ºC temperature margin and 40% margin on pressure.

The electric motor driven 2 x 50% Forced Draft (FD) fans shall be Axial fans with variable pitch blades. They shall be equipped with a lubricating oil unit and hydraulic blade pitch adjustment system. The forced flow lubricating oil unit shall include dual, full capacity oil filters and pumps. The motors shall be connected to the fan shafts with flexible couplings and shall operate at not more than 1400 RPM. The fan flow rate shall be controlled using the variable pitch blades. The fan rotors shall be statically and dynamically balanced. The fans shall be designed for test block conditions, which shall include a margin of 30 percent on flow and a 15ºC temperature margin and 40% margin on pressure.

2 x 50% Induced Draft (ID) fans shall be provided to maintain a slightly negative pressure in the furnace. The ID fans shall provide the static pressure requirements to offset the draft losses through the Boiler convective heat transfer surfaces and the Air Quality Control System (AQCS) equipment.

The ID fans shall be Radial fans with airfoil or backward curved blades designed for induced draft service in outdoor installation. The fans shall be directly driven by an electric motor with a flexible coupling and shall operate at not more than 1000 RPM. The fans shall have a forced oil lubrication oil system with dual, full capacity oil filters and pumps. Fan flow rate shall be controlled using variable inlet vanes adjustment system. The fans shall be designed for test block conditions, which shall include 35 percent (35%) flow margin including a 15ºC temperature margin and 50% margin on pressure. The impeller and shaft assembly shall be designed so that the design resonant speed of the rotor is at least 25 percent above the maximum operating speed of the assembled unit. The fan housings shall be carbon steel. The fan shafts shall be forged steel. The impeller plates and blades shall be alloy steel. Lubrication supply and return piping shall be stainless steel. The ID fans shall be provided with seismic type vibration monitoring on each ID fans bearing housing, which shall alarm high fan vibration in the DCS.

Seal air systems complete with, but not limited to fans, outlet dampers, ducts shall be provided for the pulverisers.

Scanner air fans together with all required dampers, controls and instrumentation shall be provided.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 14 – BOILER FEED PUMPS

Contents

14 BOILER FEED PUMPS

The Plant is designed with two (2) X 50% capacity turbine-driven boiler feed (TDF) pumps with booster pumps and two (2) X 25% capacity (nominal) centrifugal multistage motor-driven (MD) feedwater pump with booster pump, utilized during normal operations and Plant startup respectively.

The MD feedwater pump is also designed for backup operations in parallel to either one of the TDF pumps operating at nominal conditions.

The boiler feed pump turbines are to be fed from extraction steam. At low loads, the boiler feed pump turbines are fed from auxiliary steam. The boiler feed pumps turbine drives are direct drive, variable speed, condensing, single inlet unit. Stop valves are provided for each inlet. The boiler feed pump turbine exhausts to the main condenser. The boiler feed pumps turbine exhaust is provided with an expansion joint.

The boiler feed pumps shall be utility grade multistage, segmental ring type pumps with external casing and cartridge (pull-out barrel type). Construction with external casing and cartridge (pull-out barrel type) could also be considered subject to prior review by the Employer. The steam turbine driven boiler feed pumps' design rotational speed shall not exceed 6000 RPM. The boiler feed pumps' shutoff head shall fall between 120% and 130% of the total head at design flow. Each boiler feed pump shall be provided with mechanical seals.

The turbine-driven boiler feed pumps shall be appropriately sized for the intended service, with each pump capable of providing at least 60% of rated flow with the other associated steam turbine driven pump out of service.

The motor-driven boiler feed pump shall be appropriately sized for 25% of rated flow. Boiler feed pump suction piping and deaerator shall be arranged to deliver adequate net positive suction head available (NPSHA) so that protection logic will not trip the boiler feed pumps on low NPSHA during any normal operating scenario.

Pump minimum flow shall be provided by an automatic, modulating recirculation system between pump discharge and deaerator storage tank. Use of Automatic Recirculation Control (ARC) valves for this service is not permitted.

Each boiler feed pump shall be equipped with a control valve in the recirculation system to maintain pump minimum flow. Each boiler feed pump recirculation control valve shall be controlled independently.

The recirculating lines shall be provided with manual shutoff valves, with provisions to be normally open. Flow orifice plates shall also be located in the recirculation piping downstream of the manual shutoff valves to measure each individual feed pump recirculation flow.

The boiler feed pumps shall each have an IP discharge to supply spray water to the reheat steam system attemperator.

On each boiler feed pump discharge, a check valve and a motor-operated stop-check valve arranged in series shall be provided. If required, a warm up line tapped off each discharge line, downstream of the stop-check valve, for warming the boiler feed pump while in a standby mode of operation shall also be provided. A pressure breakdown orifice shall be provided in each warming line to help match the internal pressure in the pump casing while isolated from the feedwater discharge header.

The total feedwater pump discharge flow rate shall be the greater of either a 10 % margin of nominal feed water flow rate at BMCR, or the summation of feedwater flow rate at TMCR plus desuperheating requirements for the HP by pass system.

A difference of 50 Brinell hardness numbers (“BHN”) shall be maintained between stationary and rotating parts. All materials in contact with the process fluid shall be free of copper. The materials delivered by the Contractor shall comply with international standards and shall meet the minimum standards for materials as established by the codes in the following table:

Component	**Material**
Shafts	ASTM A276 S42000
Casing wearing rings	A564 S17400
Balance drum/disc, shaft sleeves rotating parts	A276 S43100
Pressure retaining bolts and studs	A322 Grade 4140T
Pressure retaining nuts	British Standard EN 20898-2 Grade 8 (ASTM A563 Class 9)
Impellers	A487 Grade CA6NM Class A
Ring section pumps	
Discharge and stage casings (suction)	A487 Grade CA6NM Class A
Stage casing (diffusers)	A487 Grade CA6NM Class A
Suction casing	A487 Grade CA6NM Class A
Mechanical seals	
Metals	Type 316 Stainless Steel
Rotating face	Silicon Carbide
Stationary face	Carbon
Elastomer	EPDM or Viton

The pumps shall be suitable for both continuous and intermittent service and shall operate satisfactorily without vibration, cavitations, or distress to any part through an operating range from minimum flow to maximum specified capacity.

The boiler feed pumps shall be designed for safe shutdown upon total loss of all auxiliary services for four (4) hours during a plant blackout situation. Safe shutdown shall mean safe to personnel, the boiler feed pumps, and the surrounding Plant facilities; and shall mean not creating any damage or condition requiring subsequent maintenance or inspection prior to restoration of the boiler feed pumps to service.

All boiler feed pumps clearances shall be suitable for pumping saturated hot water for up to 30 seconds without establishing the minimum pump flow and this shall be at specified operating condition in accordance with ISO 13709 - 2003, Section 5.7.4.

Wear rings, impeller, shaft sleeves, and other parts (either rotating or stationary) forming the pump assembly shall be securely locked in place and shall be renewable.

Pumps shall be constructed to permit ease of access for inspection and removal of rotating element and replacement of wearing parts without disconnecting the suction and discharge piping and without disturbing pump alignment.

All rotors shall be dynamically balanced with rotating parts connected thereto.

A separate lubrication oil system shall be furnished for each pump/motor. Lubrication oil system shall have low-pressure and high-temperature switches for alarming in the Plant control system.

Pump bearings, both inboard and outboard, shall include thermocouples to monitor bearing temperatures. External junction box shall be provided for easy termination of these bearing thermocouples. Pump and driver shall be provided with vibration probes based on manufacturer’s recommendation.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 15 – COMPRESSED AIR SYSTEM

CONTENTS

15 COMPRESSED AIR SYSTEM

The compressed air station is planned to supply compressed air shared by the entire plant for service use, instrument use and for fly ash transportation system. The compressed air system and specification shall be as per drawing 10-PM-PAYRA-16. The system is equipped with worm air compressors 6 nos of capacity 50 Nm^3/min. To ensure the quality of compressed air and decrease the number of air compressors, the compressed air system for miscellaneous use / Instrument use and Fly Ash System is configured according to the different quality requirements of the air use points for this compressed air, with freezer, Micro Heat Regeneration combined dryers of 60 Nm^3/min and the post treatment equipment like pre-filter, post filter and Ultra Filter for Deoil, water removal and impurity removal treatment.

The corresponding compressed air storage tanks shall be equipped for the points using the compressed air for instrument use, service use, ash handling and transportation, ash removal instrument, etc. The air is led and connected from behind the corresponding storage tanks; the main pipe for ash handling and transportation use and the main pipe for instrument use are connected with check valve.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 16 – FEEDWATER HEATERS/DEAERATOR

CONTENTS

16 FEEDWATER HEATERS/DEAERATOR

Feedwater heating shall be accomplished with feedwater heaters consisting of low-pressure heaters, a deaerator, and high-pressure heaters. The number of HP, LP heaters shall be decided by the bidder to obtain the optimum plant efficiency at TMCR condition. For heater arragements and drain detail refer Principle Thermal System drawing 10-PM-PAY-03.

The feedwater heaters shall be of the horizontal U-tube design utilizing extraction steam to heat condensate and feedwater. A design fouling resistance shall be applied in accordance with the latest revision of the HEI Standard for Closed Feedwater Heaters.

16.1 HEATER DRAINING SYSTEM

In regular service, each row of the high pressure heaters uses the series drainage pattern stage by stage, i.e. from the heater of higher pressure to the ones of lower pressure, the drainage of no. 3 high pressure heater to the deaerator; the drainage of No. 8 low pressure heater to the steam condenser.

Other than regular drainage, the heaters are also equipped with emergency drain lines to open the draining valve in time for the heater accidents and drain water directly into the drain flash tank of the steam condenser and then into the condenser after pressure release.

The drainage of gland steam cooler is discharged into the steam condenser through the U-shaped water-sealed pipe.

The heater draining system is designed in the standard of ASME TDP-1 (Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation).

Each heater (including the deaerator) is equipped with startup exhaust and continuous exhaust to purge the heater of the non-condensable gas. The startup exhaust on the steam side of all the high pressure heaters discharges the atmosphere and the continuous exhaust is all connected to the deaerator. The startup exhaust and continuous exhaust on the steam side of the low pressure heaters are all connected into the steam condenser separately. The air-bleeding of all heaters discharge the atmosphere. The deaerator, including both the continuous exhaust and startup exhaust, discharges the atmosphere.

All heaters shall be arranged with the heater longitudinal axis horizontal.

The LP Heaters tubes shall be made of stainless steel

The HP Heaters tubes shall be seamless and made of carbon steel

The allowable pressure drop through all HP feedwater heaters shall not exceed 280 kPa, and the maximum feedwater tube velocity shall be limited to 3 m/sec.

The allowable pressure drop through all LP feedwater heaters shall not exceed 280 kPa, and the maximum feedwater tube velocity shall be limited to 3 m/sec.

The shell side of all heaters shall be designed for full vacuum in addition to the positive design pressure. Shells shall be of all-welded construction, with cutting planes for tube bundle access.

The heaters shall be designed in accordance with HEI Standard for Closed Feedwater Heaters for the fouling factors and heat transfer area. The conception will be according to the supplier standard. The high-pressure heaters with common bypasses shall be such that with any heater or group of heaters out of service and bypassed, the Plant shall be capable of generating the guaranteed electrical output at the reference conditions.

16.2 STEAM EXTRACTION SYSTEM

The power unit adopts adequate non-regulated extraction steam including high pressure cylinder exhaust for high pressure heaters, deaerator, boiler feed pump turbine and auxiliary steam system low pressure heaters.

To prevent turbine overspeeding, except for the extraction pipes of the last two stages, the rest all have positive-closing automatic check valve (pneumatic control).

The turbine steam extraction at all stages, except for that of the last two stages, all have dynamoelectric isolation valve with the function of quick closing as the main means for anti-water protection.

The steam extraction of the last two stages is designed with no valves since the heater is located at the condenser throat, with the four 7-stage extraction pipes and four 8-stage extraction pipes all arranged inside the condenser.

As required of ASME TDP-1, draining points should be arranged before and after the dynamoelectric isolation valve of the extraction pipes of all stages as well as the lowest point of the pipes to ensure no hydrops in the system when the power unit starts up or shuts down and the heater goes wrong.

The high pressure heater of each stage all adopts the 100% capacity heater; the deaerator is a 100% capacity heater with the low pressure heater at 5-, 6-, 7- and 8-stage all of 100% capacity. However, the final arrangement of extractions and heaters shall be determined by bidder.

Suitable lifting attachments shall be provided on each heater to facilitate access to tube bundle for maintenance.

A deaerator shall be provided as a stage of feedwater heating. The deaerator shall be a spray type heater. The storage tank shall be sized to provide at least 5 minutes of full load boiler feed pump flow with the deaerator water elevation at the low water level at the beginning of the 5 minute period.

The maximum oxygen content of the deaerator effluent shall not exceed 0.005 cc per liter.

All metal shall be in carbon steel except the perforated trays which are in stainless steel.

The deaerator shall be designed in general accordance with the latest edition of HEI Standards and Typical Specifications for Deaerators. Corrosion allowance shall be 3.2 mm. The conception will be according to the supplier standard.

As part of the detailed design effort, a transient analysis shall be performed for the boiler feedwater/condensate system. Various parameters, such as deaerator storage capacity, pipe size and routing, and operating conditions, shall be considered. The purpose of the analysis shall be to verify that adequate net positive suction head (NPSH) on the boiler feed pumps is maintained for operating conditions, including transient events. As a minimum, the deaerator shall be provided with but not limited to:

1. Level control
2. gauge glass standpipe
3. Two-gauge glass kits
4. Pressure gauge
5. Safety relief valve(s)
6. Two thermometers
7. High
8. High-high
9. Low
10. Low-low level alarm switches
11. Overflow system.

Suitable means of access shall be provided for all deaerator internal parts. A suitable door shall be provided above the water level for access to the heater section. Access openings shall be hinged or equipped with davit assembly and shall be provided with permanent-type gaskets.

Feedwater heaters and deaerator shall be provided with connections to allow for corrosion protection by nitrogen.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 17 – CONDENSER

Contents

17 CONDENSER SYSTEM

17.1 CONDENSER

The turbine shall be provided with a surface type condenser to condense turbine exhaust steam. The condenser shall be a double-shell, double pass and double-pressure with titanium tubes. An on-line condenser tube sponge ball cleaning system shall be provided. For condenser arrangement refer principle Thermal Power System draining 10-PM-PAY-03

The condensation system adopts intermediate pressure condensate polishing system with no condensate booster pump: it is a simple system. The condensation water in the condenser hot well after boosting in the condensate pump, enters into the deaerator through the intermediate pressure condensate polishing unit, the gland steam cooler and the low pressure heater.

The system adopts 2 x 100% capacity condensate pumps, one for operation and one for backup. The system is equipped with a full capacity gland steam cooler, full capacity surface low pressure heater, one deaerator.

The thermal design of the condenser shall be in accordance with applicable HEI Standards. The conception of the condenser and the mechanical design shall be in accordance with supplier rules. Tubes shall be a minimum of 24 mm diameter and shall have an average wall thickness of 0.5mm for normal tubes and 0.7 mm for impact tubes. The quantity of tubes shall result in a water velocity of up to 2.6 m/s at rated load with 5 % of tubes plugged.

All parts and components of the equipment shall be capable of expanding and contracting through complete cycles of operating pressures and temperatures including startup, shutdown, pre-startup cleaning, and one shell out of service without damage or distress.

The shell and hotwell plates and welds shall be provided with an appropriate level of corrosion allowance of 0.8 mm on each wetted side and in accordance with HEI Standards.

The condenser hot well storage working capacity between normal working level and low low working level shall be at least 3 minutes (retention time) when operating at TMCR conditions.

The condenser shall be provided with 5% spare tubes installed.

The condenser shall be rolled and welded titanium tubes and the tube sheets shall be made of carbon steel with cladding.

The waterboxes shall be carbon steel with an internal neoprene – lined of 3 mm thickness. The waterbox shall be divided to provide for half condenser isolation for manual on-line condenser cleaning.

The condenser waterbox shall have a protective coating and shall be designed for full vacuum as well as the expected positive design pressure of 5 barg. The condenser shall be protected from over pressurization by rupture disc(s) or pressure relief device(s). The shell is designed for full vacuum up to a pressure of 0.4 barg.

A cathodic protection system shall be provided for the water boxes.

Piping, valving, and instrumentation shall be provided for individual condenser waterbox isolation for on-line cleaning. Each inlet and outlet connection at each waterbox shall have an expansion joint and a single isolation butterfly valve. Each waterbox shall be flanged and removable for maintenance.

The condenser tube velocity shall not cause flow induced vibrations or erosion.

The tube bundle design shall incorporate steam lane patterns that promote efficient steam flow into and around the tube bundle, thereby providing efficient use of the available (in-tube) cooling water. Steam flow to the lower portion and below the tube bundle shall be designed to promote reheating of condensate droplets, which are subcooled as they fall through the tube bundle (on the outside of the tube bundle).

An expansion joint shall be provided between the turbine and the condenser connection to accommodate thermal expansion and the resulting differential movement between these components. It shall be a rubber joint. .

The condenser shall be provided with the vents and drains necessary for operation.

Suitable means of access shall be provided for inspection and maintenance of the condenser internals. The hot well outlet shall be provided with a grate to serve as a vortex breaker and screen for any large objects.

The condenser shall be equipped with two (2) x 100% capacity liquid ring vacuum pumps air exhauster system in accordance with HEI Standards.

17.2 VACUUM-PUMPING SYSTEM

At the startup beginning, this system is used to pump the air from the steam turbine, the space on the steam side of the steam condenser, auxiliary pipelines and equipments to meet the requirements for turbine startup; in regular service, it is used to exhaust the non-condensable gas accumulated in the air area of the steam condenser.

Three sets of water ring vacuum pump of 50% capacity are equipped for the vacuum-pumping system on the condenser steam side. The vacuum pump is connected to the steam condenser. In regular service, two vacuum pumps work and one vacuum pump backs up; at the power unit startup, three vacuum pumps all works to shorten the startup time.

Furthermore, there are also many auxiliary systems supporting the power unit, e.g. gland seal drain and vent system, boiler drain system, service water system, compressed air system, turbine lube oil system and so on.

17.3 CONDENSATION SYSTEM

The condensation system adopts intermediate pressure condensate polishing system with no condensate booster pump: it is a simple system. The condensation water in the condenser hot well after boosting in the condensate pump, enters into the deaerator through the intermediate pressure condensate polishing unit, the gland steam cooler and the low pressure heater.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 18 – CONDENSATE EXTRACTION PUMPS

CONTENTS

18 CONDENSATE EXTRACTION PUMPS

Pumping of condensate from the condenser hot well through the Low-pressure feedwater heaters to the Deaerator shall be accomplished by two (2) x 100% capacity, motor driven, condensate extraction pumps. The condensate extraction pumps shall be wet suction pumps. The pumps shall have direct drive electric motors.

The maximum pump suction specific speed of the first stage shall not exceed 11,500.

The design of the pumps will be such that no critical speed shall occur within 25 percent (25%) of the operating speed.

Each condensate pump shall include a basket type suction strainer. The condensate regulator valve station shall include a startup regulator.

The condensate extraction pump's rotational speed shall not exceed 1800 RPM.

The shutoff head shall not exceed 142% of rated head, with a minimum shutoff head of 125% of rated head. Adequate NPSHA shall be provided to facilitate cavitation free operation at any operating condition.

The condensate extraction pump's discharge flange centerline elevation should be below the condenser hot well low-low water level set point. If the discharge center line is above the low-low water level set point, then a water hammer analysis shall be performed and design features installed to mitigate unacceptable pressure spikes upon pump start.

The condensate extraction pumps shall be protected by providing minimum flow through a pneumatic or hydraulic actuated condensate recirculation control valve. The recirculation control valve logic shall be implemented in the DCS to ensure that minimum flow is maintained through the condensate pumps and/or the gland steam seal condenser during operation. The recirculated water shall be discharged back to the condenser hot well. The recirculation system shall be designed to handle the minimum flow required for two pumps.

Wear rings, impellers, shaft sleeves, and other parts (either rotating or stationary) forming the pump assembly shall be securely locked in place and shall be renewable. Wear rings shall be provided on all impeller entrances, if applicable.

Each pump shall have a suitable, steadily rising head characteristic curve with decrease in capacity, suitable for the service specified. The vibration levels as measured on the bearing housing shall not exceed the level specified by ISO 10816-7 Standards.

Each pump and motor shall be furnished with vibration monitoring probes to provide complete vibration analysis. Vibration monitoring probes shall be connected to DCS.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 19 – CIRCULATING WATER PUMPS

CONTENTS

19 CIRCULATING WATER PUMPS SYSTEM

19.1 CIRCULATING WATER PUMPS

Three (3) x 50% capacity circulating water pumps shall supply cooling water to the condenser and auxiliary cooling water system. Vertical wet pit, mixed flow pull out type cooling water pump shall be adopted. Refer drawing 10-PC-PAY-01 and 10-PC-PAY-02 in Attachment B4 of Section 5.

Each 660MW Plant owns a CW pump house which will be conjunction with the intake bay. The cooling water pump house owns four 50/10T EOT crane. The intake bay owns a 16/3.25T EOT crane.

Design of the pump shafts shall be such that any critical speed is at least 25 percent greater than the maximum operating speed.

Turning vanes shall be provided in the pump discharge as required to ensure uniform velocity distribution, if applicable.

Each pump shall operate satisfactorily in parallel operation. In double pump operations, when bringing out of service one of the pumps, the pump remaining in operations shall provide at least 70% of the total system design flow capacity based on two pumps operating in parallel.

Circulating water pumps shall have a maximum design speed of 900 RPM. Pump motors shall be furnished with integral non-reversing ratchets to prevent pump reverse rotation. Pump motor bearings shall be oil lubricated.

The table below sets out the minimum standard of materials that shall be delivered:

Component	**Material**
Impeller, Suction bell, Impeller bowl/shroud/inner casing	Alloy 2507 ASTM A890 Grade 5A
Shaft	Enclosed Shaft, Service Water Lubricated: Stainless Steel ASTM A276, Type 410 Condition T and Alloy 2507 for Bowl Shafting
Shaft sleeve	Enclosed Shaft, Service Water Lubricated: Stainless Steel ASTM A276, Type 420
Shaft enclosing tube, Column, discharge head, and turning vanes	Alloy 2507
Wearing rings (if required)	Manufacturer’s standard for the intended service.
Pedestal	Carbon Steel: ASTM A36 with Manufacturers Standard Coating

Component	Material
Baseplate, Soleplate	Carbon Steel: ASTM A36 with Manufacturers Standard Coating
Radial shaft bearings	Water Lubricated, Bronze Backed Cutless Rubber
Column and bowl bolting	Alloy 2507 4% Moly
Pedestal to drive motor and baseplate to soleplate bolting	Carbon Steel with coating

Lifting lugs or eyes shall be provided to facilitate handling. Each pump shall be furnished with either a motor or hydraulic-operated butterfly isolation valve by means to prevent excessive reverse flow if one pump trips.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 20 - FIRE PROTECTION AND DETECTION SYSTEM

CONTENTS

20 FIRE PROTECTION AND DETECTION SYSTEM

This section covers the minimum design, shop fabrication, installation and testing requirements for the fixed protection systems, early warning detection systems, alarm systems, and portable fire protection equipment. Fire protection equipment shall be arranged to appropriately protect the Plant and equipment in the event of fire.

It is not the intention to specify herein all fire protection and detection systems or all details of design and construction therefore. The Contractor shall ensure that all fire protection and detection systems required by applicable Laws and codes are provided, and that the equipment therein has been designed, fabricated, and erected in accordance with the applicable Laws and codes.

20.1 SCOPE OF WORK

The fire protection and detection systems (“Fire Protection and Detection System”) shall include, but shall not be limited to, the following: all fire water tanks, fire water pumps and drivers, fire water pump controllers, fire water pump enclosure(s), pump foundations, underground piping, hydrants, isolation valves, spray nozzles, sprinkler heads, heat and smoke detection devices, gas fire extinguishing system, froth fire extinguishing system, mobile fire extinguisher fire extinguishing system, strainers, OS&Y valves, non-rising stem gate valves with wall post indicator valves, sprinkler and spray system piping, fittings, strainers, fire department connections, pipe hangers and supports, expansion joints, valve enclosures, alarms, controls, local control panels, firefighting power supply and lighting system, wiring, conduit, fire detection devices, fume prevention and extraction system, instrumentation, portable extinguishers, standpipes, hose cabinets, hoses, and valve house enclosures as required for complete fire protection and detection system. The fire water distribution pipe lines outside buildings shall be underground with preparations as per applicable codes.

20.2 PERFORMANCE AND DESIGN REQUIREMENTS

The minimum performance and design requirements for the fire protection and detection systems are indicated in section Codes and Standards below.

In areas that are not continuously occupied and with any potential fire risk, automatic smoke detection shall be provided at the location of each fire alarm control unit(s) to provide notification of a fire at that location. Where ambient conditions prohibit installation of automatic smoke detection, automatic heat detection shall be permitted.

All conductors shall be in dedicated fire protection conduit. Conductors shall not be permitted in trays.

20.3 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply:

Work	In Accordance With
Overall design	NFPA and applicable Local Codes and Standards

NFPA 850 shall be used as a guide for the plant fire protection design.

Any conflict between referenced codes or standards, or between the standards and these specifications, shall be referred to the Employer who shall determine which standard or specification requirements shall govern.

20.4 MATERIALS

The following materials shall be used in the provision of the fire protection and detection systems:

Component	Material
Piping	
Sprinkler/Spray piping (downstream of isolation gate valve)	ASTM A53, Grade B, galvanized, seamless or welded (ERW); or ASTM A106, Grade B, galvanized. Minimum Schedule 40
Dry-pipe and preaction systems (downstream of isolation gate valve)	ASTM A53, Grade B, galvanized; seamless or welded (ERW); ASTM A106, Grade B, galvanized (no copper or brass tubing or piping). Minimum Schedule 40
Wet-pipe systems	Galvanized piping required for outdoor systems. Minimum Schedule 40
Dry pilot piping	Galvanized ASTM A53, seamless or welded (ERW), Schedule 80, Grade B
Air piping	Minimum 13 mm outside diameter

Component	Material
Piping upstream of the sprinkler and spray systems	Black steel, ASTM A53, Grade B, seamless; or ASTM A106, Grade B, seamless. Minimum Schedule 40 (Galvanized piping required in outdoor areas)
Foam piping	ASTM A53, Grade B, black steel, Schedule 40 (Galvanized piping required for outdoor systems).
Flanges	
Flanges	Hot-dip galvanized following welding when connected to galvanized pipe
Foam flanges	Class 150 RF flanged ends
Foam fittings	Standard weight, Class 150 RF flanged ends
Piping 50 mm and smaller	Screwed or shop welded. (UL or FM Listed grooved style fittings are acceptable except where piping is attached to the turbine pedestal.)
Piping larger than 50 mm	Welded flanges or shop welded connections. (UL or FM Listed grooved style fittings are acceptable except where piping is attached to the turbine pedestal.)
Pipe accessories	
Dry pilot fittings	Cast iron, galvanized, ANSI B16.4 Class 250; or malleable iron, galvanized, ANSI B16.3 Class 150 with threaded ends
Dry pilot unions	Brass to iron seats
Sprinkler and spray fittings (threaded or flanged: tees, couplings, elbows, caps, and reducers)	ANSI B16.3 or B16.1 malleable iron, Class 150 (mitered fittings are not acceptable)
Sprinkler and spray fittings (except wet-pipe)	Galvanized, ASTM A153; no bushing, slip type, or clamp-on rubber gasketed fittings
Foam pressure proportioner tank	Carbon steel
Plugs (sprinkler system)	Square head, dissimilar to the fitting to which they are attached
Gaskets	Red rubber sheets, 1.6 mm thick, full face, ASTM D2000, No. 2AA705A13L14
Thread sealant	Teflon ribbon, Optional for gas suppression piping.
Thread tolerances	NFPA 13 and ANSI B1.20.1 pipe threads

Component	**Material**
Bolts and nuts	Steel machine bolts
Plugs	Square heads and of a metal dissimilar to fitting to which they are attached
Piping supports	Per NFPA 13 and 15
Supplementary support beams (pipe support)	ASTM A36, fireproof construction
Riser lugs	ASME B31.1
Hanger rods	Per NFPA 13
Water shields	Viking model B-1, or equivalent.
Valves	
Gate valves	OS&Y type, flanged ends (butterfly valves are not acceptable)
Control panels (LFAP)	NEMA 4
Control panels (MFAP)	NEMA 12 (manufacturers standard panel will be considered in rooms with no water suppression and not likely to see any abnormal dust conditions)
Component	Material
Fire water pumps	
Pump casing, discharge head, suction bell, and pump bowls	Cast Iron, ASTM A48
Pump impellers	Bronze, ASTM B584
Pump shaft	Carbon Steel, AISI C1045
Pump shaft sleeves	Bronze, ASTM 62
Pump wearing rings	Bronze, ASTM B584
Vertical only	
Pump column	Cast steel, ASTM A120, hot-dipped galvanized
Wearing rings	Bronze, ASTM B584
Shaft and shaft enclosing tube	AISI Type 416 stainless steel
Bearings	Cutless rubber
Shaft sleeves	AISI Type 304 stainless steel
Suction strainer	Bronze
All bolting	AISI Type 316 stainless steel

Notwithstanding the above, the Contractor shall verify that the materials prescribed are suitable for the Employer's intended use based on the water quality in contact with the components.

20.5 TEST REQUIREMENTS

This testing is to be considered part of the Contractor's scope of work and all associated costs shall be in accordance with the Contract. The following tests, including such other tests as may be required by the relevant fire authorities, shall be conducted in accordance with the specified source, and in accordance with such procedures as may be required by the fire authorities:

Tests	In Accordance With	Conducted By
Testing and system acceptance of water based fire protection systems	NFPA and applicable building code	Contractor
Testing and system acceptance of gaseous fire protection systems	NFPA and applicable building code	Contractor
Testing and system acceptance of fire alarm system	NFPA and applicable building code	Contractor
Fire water pump Shop Test	NFPA	Contractor
Fire water pump Field Acceptance Testing	NFPA and local codes/standards	Contractor
Entire System	Applicable NFPA and local building codes	Contractor

20.6 SPRINKLER AND SPRAY SYSTEMS

The fire protection equipment shall be arranged to adequately protect the Plant and equipment in the event of fire.

The piping shall be arranged with adequate slope and valved vents and drains so as to be completely drainable.

Special emphasis shall be given to the design of the fire suppression systems to prevent water supply and dry pilot piping and nozzles from interfering with required Plant repairs or routine maintenance.

Valves installed between alarm initiating devices intended to signal activation of a system and the fire suppression system shall be supervised.

20.7 LOCAL FIRE ALARM PANEL (LFAP)

Local fire alarm panels shall be furnished and installed throughout the Plant to supervise and annunciate fire protection system conditions. All local control panels shall be capable of operation as a stand-alone system.
Enclosures subject to potential water spray or environmental conditions not designed for by the manufacturer shall be within a NEMA 4 enclosure. When a NEMA rated enclosure is required, the system shall adopt and maintain the listings and/or approvals specified by NEMA.

Internal devices shall be factory wired to terminal blocks. When a manufacturer's panel is used, a junction box shall be located near the panel to house the terminal blocks. When a NEMA rated enclosure is supplied, sufficient space shall be allocated to conveniently locate the terminal blocks on the back or bottom of the enclosure. Lightning protection shall be supplied on all circuits entering or leaving the structures or buildings as minimally required per NFPA 70, Article 800. Components for lightning protection shall be installed in a dedicated junction box.

Each local fire alarm panel shall continuously monitor its associated fire protection and detection system(s) for fire alarms, supervisory trouble signals, and circuit trouble signals. Upon receipt of a fire alarm, the given panel shall activate appropriate system valves, auxiliary relay, and a fire alarm bell in the area or zone affected. Upon receipt of a trouble or supervisory alarm, the panel shall activate individual alarm indicating lamps on the panel and a trouble horn at or near the panel. Trouble and supervisory signals shall be distinctive, i.e., the mixing of two or more signals on one circuit is not allowed.

Upon receipt of any fire alarm, each local panel shall activate a pair of normally closed, electrically isolated contacts or send the information via network which will be used for operating remote alarms in the Central Control Room.

20.8 FIRE DETECTION AND ALARM SYSTEMS

Each independent fire detection system shall be designed to provide adequate fire detection and annunciation in each of the areas protected. Each detection control panel shall continuously monitor detection systems for fire or trouble condition and activate the appropriate fire or trouble alarm(s) as required. These detection and alarm functions shall be performed independently of any other Plant equipment or facility.

The firefighting centralized alarm control device is set in the central control room of main power house. The firefighting watch office is in the second floor of fire house. The watch office is provided with regional alarm panel and centralized control room linkage to perform firefighting supervision on entire plant. It will also have direct communication with local town fire control department. The activation of any fire detector shall initiate a fire alarm condition at the appropriate local fire alarm panel and the Main Fire Alarm Panel (MFAP) located in the Central Control Room.

A fire alarm system shall be furnished in accordance with local building codes and NFPA requirements. The fire alarm system shall be designed in accordance with the requirements of NFPA 72. Fire alarm signals shall be processed to a central supervising station located in the Central Control Room. Signals shall include indications of water flow, fire alarm, and equipment status, as appropriate. Stand-alone local fire alarm control panels shall be provided as appropriate throughout the site area, and shall communicate via network wired in a loop configuration.

20.9 MAIN FIRE ALARM PANEL (MFAP)

The Contractor shall furnish and install the MFAP in the Central Control Room in accordance with all codes and standards to annunciate trouble, supervisory, and fire alarm signals from all fire protection and detection systems provided for the Plant.

An annunciator panel integral to or located beside the MFAP shall contain lamps that are easily viewable under all conditions, to annunciate distinctive alarm, trouble, and supervisory conditions; terminal blocks for all external circuits (for MFAP and remote annunciator); and push-button controls to start each fire water pump. Each lamp and switch shall have a distinct label located adjacent to the component. Space on the panel shall be supplied for a minimum of ten (10) future suppression or detection systems. The MFAP location in the Central Control Room shall allow sufficient space for the addition of an identical MFAP next to it when the Additional Unit is installed.

Dedicated contacts shall be supplied for the DCS to monitor the MFAP. A separate contact shall be supplied for general alarm, general trouble, and general supervisory conditions. Failure of MFAP operation must not impair the operation of local control panels.

The panel shall have a minimum of ten (10) spare alarm zones requiring only field wiring for future use. Switches to start fire water pumps shall be located on the face of the panel.

20.10 MANUAL FIREFIGHTING EQUIPMENT

A complement of portable fire extinguishers rated for Class A, B, and C fires shall be furnished and located throughout all buildings within the Plant in accordance with the applicable Laws and codes, in particular NFPA requirements. Additionally, portable CO_2 extinguishers should be located in areas containing sensitive electrical equipment, such as the Central Control Room and the electrical switchgear rooms.

A Class III standpipe system shall be furnished for all buildings and structures requiring such protection in accordance with the local building codes, NFPA recommendations, and standard industry practice. The system will include both 65 mm hose valve and 40 mm hose valve connections for occupant use. The 40 mm inch hose connections will be provided with a hose rack, complete with 30 m of industrial grade fire hose and industrial fog nozzle. Hose racks or reels shall be provided with a Class C electrical fog nozzle (non-brass).

20.11 FIRE WATER SUPPLY

The fire water supply system shall be designed in accordance with all NFPA recommendations. New service water / firewater storage tanks shall serve as the source of fire protection water. The tank shall provide a minimum two (2) hours dedicated fire water supply for the largest automatic suppression system demand, concurrent with an appropriate demand for hose streams. Refer drawing 10-PM-PAY-14, diagram of Fresh Water Supply System in Attachment –B4

20.12 FIRE WATER PUMPS

Plant fire water shall be supplied to the automatic and manual fire systems by three (3) X 100 percent (100%) capacity fire water pumps. Two pump shall be electric motor driven; the other pump shall be diesel engine driven. The diesel-driven pump shall be furnished with a fuel storage tank that has a capacity sufficient to provide eight (8) hours of fire water pump operation at 100 percent (100%) of the rated pump capacity. Each fire water pump shall have a flow capacity equal to at least the sum of the largest single automatic suppression system demand plus the outside hose demand. 2x100% electric motor-driven pressure maintenance pump (jockey pump) shall be furnished to maintain pressure in the fire protection system piping during normal operations.

Piping, flanges, sprinklers, and other components downstream of the booster pumps shall be appropriately rated for higher pressures as necessary.

All fire water pumps shall be capable of pumping satisfactorily at the design conditions and at any potential conditions ranging from minimum to maximum net positive suction head available (NPSHA).

20.13 FIRE WATER DISTRIBUTION SYSTEM

The fire water distribution system shall include piping, sectional valves, and yard hydrants and shall be designed in accordance with the requirements and recommendations of NFPA. The piping and sectional valves will be arranged to encircle the power block, (consisting of the boiler, steam turbine and generator buildings) and provide fire service to all buildings, structures, fire hazards, and yard areas that require coverage. The yard underground piping system shall be laid out with consideration given for the installation of the Additional Unit, including isolating valves to allow for future tie-in when the piping distribution system is expanded.

Sectional gate valves shall be furnished in the yard piping for isolation to minimize concurrent impact to both automatic and manual suppression systems serving a given area in the event of a single break in the underground piping. Buried sectional gate valves shall be furnished with post indicators or roadway boxes, depending upon their location and potential interference with traffic. Hydrants shall be supplied with header isolation gate valves. The hydrants shall be located in strategic areas at maximum intervals of approximately 90 m along the buried yard loop or branch line piping, and at maximum intervals of 150 m in remote areas such as around the coal pile(s). This distribution of hydrants shall comply with the relevant Laws and codes.

Interior fire protection loops shall be provided with at least two valved connections to the yard main with appropriate sectional control valves on the interior loop.

Fire main connections for standpipes shall be arranged so that a fire main break can be isolated without interrupting service in the fire water distribution system simultaneously to both fixed protection and hose connections protecting the same hazard or area.

20.14 FIREFIGHTING TRUCKS

Firefighting trucks are provided for the power plant, including 1 water firefighting truck, 1 dry powder and foam firefighting truck, 1 fire control patrol and command vehicle and 1 fire house.

20.15 FIRE PROTECTION AND DETECTION SYSTEMS

Automatic fire protection and detection systems shall be furnished for all buildings, structures, and specific hazards requiring such protection in accordance with applicable Laws and codes, in particular the NFPA requirements. Additionally, specific hazards will be protected with fire suppression and/or detection systems.

The Contractor shall perform a fire risk analysis to determine all of the forms of fire protection required and provided throughout the Plant.

Dedicated battery, electrical, and control rooms shall be provided with smoke detection, manual pull stations, and audible/visual annunciation systems.

The coal silos shall be furnished with carbon monoxide (CO) and methane gas detection for the early detection of silo fires. An inerting system using low-pressure carbon dioxide (CO_2) shall be furnished to inert the silos during shutdowns. The manually initiated release of CO_2 shall be possible both from the local control room and the coal silo.

Standpipes and hose stations shall be furnished and installed in the boiler building and throughout the steam turbine building in accordance with the applicable Laws and codes, in particular local building codes and NFPA.

20.16 TRANSFORMER SEPARATION AND CONTAINMENT

Transformer separation and oil containment shall meet all recommendations of the applicable codes in particular NFPA.

20.17 MISCELLANEOUS

Combustibles shall not be stored beneath or near the chimney flue unless a minimum 2-hour fire barrier and automatic sprinkler system are also installed.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 21 – AIR QUALITY CONTROL SYSTEM

CONTENTS

21 AIR QUALITY CONTROL SYSTEM

This section covers the general design and performance requirements of the Electrostatic precipitator (ESP) and Flue Gas Desulfurization (FGD) system to be provided for the boiler. Two (2) ESP casing system shall be provided for the boiler and shall be located between the air heaters (AH) and the induced draft (ID) fans. One absorber tower FGD system for the boiler shall be provided and located between the FGD booster fans and the chimney.

21.1 OPERATING REQUIREMENTS

The Air Quality Control System (AQCS) equipment shall be designed for safe and reliable operations under all boiler operating conditions. The design of AQCS shall be based on treating 100% of the boiler flue gas flow through the ESP and 100% through the FGD. AQCS equipment shall also be designed for cyclic operation of the Plant (100% boiler load for 10 to 16 hours per day and reduced load operation as low as 30% boiler load for remainder of the day).

The Contractor shall be responsible for the design of a flue gas bypass for the ESP and FGD system. Design shall prohibit bypass of ESP during the unit's normal operating conditions from startup to shutdown or part-load operations. Bypass shall be utilized during abnormal transient conditions of high temperature excursions or during pre-startup tests like fan draft tests.

FGD bypass shall be designed to satisfy the emission requirements while burning low sulphur coal and during transient operating conditions of high temperature excursions. The bypass system shall include damper design capable of modulating the flue gas bypass stream for temperature mixing to 100% flue gas flow at normal operating conditions of the unit.

21.2 PERFORMANCE AND DESIGN REQUIREMENTS

The air quality control equipment must be able to provide satisfactory service and performance under all boiler operating conditions and within the design fuel analysis and ranges indicated in Section 5 Chapter 1 (Site Data) and the types of coals listed in **Attachment B3**.

21.3 DESIGN MARGIN

The following design margin and redundancy criteria shall apply in accordance with the AQCS requirement unless otherwise noted:

Equipment	Design Basis	Redundancy
ESP	2 x 50%	
Casing	2 x 50%	
Flue Gas Desulfurization		

Equipment	Design Basis	Redundancy
Absorber tower	1 x 100%	
Absorber pumps	3 x 100%	1 x 100%
Treatment Plant	1 x 100%	
Aeration fans	3 x 50%	1 x 50 %
FGD Booster fans	1 x 100%	

21.4 MATERIALS

All materials used shall be resistant to the corrosive and erosive characteristics of the AQCS and supporting systems. The materials shall be lined with a corrosion and erosion resistant liners if necessary.

21.5 ARRANGEMENTS

AQCS equipment and arrangement shall provide adequate space for access, cleaning, maintenance, stairwells, walkways, lay-down area, access hoistsways, monorails and other equipment furnished by the Contractor. The absorber tower, auxiliary systems, and ductwork shall be arranged to permit access to the base of the stack. The AQCS shall be protected to prevent erosion, corrosion, cementation and plugging.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 22 – ELECTROSTATIC PRECIPITATORS (ESP)

CONTENTS

22 ELECTROSTATIC PRECIPITATORS (ESP)

22.1 SCOPE OF WORK

1) Electrostatic precipitator shall be complete in all respects including all components and accessories stated in this section for the steam generator.

2) Electro Static Precipitator (ESP) with microprocessor based controller shall include outside shell, structural steel supports and framework, base plate, anchor bolt, access ladders, platforms, safety rails, stair-ways, walkways, access doors and weather proof pent house. The ESP shall have two independent parallel casings and four parallel gas paths.

3) ESP electrical system including:
   a) 415 V switchgear and switchgear-cum-MCCs.
   b) Motor control centers, AC/DC distribution boards and miscellaneous electrical items for above.
   c) Electrical control desks/panels, relay panels, data logger panels, Programmable logic panels, etc.
   d) Miscellaneous local panels.
   e) All electrical equipment and systems integral with mechanical equipment, systems and subsystems.
   f) Above ground earthing and lightning protection.
   g) Lighting inside the ESP including distribution panel.

4) The following equipment complete with all accessories.
   a) Complete set of local control boards/panels.
   b) Local push-button stations: As required
   c) Local isolating switch units: As required
   d) Miscellaneous starter cum control panels: As required.
   e) Programmable logic control panels: As required.

The following items shall be provided:

1) Furnishing, mounting, and wiring of all equipment, devices and accessories.

2) Floor channel sill, vibration damping pad, and kick plates for all floor-mounted control boards/panels, complete with holding down bolts and nuts.

3) Mounting hardware for all control boards/panels, local push-button stations, and local isolating switch units.

4) Power, control and instrumentation cables in accordance with this specification enclosed. Other cables including special cables, if any, which are necessary in accordance with proven engineering practice for satisfactory and trouble-free operation of the entire cable system of the Project shall also be provided. These shall include all

such cables for electrical systems integral with mechanical equipment systems and subsystems.

5) Miscellaneous materials and items required to complete the erection work under this Specification. These materials and miscellaneous items shall include, but not be limited to, the following:
    a) Galvanized steel prefabricated cable trays; coupler plates; nuts, bolts, and washers; reducers; covers; wall brackets; hanger clamps; straight run, elbows, bends; etc.
    b) Galvanized steel rigid/flexible conduits and accessories, ferrules, lugs, glands terminal blocks, galvanized sheet steel junction boxes, cable fixing clamps, nuts and bolts, etc., as required.
    c) Cable termination and jointing kits as necessary.
    d) All necessary erection materials, consumables, and sundry items including arc welding rods to complete the installation for satisfactory and trouble free operation.
    e) Mild steel rods, galvanized steel flats, galvanized steel rods, lead coated copper tube suitably brazed with galvanized steel band ring, galvanized steel wires, etc., required for grounding and lightning protection system shall be supplied in standard lengths.

6) Suitable monorails with electrical hoist of adequate capacity shall be provided by the Contractor.

7) ESP model test and based on its results the installation of guide vanes / flow Splitters.

8) Matching flanges along with all bolts, nuts, gaskets, etc. required for connection to piping and ducting.

9) Foundation base plates, bolts, nuts, lock nuts, washers, anchor materials, packing shims, embedment, grouting cement etc.

10) Flue gas inlet distribution system complete with perforated plates, turning vanes, deflector plates, flow splitters and all necessary gas flow control devices in the inlet cones warranted by the results of model test, complete with rapping devices, duct stiffening devices, interior bracings, slide plates, access doors, brackets, supporting structures, hangers, sampling connection, etc.

11) Collecting and discharge electrode systems.

12) Electrode rapping system complete with structural supporting frame, drives, and automatic rapping control, etc.

13) Ash hoppers complete with heaters, level monitors and indicators, outlet flanges, jointing material, poke holes, access doors and walkway beneath the hoppers.

14) Transformer-rectifier sets, complete with bus sections, grounding switches, marshalling boxes, tank wheels etc.

15) Insulators along with heating and ventilation system (if required) for insulator compartment complete with heaters, fans (if required) and necessary controls etc.

16) TR set control cubicle one for each TR set, having microprocessor based intermittent charging controller, which shall be hooked to ESP management system, enclosure for TR set.

17) Microprocessor based controller for control of emitting Electrode and collecting Electrode rapping operations.

18) Microprocessor based ESP-management system covering co-coordinated controls, display unit and printer for the above-mentioned controllers.

19) Auxiliary control panel (MCC) for power supply to rapping motors and hopper heaters one for each pass of each ESP casing.

20) Galvanized junction boxes, galvanized cable trays and support for cable trays and local push button boxes.

21) All power, control, instrumentation /special cables of FRLS PVC/XLPE type unless specified otherwise shall be provided. Also heat resistant cables for making hopper heater connections up to local junction boxes.

22) Erection and cable erection accessories including cable trays, tray supports, cable glands, ferrules, tag numbers etc. for complete ESP installation.

23) Complete above ground grounding and equipment earthing system.

24) Drive motors, couplings and coupling guards for all rotating axillaries.

25) Inspection and maintenance access doors, frames and safety locks.

26) Safety devices, safety barriers etc.

27) All test instrumentation and equipment required for performance tests as specified.

28) Walkways, platform and access ladders.

29) Erection, testing and commissioning as specified.

30) Provision of water washing system for the precipitator and hoppers along with all piping, valves, nozzles etc.

31) Thermal insulation complete with lagging, wire mesh, fixing cleats, covering etc.

32) Paints and painting of all equipment and auxiliaries as per the specification.

33) Spare parts, consumables and special tools shall be supplied as per Chapter 3 of Section 5.

34) Any other equipment/system not covered above but required for the completeness of the specified equipment and services shall also be furnished unless specifically brought out under “exclusions” herein.

22.2 TECHNICAL REQUIREMENTS

The electrostatic precipitator shall have two parallel sections (casings), each capable of independent operation. A minimum clear spacing of 1500 mm shall be kept between two adjacent sections to ensure maintainability during shutdown of any one of the sections. For each ESP section, gas-tight dampers on inlet and outlet shall be provided so that one section can be maintained while the other is in service.

22.3 GAS DISTRIBUTION SYSTEM

Gas distribution system shall be provided at the precipitator inlet flange and if necessary at the outlet flange to achieve good distribution throughout the unit with maximum utilization of collection area at inlet and outlet. It shall be designed to minimize local velocity regions and to avoid by passing and re entrainment of dust. To achieve the above, internal baffles etc., shall be provided. The distribution screens shall be of modular design. The Contractor shall give full description of the gas distribution system, stating the means he proposes to use to keep the distribution screen clean.

22.4 CODES AND STANDARDS

The equipment and materials supplied shall comply with the appropriate Standards or agreed internationally accepted standards. This system shall be manufactured and tested in accordance with the respective supplier's practices, specifications, and National Standards as deemed applicable to the equipment and materials. Where the Bidder wishes to use alternative codes or standards, the adopted alternative standard shall be equivalent or comparable to the standards mentioned in this specification.

In respect of aspects requiring statutory clearances, relevant Codes and Standards shall be adhered to by the Contractor. In other cases, internationally accepted standards listed in the specification can be adopted.

In the event of any conflict between the codes and standards referred above, and the requirements of this specification, the requirements, which are more stringent in accordance with international power industry practice, shall govern.

22.5 EQUIPMENT LIFE AND MODE OF OPERATION

The complete system including all the equipment individually and collectively shall be designed for continuous operation for an economic service life of 30 years under the prevailing site conditions and for the type of duty intended. Each ESP shall be designed to achieve its rated guarantee values mentioned as per design criteria for the entire life period.

ESP shall be designed for continuous operation with respect to the plant base load and cyclic modes. It may also be required for it to participate in automatic load frequency control system.

22.6 NOISE LEVEL REQUIREMENT

All equipment shall not exceed a sound level of 85 DBA at 1-meter horizontal distance from the equipment, 1.5 meters above the floor or any personnel platform.

22.7 INSULATORS AND INSULATOR COMPARTMENT

In the precipitator, each individual discharge electrode system shall be supported from the required number of high-tension insulators. These insulators shall be properly housed in insulator compartments so that they remain dry and clean.

The high voltage conductors shall be enclosed in weatherproof ducts. The insulator compartments shall be equipped with electrical heating by thermostatically controlled heating elements in order to keep the temperature above the dew point of flue gases.

22.8 COLLECTING ELECTRODE

The collecting electrodes shall be designed to maintain good dimensional stability and the collecting efficiency at desired level. Adequate collecting area should be provided to achieve the specified outlet emission under the specified conditions of operation. The collecting plate material shall have good forming properties. The profile of the collecting plates shall be such as to limit the re entrainment of the collected dust at the time of rapping. Each plate shall be shaped by roll using deep-drawing quality steel sheets and shall be stiff enough to withstand the rapping impact. The collecting plates shall permit maximum corona power to be applied for operation at peak efficiency under all conditions. The electrode spacing shall be 400 mm. Collection electrode plate thickness shall be not less than 18 gauge.

22.9 COLLECTING ELECTRODE RAPPERS

The rapping mechanism for collecting electrodes shall ensure proper uniform rapping of each plate at regular intervals. The direction of plate rapping shall be so selected as to achieve greatest effectiveness of fly ash shedding. Clearance between electrodes shall not be disturbed by rapping.

Care shall be taken in the design and construction of the plate rapping mechanism to limit re entrainment of collected dust into the gas stream during rapping operation. The system shall be designed for continuous sequential rapping to eliminate puffing at the stack. Frequency of rapping shall be kept to a minimum in order to limit dust re entrainment. The rapping mechanism shall be of such design as to offer flexibility of control within wide limits.

Separate rapping equipment shall be provided for each field so that frequency of rapping can be adjusted suitably in that area in accordance with the dust buildup, inlet loading, and changing gas volumes. Remote manual operation of rapping shall also be provided. The rapping force shall be adjustable at site during commissioning and maintenance.

All internal parts of rapping mechanism shall be accessible for inspection and they shall be placed on wide access passages. Necessary lubrication system shall be provided for the rapping mechanism.

22.10 DISCHARGE ELECTRODES

The high-tension discharge electrodes shall be made of durable and corrosion & erosion resistant material such as Stainless steel. They shall be accurately centered between successive collecting electrodes. The supporting framework shall be robust and maintain the alignments perfectly within the allowable limits even after long periods of continuous operation. This type of cross section shall also ensure an even distribution of corona discharge over the entire length of the discharge electrodes.

22.11 DISCHARGE ELECTRODES RAPPERS

Suitable rapping devices complete with drive units shall be furnished for rapping of the discharge electrodes at regular intervals. The rapping mechanism shall be of proven design. The rapper shaft shall be properly insulated and the insulators shall be provided with electric heating to prevent condensation and flashovers. All parts requiring frequent attention shall be easily accessible for inspection when the Unit is in operation.

22.12 DISCHARGE ELECTRODES FRAMEWORK

The discharge electrode framework shall be designed to obtain a stable configuration. The entire framework shall be thoroughly braced to form a rigid structure. All sharp edges and the ends of the frame parts shall be rounded to avoid excessive flashovers. The discharge system assembly shall ensure highly accurate spacing. Anti sway devices shall be provided to prevent shifting and swinging of the frames. Framework shall be so designed that the clearance between electrodes is not disturbed during rapping.

22.13 DUST HOPPERS

The storage capacity of the hopper shall be based on worst coal. The capacity shall be adequate to hold the maximum ash collection for a minimum period of 8 hours. The ash carryover to ESP shall be taken the total ash produced while burning worst coal at 100 percent BMCR. The design shall take into consideration the possible variation in the ash collection at different points and each hopper shall be designed for maximum possible loading. The ash density shall be taken to 750 kg/m3 for calculating storage capacity. A margin of at least 10 percent shall be provided in the hopper capacity over calculated values. For structural design, however, the ash density shall be considered as 1350 kg/m^3.

Hoppers shall be of welded construction using steel plates, suitably stiffened and not less than 6 mm thick. The hoppers shall be of inverted pyramidal type with flanged outlet connection of adequate size. The outlet flanges shall be of standard dimensions and shall be located at a sufficient height above the ground floor level for attaching to the fly ash removal system. The ash handling system valves and piping shall be supported from the hopper flange and hopper wall through suitable hanger connection. Attention shall be given to the design and construction of the hopper to ensure free discharge of ash under all conditions. Side angle between hopper sides and horizontal shall be greater than 60^o. The internal surface of the hopper shall have a smooth finish. Lower 1/3 rd of the hopper inside wall shall be lined with SS plate. The hopper shall be electrically heated to prevent bridge formation inside the hoppers. The thermostatically controlled heating elements shall be designed adequately to maintain ash temperature near hopper outlet above dew point between 120^oC to 150^oC.

The ESP shall be complete with panels, switches, fuses, etc., required for the heating elements complete with all cabling, cable trays, etc., between the panel and the heating elements. External surface of hoppers shall be properly insulated. The Contractor shall provide necessary fluidizers connection in hopper. The fluidizing blowers and pipe work shall be provided by others. All hoppers shall be fitted with gas baffles for preventing entry of gas into hoppers and consequent ash re pick up. Each hopper shall be provided with two 100 mm diameter poke holes with screwed caps. The poke holes shall be so oriented that the probes would not ram into sources of high voltage. The height of the hopper outlet above the floor shall be suited to the requirements of ash handling system, as specified elsewhere. Water ingress in the rainy season shall be guarded properly.

22.14 CASING

Each of the ESP sections shall be housed in its own separate casing. The casing heights and lengths etc., necessary to obtain the required minimum collection area shall be such that the overall size and layout of ESP fit into the space limitations as brought out in the relevant tenders drawing.

The ESP elements shall be enclosed in gas tight weather proof all welded reinforced steel plates. Sway bracing stiffeners and other local members shall be incorporated directly into the shell construction. The ESP casing shall be fabricated from all welded reinforced 6 mm thickness carbon steel plates conforming to ASTM A36. The Exposed surfaces shall be self-draining and seal welded to prevent ingress of moisture during monsoon.

The ESP casing and its elements shall be designed to withstand a pressure +/- 500mmwc and a temp of 200 deg C. In case of any unscheduled outage of the air heater the temp of flue gas at inlet to ESP may rise to about 350 °C. This temp excursion may persist for about five minutes until preventive measure are taken. The ESP and its element shall be designed to withstand this temp excursion without damages. Adequate provision shall be made to accommodate thermal expansion and movements as required by the arrangement and operating conditions

The casing shall be gas tight. In order to prevent distortions the structural design shall take care of the unequal expansions, care shall be exercised in the design and fabrication of the precipitators to reduce air in leakage to minimum. All joint which do not require opening during maintenance and or inspection shall be seal welded.

The ESP casing and hoppers shall form a common structure suitably reinforced to with stand the wind load, earthquake load and load due to dust storage in the hoppers etc.,

The inlet/outlet of the precipitator shall be provided with suitable flanged connection with the flue gas ducting which shall be completely seal welded on the inside and outside after assembly.

Access doors of quick opening type shall be provided to allow entry to all sections of the ESP for maintenance and access The size of these shall not be less than 600 mm dia, if circular or not less than 450 mm x 600 mm if rectangular. They shall be provided with safety chain and grounding strap. Doors shall be capable of being padlocked. Design shall be such as to eliminate air in leakage through the doors. All doors providing access to high voltage parts shall have warning signs permanently attached and marked “Danger High Voltage”.

The ESP shall be guided anchored or supported by lubricated plates/rollers bearings at such locations as may be required to limit ESP/ ductwork expansion joint forces or movements. Each casing shall be restrained to grow in a radial direction from the anchor point. In case lubricated plates are used these shall be covered under all conditions of precipitator movement by 304 SS plate.

22.15 PLATFORM WALKWAYS AND STAIRS

The equipment shall include the required platforms, walkways, and stairs to provide access for proper operation and maintenance of all parts of the precipitator. Clear headroom of at least 2.2 meters shall be maintained over platforms and walkways. The access to the precipitator top shall be by means of stairways and not by rung ladder. The staircase and walkways shall be at least 1200 mm wide. Stair risers shall not exceed 200 mm and treads shall not be less than 250 mm.

Suitable platforms and access stairs shall be provided for access to all the manholes provided at each ash hopper.

22.16 SUPPORTING STEEL WORKS

All structural steel works required for the precipitator shall be provided. These steel works shall include column, base plates, anchors, anchor bolts, sleeves, inserts, beams, girders, and other steel necessary for installation and foundation of equipment. The steel structure shall be designed taking into account the weight of fly ash in the hoppers load due to dust in pipes, live and dead loads, wind load, and seismic load.

22.17 STABILITY OF STRUCTURE

The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operation. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area. For the purpose of guying the Contractor shall not use other structures in the vicinity, which are likely to be damaged by the guy. Such temporary bracings used shall be removed by him at the end of the job from the site of work.

22.18 FLOOR GRATING

Floor grating for floors, platforms, stair landing and other locations shall be electro forge welded, rectangular type having 5 mm bearing bars spaced on 30 mm centers, 32 mm deep cross bars shall be spaced 100 mm on centers and be welded into the bearing bars to provide a non-slip surface. The grating shall be of steel. All grating shall be hot dipped galvanized conforming to the relevant standards.

Floor grating shall be neatly cut and bent around all openings. Unless otherwise indicated, bending shall form a 100 mm high curb. Grating at head of stair runs shall have an applied cast iron abrasive surfaced nosing similar to that specified for stair treads.

Grating panel shall be removable and shall have the bars of adjacent panels aligned.

Grating will be anchored to supports with bent clip fasteners secured to threaded studs, field welded to the supporting members. Two clips at each end of each panel and one clip (staggered) at each intermediate support shall be provided.

Penetrations through gratings and floor plates that are not shop fabricated (generally openings under 500 mm in nominal size pipes and for conduits etc.,) are to cut in the field as required. Such openings shall be neatly trimmed concentric with the penetration or as required to provide for movements. Generally 50 mm clearance shall be left over insulation and 25mm clearance at bare metal. Openings may be ganged where accepted by the engineer.

Opening under 150 mm in maximum dimensions may be squared off. Larger openings shall be suitably shaped. All gratings openings shall be kick plated or banded to match the shop-fabricated work. Any openings requiring special treatment or additional support framing for a proper finished installation, suitable methods or modifications shall be considered.

All gratings for a given area shall be positioned and aligned before the stud bolts are located and welded to the supporting members.

22.19 STAIR TREAD AND NOSING

Solid stair treads and risers for the two main access stairs within the enclosed portion of the building shall be minimum 1200 mm wide raised pattern chequered plate, 6 mm thickness. The tread and riser shall be formed in one piece and supported on and bolted with countersunk bolts to angle brackets welded to stringers. Solid stair treads shall be shop painted. The continuation of these stairs above the enclosed area shall have grating treads and shall be 750 mm minimum.

Grating stair treads shall be welded rectangular type having 5 mm plain bearing bars, 25 mm deep for treads up to 825 mm in length and 32 mm deep for treads between 825 mm and 975 mm in length. Treads shall have two 11.5 mm holes at each end for securing treads to stair stringer with 10 mm machine bolts and nuts. All grating stair treads shall be hot dipped galvanized after fabrication conforming to relevant standards.

Each grating tread shall be provided with an applied cast iron nosing, which is a minimum of 32 mm wide and surfaced with abrasive granules.

22.20 FLOOR PLATE

Chequered steel floor shall be raised pattern rolled steel floor plate, to thickness as required by design, each cut from a single piece without welded seams. Chequered plate, curb plates and angles shall be neatly finished without gauges and shall be ground smooth. Plates not welded to supporting steel shall have 36 mm dia holes symmetrically located to permit lifting.

Chequered plates shall be shop painted as per relevant specifications.

22.21 THERMAL INSULATION AND CLADDING

The Contractor shall provide Insulation and Cladding as per specification.

22.22 TRANSFORMER RECTIFIER UNIT

The high voltage DC supply to the ESP shall be from an adequate number of transformer-rectifier (TR) units. The transformer-rectifier shall be suitably mounted on the top of the precipitator. Each leg of the transformer-rectifier shall not be connected to more than one bus section. The transformer-rectifier units shall be provided with protection against surge, excess temperature rise, and under voltage. The transformer-rectifier units shall be suitable for operation at 50^{o}C ambient temperature (design) having mineral oil-filled type class ONAN cooling. The transformer and its associated equipment shall conform to the approved international standards (such as ANSI, IEEE, NEMA, BS, DIN, JIS, etc.). Each section field shall be provided with one TR set.

The rectifiers shall be silicon diode type having proven service over at least 5 years and shall conform to relevant approved international standards. The rectifier units shall be suitably arranged to give satisfactory operation at all loads with arrangement to take any one unit off the system without affecting operation of the precipitator.

Each TR set shall be placed on a metal tray to collect leakage/spillage oil. All such trays shall be connected to common drainpipe, which shall be extended up to ground level with necessary valves.

The TR set shall be of reputed make, having adequate proven experience of use.

The high voltage rectifier set shall preferably be located in a separate chamber, other than the transformer tank, in order to facilitate replacement/maintenance of the diodes.

Over current protection shall be provided in case of failure of diodes.

22.23 CONTROL PANELS

The system shall be intermittent pulse control and microprocessor based.

ESP MCC Auxiliary control panels and rectifier control cubicles shall all be housed in a separate control room adjacent to the precipitators. The Contractor to indicate the size of control room required in his proposal. In addition, one electrical control panel for control, indication, metering, annunciation of incomers, and bus couplers transformer trouble shall be provided for each Unit. On electrical control panel, audiovisual annunciation shall be provided for circuit breaker trip/trip circuit unhealthy, incomer under voltage, various transformer trouble (both alarm and trip stage).

Auxiliary Control Panel
Auxiliary control panel shall regulate the operation of rapping motors and heating elements pertaining to one pass of the system. Separate control panel shall be provided for each horizontal pass of the precipitator. Each auxiliary control panel shall consist of necessary relays, master controllers, timers, switches, indicating lamps, etc., necessary for the efficient operation and control of individual/group rapping mechanism and heating elements. Master controller and timer shall be designed to control the sequence and frequency of the operation of rapping mechanism of the collecting and discharge system of the different fields of the precipitators. Signal lamps shall indicate overload tripping of the rapping motors.

Rectifier Control Cubicle
The control cubicles for the transformer-rectifier unit shall incorporate protections for abnormal conditions. It shall include devices like arc suppression unit, under voltage protection, protection for excessive temperature rise, and internal short-circuit of the transformer winding. The panel shall be complete in all respects with DC and AC ammeters, voltmeters, circuit breaking devices, pulse rate controller, bus bar, control/switches, indicators, visual and audio alarm overload and earth fault protection, current limiting relays, polarity switch (if applicable), and all necessary relays. The panel shall also provide all necessary interlocks, automatic regulator, and other protective devices for safe and efficient

operation of the precipitator and safety for operating personnel. DC voltage and current measurement shall be directly from the DC side.

22.24 ESP MANAGEMENT SYSTEM AND RAPPER CONTROL PANEL

Each stream of ESP shall be provided with an integrated microprocessor based ESP management system. The EPMS and rapper controller of each stream of ESP shall be housed in a single or two separate control panels.

22.25 AIR CONDITIONING FOR THE CONTROL PANELS

All the control panels shall be housed in a separate control room adjacent to the precipitator. Air conditioning shall be provided for all the control panels Heat loads of each of the panels for designing air-conditioning equipments shall be brought out in the offer.

22.26 CONTROLS AND INSTRUMENTATION

The control and instrumentation shall be designed for automatic as well as local/remote operation. Each set of ESP shall be provided with complete control system consisting of T/R set controllers, rapper controllers, hopper heat controllers, insulator heaters and pressurization system controllers, ESP management system and all other controls required for safe, efficient and reliable operation of ESP.

22.27 ANNUNCIATION PROVISION

Annunciation in the unit control room shall include the following.

a) ESP rectifier faulty.
b) Electric supply to ESP fails.
c) Rapping mechanism trip.
d) Outlet dust emission level high.
e) Under voltage.

22.28 415-VOLT POWER WITH MOTOR CONTROL CENTER

415-volt power with motor control center with two incomers and one bus coupler (all electrically operated ACB controlled), required number of active and spare outgoing feeders for control of various ESP drives and loads shall be provided.

22.29 CABLES

All power and control cables including special cables as required for inter-connection of transformers, switchboards, MCC control cubicles, auxiliary control panel, rectifier units, heaters, rapping mechanism motors, remote signaling devices, etc., of EP system and air conditioning, ventilation, and lighting equipments shall also be supplied and installed. Lifting and handling arrangements for transformers, switchboard, all other boards, panels/equipment, transformer rectifiers, and drawing oil from the oil pan of the rectifier shall also be covered.

22.30 EARTHING AND SHIELDING

All electrical equipment shall be properly protected and two terminals shall be provided for earthing of each equipment. Earthing of electrical equipment shall be done as detailed elsewhere.

22.31 CABLING

Supply and installation of cable trays and laying, termination and connection of all power and control cable is to be included. Cabling shall be complete with cable numbering tags, core ferrules, cable glands, supports, and accessories. Connection between the transformer rectifier units and the discharge system shall be provided by bus bar in ducting.

22.32 SAFETY INTERLOCKS

Safety sequential interlocks with mechanical key exchange boxes shall be provided to prevent access to interior of precipitator or hoppers unless all transformer-rectifier sets are de-energized and grounded.

This should be achieved by key interlock between the rectifier feeder circuit breakers and the door lock of the precipitator hoppers and roof doors.

22.33 MONORAIL AND HOIST

Suitable monorail with electrical hoist of adequate capacity for handling TR set and/or 250 l/h oil filter machine from ground level to ESP top shall be provided by the Contractor.

22.34 SPECIFIC DESIGN CRITERIA

The dust concentration at the outlet of the electrostatic precipitator shall be as specified here in below. The collection efficiency of the electrostatic precipitator offered shall be designed for the dust concentration and flue gas flow indicated, under different operating conditions. The Contractor shall submit correction curves for changes in efficiency (plus or minus) with changes in flue gas volume (80 percent to 110 percent of the maximum flue gas flow at the outlet of air heater), dust concentration (80 percent to 110 percent of the maximum dust concentration at outlet of air heater) and any other parameter considered relevant by the Contractor. These figures shall be binding during analysis of the performance test data and final assessment.

SL NO	Description	Specific design criteria	Remarks
1	No of ESPs	One	
2	No of independent casing	Two	
3	No of parallel gas flow paths	Four	
4	Capacity of each gas path	30% BMCR Gas flow	
5	No of fields in service		As required to meet outlet emission described below
6	Electrode spacing	400 mm	Ash Resistivity is 10^11 ohm.cm
7	Specific collecting area		As required to meet outlet emission described below
8	Velocity of flue gas through ESP	As per manufacturing standard	0.8 m/s
9	Design pressure	Minimum +/- 500 mmWC	
10	Type of control	Microprocessor/EPIC based Intermittent charging / semi pulse and rapper /heater control	
11	Height of ash hopper outlet flange	Minimum 3.5 m	
12	Ash density for volume computation of ash hopper	750kg/cum	
13	Ash density for structural design (strength computation)	1350 kg/cum	
14	Ash properties	As given under coal / ash analysis	
15	ASH Hopper storage capacity	8 hours, Pyramidal, inverted with angle >60 deg.	
17	Air in leakage	Shall not exceed 0.5 % of the inlet gas flow measured at BMCR, Design/ Worst coal operation	
18	Flue gas properties (AH outlet)	Oxygen = vol % CO2 = vol % SO2= vol % H20 = vol % Specific weight =	
19	Gas draft at ESP inlet		

Performance of ESP shall be such that the outlet dust emission shall be as per requirement specified in Chapter 1 of Section 5 at BMCR design / Worst Coal.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 23 – FLUE GAS DESULFURIZATION

CONTENTS

23 FLUE GAS DESULFURIZATION

The flue gas desulfurization system (FGD) shall comply with the requirements of relevant national laws and regulations in effect, the fire control and health protection requirements, and the requirements of the production flow.

The layout of the FGD system shall be such that the relevant devices are arranged closely, ensuring the pipeline runs smoothly and is short and convenient. In this project, each flue gas desulfurizing unit is provided with one absorber. Two absorbers are respectively arranged at both sides of boiler stack, and such equipment of the absorber system as slurry circulating pump, oxidation fan, sump and gypsum discharging pump are arranged near the column. Each boiler is provided with one slurry circulating pump and one oxidation fan room and with such equipment as slurry circulating pump and oxidation fan.

Gypsum dehydration workshop and desulfurizing waste water treatment station are arranged between the slurry pump and oxidation fan room behind the flue, thus shortening the transportation distance of materials, saving the land and also facilitating inspection and gypsum transportation.

In order to sufficiently use the site, the accident slurry tank is arranged on the vacant land near the desulfurizing facility.

23.1 DESULFURIZING SYSTEM AND EQUIPMENT

The FGD system shall utilize the wet limestone-gypsum flue gas desulfurization technology. The availability rate of desulfurizing unit shall be ≥ 98%, and the desulfurization efficiency shall be ≥ 90%. Desulfurizing unit can adapt to any load between boiler minimum stable load without auxiliary fuel support conditions and BMCR conditions, is provided with a flue gas bypass and a desulfurizing blowdown fan of which the pressure head overcomes the resistance of the desulfurizing system. Under the design conditions, the net flue gas temperature at the stack inlet is about 50°C.

Use domestic equipment if possible and reduce the import of key equipment and materials so as to decrease the project investment cost. Two flue gas SO_2 absorbers, one for each boiler shall be provided, with a set of absorbent preparation systems, gypsum dehydration system, water supply system for desulfurizing unit, slurry drain-off system and recovery system and compressed air system commonly used by two boilers.

The FGD system diagram is shown in the drawing no. 10-PM-PAY-07.

23.1.1 ABSORBENT PREPARATION SYSTEM

Finished limestone blocks supplied to the power plant are to be transported to the plant for storage by truck. There shall be a limestone storage yard in the plant, and the storage yard should be able to store such a volume of limestone for no less than 40 days of two boilers burning design coal under BMCR conditions. Limestone in the limestone storage yard should be transported by limestone truck to the discharge workshop in the desulfurizing and slurry preparation area, and limestone blocks are discharged by the vehicle-mounted discharge system via discharge bucket, oscillating feeder, de-ironing separator and bucket elevator into the limestone block warehouse. This project should have 1 limestone block warehouse which is able to store such a volume of limestone for no less than 3 days of two boilers burning design coal under BMCR conditions.

Limestone blocks in the block warehouse are conveyed to a wet grinder via belt weighing feeder and ground into limestone slurry, which, after being mixed with water to a weight concentration of about 30%, is sent to the absorber by a limestone slurry feed pump. The volume of limestone slurry into the absorber is controlled according to the SO_2 concentration at the inlet and outlet of desulfurizing unit and the pH value of the slurry in the absorber.

Two boilers should share 1 limestone slurry tank, with its effective volume to be designed as per the volume of limestone slurry generated when two boilers have burnt design coal for 8 hours under BMCR conditions. There should be 3 limestone slurry feed pumps for the absorber, with 2 running and 1 standing by.

23.1.2 SO_2 ABSORPTION SYSTEM

Flue gas having passed through the dust remover of each boiler flows into the absorber for washing via a flue formed by the combination of outlets of two draught fans, and flue gas washed is discharged through the stack after fog reduction by the demister. The flue gas temperature in front of the inlet of stack is about 50°C.

The boiler desulfurizing system of this project is provided with a bypass flue. When the equipment of the desulfurizing system needs to be inspected or temporarily stopped, the flue gas bypass flue can be opened to guarantee the normal operation of the unit. A desulfurizing blowdown fan is arranged to overcome the flue gas resistance of the desulfurizing system. Each boiler should be provided with 1 absorber which is designed as a countercurrent spray column. Flue gas flows into the absorber via a side inlet, and has a countercurrent washing contact with atomized limestone slurry and triggers chemical reaction in the ascending area in the column. After countercurrent washing, flue gas is discharged into the stack via the net flue gas flue with water removed by the demister located at the top of the absorber.

The absorber adopts the structure of spraying empty column. It is provided with 3 spraying layers, and each layer is provided with one slurry circulating pump. Each absorber is provided with 3 (with no standby) slurry circulating pumps of different flow and different lift.

SO_2 in flue gas chemically reacts with $CaCO_3$ (calcium carbonate) in limestone slurry in the washing area at the upper part of the absorber and thus generates $CaSO_3$ (calcium sulfite). Flue gas contacts countercurrent with slurry from the bottom of the absorber. Because of the fully gas-liquid contact, mass transfer process occurs at the gas liquid

Flue gas contacts countercurrent with slurry from the bottom of the absorber. Because of the fully gas-liquid contact, mass transfer process occurs at the gas liquid interface, and SO_2 and SO_3 in the flue gas turn to corresponding acid compounds.

By keeping the solid contents of the slurry at a certain range, the gypsum crystallization process can be optimized, by the growth of new gypsum crystals in the existing gypsum crystal nuclei. The gypsum as final product can be discharged from the system. The clean flue gas after the absorbent washing desulfurization, is discharged to the chimney after droplet removal by the demister. The oxidation air system is set to fully and quickly oxidize and absorb the calcium sulfite in the slurry pool of the absorber.

The absorber shall be a steel structure with the glass flake for anti-corrosion, and factory processing and on-site assembly. The absorber diameter is 17 meters, height about 43.5 meters, and slurry pool capacity for 2600 m^3. Spray air tower shall be adopted for the absorber, without packing device.

The absorber shall adopt 2 level roof type demisters, to ensure the removal of 99% of the more than 20 micron droplet in the flue gas. Under the design condition, the flue gas droplet density in the outlet of the demister is 50 mg/Nm^3 and flushing water system is set for the demister.

In order to prevent solid particles of the slurry settling in the absorber reaction tank and provide a good mixing effect at the same time, liquid reaction pool in the operation should be fully stirred. And the stirring of the reaction pool is done through the agitators arranged along the absorber wall.

At the entrance of raw gas at the absorber, the slurry washing device and the rain cover device are set to prevent slurry deposits. The overflow pipe of the absorber slurry pool is set to prevent the absorber slurry pool level from exceeding a maximum height. The top overflow pipe adopts direct flow and seal water tank is added at the bottom.

Each absorber should be provided with 2 oxidation fans (1 running and 1 standby), which are used to blow air into the reaction tank at the bottom of the absorber to react with $CaSO_3$ (calcium sulfite) in the slurry and to finally generate $CaSO_4 \cdot H_2O$ (dehydrate gypsum).

Each absorber shall be provided with 4 slurry agitators, which are used to mix the slurry in the reaction tank so as to prevent gypsum in the reaction tank from depositing and hardening.

Each absorber should be provided with 2 (1 running and 1 standby) gypsum slurry discharging pumps to continuously convey gypsum slurry from the absorber to the gypsum dehydration system. The weight concentration of the gypsum slurry discharged is about 15%.

23.1.3 SLURRY DISCHARGE AND RECOVERY SYSTEM

Two boilers share one accident slurry tank and one slurry return pump. The accident slurry tank is designed to have an effective volume able to store slurry when one absorber is at the normal liquid level. Before the absorber is restarted, slurry in the accident slurry tank is returned to the absorber via the accident slurry return pump.

The slurry tank, slurry pipe and slurry pump of the desulfurizing unit should be flushed when the unit stops running, with flush water collected into the sump in each area and then conveyed to the accident slurry tank or the absorber via a pump. Two sumps are temporarily arranged in the absorber/dehydration area and the slurry preparation area.

23.1.4 GYPSUM DEHYDRATION SYSTEM

Each absorber is provided with one gypsum slurry hydrocyclone. Gypsum slurry (with a weight concentration of about 15%) discharged from the absorber flows into a vacuum belt dehydrator for dehydration after being concentrated into a weight concentration of 40%-50% at the hydrocyclone. Dehydrated gypsum has surface water content of about 10%-15% and is discharged into the gypsum storage room pending transportation.

Two boilers share two vacuum belt dehydrators, and each vacuum belt dehydrator is provided with 1 water-ring vacuum pump. The output of each vacuum belt dehydrator is designed as per 75% of desulfurized gypsum produced when 2 boilers burn design coal under BMCR conditions.

Effluent liquid separated by the gypsum slurry hydrocyclone flows into the gypsum slurry reflux tank. A portion of effluent liquid is sent by a reflux pump back to the absorber for recycling, and another portion of effluent liquid is sent by the feed pump of the waste water hydrocyclone to the waste water hydrocyclone for further concentration, with its bottom flow returning to the gypsum slurry reflux tank. The effluent liquid is discharged into the waste water tank and sent by the waste water pump to the desulfurizing waste water treatment station for treatment.

Two boilers share one gypsum storage room, with the storage capacity designed according to 24 hour gypsum output when two boilers burn design coal under BMCR conditions; when gypsum cannot be temporarily utilized in a comprehensive manner, it is transported by truck to an ash disposal area and stored separately with clinker.

23.2 ELECTRICAL SYSTEM OF THE FLUE GAS DESULFURIZATION SYSTEM

23.2.1 PRIMARY ELECTRICAL SYSTEM

The desulfurization 6kV load of this project is to be from 6.6kV section of unit plant, desulfurization MCC is to be arranged for the desulfurization 415V load of each unit, and the power supply is from the boiler PC section of such unit. The desulfurization accident security load is to be from the boiler accident security MCC section of the unit plant.

23.2.2 SECONDARY ELECTRICAL SYSTEM

23.2.2.1 UNINTERRUPTED POWER SUPPLY SYSTEM

Desulfurization island is provided with an AC uninterrupted power supply system (UPS). UPS shall continuously supply its loads when power failure occurs to the whole plant and shall run for not less than 30 minutes under rated voltage. The loading rate of UPS shall not be more than 60% when it runs normally. The loading rate of UPS standby feeder circuit shall not be less than 20%.

23.2.2.2 DC SYSTEM

The desulfurization island shall be provided with two DC 110V systems, which supply DC load to such equipment requiring DC power supply as electric control, signal, relay protection and breaker.

23.2.2.3 CONTROL AND PROTECTION

The electrical system of the desulfurization island is brought under DCS control of desulfurization island and is provided with no conventional control panel.

23.2.2.4 AUTOMATIC DEVICE AND SYNCHRONIZATION

The electrical system of desulfurization is provided with no synchronizing device, and the break-before-make operation mode is applied to the switch of all power supply inlet wires so as to prevent different power supply from running in parallel. Locked wiring is applied to electrical wiring.

23.2.2.5 RELAY PROTECTION

The low-voltage transformer and 6kV high-voltage motor of desulfurization use a microcomputer integrated protection device, which is installed in the 6kV switchboard instrument room. The 380V incoming supply, sections and feeder lines of frame breaker are protected by intelligent protectors of the breaker, and other 380V feeder lines are protected by breaker with plastic case and thermal relay.

23.3 THERMAL AUTOMATION OF THE FLUE GAS DESULFURIZATION SYSTEM

The scope of design of the thermal automation part of the desulfurization system of this project covers: the instrument control system design of the FGD system of boilers #1 and #2 and the FGD common systems.

The control of flue gas system and absorption and oxidation system of the desulfurizing system is included in the DCS system of unit plant. Such common systems of the desulfurization system as absorbent preparation system, gypsum treatment system and waste water treatment system are connected to the common DCS network. The control cabinet and the operator station of the desulfurization control system are arranged in the desulfurization complex.

This project uses wet limestone-gypsum flue gas desulfurization system, which is provided with a flue gas bypass. The centralized control mode of unit control room is to apply to the desulfurization system, the control of absorption and oxidation systems of the flue gas system are respectively included in unit plant DCS, and the electric control building of desulfurization is provided with an on-site control room and an operator station. The control of such common systems of desulfurization as absorbent preparation system, gypsum treatment system and waste water treatment system are included in the common DCS control.

An on-site desulfurization control room and an electronic equipment room are arranged in the electric control building on the desulfurization site and are provided with operator stations/engineer stations, electronic cabinets, etc. The operator is able to control the start-stop operations, monitor the entire desulfurization system including its accessory equipment and handle accidents through the operator workstation in the on-site desulfurization control room. The desulfurization system can also be monitored in the DCS operator station of the centralized control room.

23.4 SUPPLY OF WATER AND GAS FOR THE FLUE GAS DESULFURIZATION SYSTEM

Water for the desulfurization unit mainly includes water for cooling and sealing mechanical equipment and process water. Water for cooling and sealing is supplied by the industrial water system of the power plant to the desulfurization area, and water from cooling and sealing is recovered and used as makeup water for process water of the desulfurization system.

Desulfurization process water uses reused water of the power plant and is supplied by process water pump to each water consuming point of the desulfurization system, mainly including:

- Absorber evaporation water, water for limestone slurry preparation and water for the gypsum dehydration system; and
- Flush water of the demister and all slurry conveying equipment, conveying pipelines and storage tanks.

A separate flush water pump shall be provided for the demister of the absorber so as to provide flush water for the demister and make up the absorber evaporation water when the absorber is running.

Compressed air shall be supplied by the compressed air system of the plant, and one gas storage tank shall be provided for the desulfurizing unit.

23.5 WASTE WATER TREATMENT

The desulfurizing unit needs to discharge a certain amount of waste water to the desulfurization waste water treatment system to separate heavy metal and other precipitable substances by such means as neutralization, flocculation, precipitation and filtration. Waste water shall be comprehensively utilized and the discharged waste water shall be treated to the water quality levels set out in the Bangladesh national standard for comprehensive discharge of waste water. Please refer to Section 5, Chapter 25 for the waste water treatment system details.

23.6 FLUE GAS DENITRATION

The supercritical boiler of unit of this project is assumed to achieve emission levels of NOx in compliance with relevant environmental protection standards. However, foreseeing stricter standards being put in place in the near future, a space near the boilers #1 and #2 shall be reserved for the installation of a flue gas denitration system. Additionally, the boiler bodies shall have the provisions for installing the said denitration system.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 24 – BOILER FEEDWATER TREATMENT

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24 BOILER FEEDWATER TREATMENT

The boiler make-up water treatment system for this phase is designed according to the demand of make-up water of 2 x 660MW coal-fired power units, with the expansion space for future similar units. Refer drawing nos. 10-PM-PAYRA-12, 10-PM-PAYRA-13 and 10-PM-PAYRA-10 in Section 5 Attachment B4.

The fresh water source for boiler make-up water treatment system is the river water from Andharmanik River. The Contractor is required to investigate water quality report in all seasons so as to check the accuracy of the system as necessary and ensure the reliability of system selection.

24.1 DEMINERALIZED WATER TREATMENT

According to the water quality characteristics of the water source to be use for the Plant and the requirements for water quality of ultra-supercritical power unit, the boiler make-up water treatment system of this project shall use membrane technology as describe below subject to Contractor's design optimization. The design flow through output capacity shall be 2 x 100% streams.

Clear water from clean water station → ultrafiltration security filter → ultrafiltration membrane component → ultrafiltration water tank → one-stage reverse osmosis high pressure pump → reverse osmosis security filter → one-stage reverse osmosis membrane component → two-stage reverse osmosis high pressure pump → two-stage reverse osmosis membrane component → freshwater tank → EDI booster pump → EDI security filter → EDI device → demineralized water tank → demineralized water pump → main building.

The above membrane technology will improve the water quality stability and the water quality will not fluctuate for the change in raw water quality. Consumption of chemicals and waste water discharge shall be reduced. In addition, the membrane technology requires smaller area and also improves system reliability with full automation controlled by DCS.

24.1.1 DEMINERALIZED WATER QUALITY

The Boiler make-up water treatment system shall produce the following minimum requirements for the power unit:

Conductivity (at 25ºC) ≤ 0.15 µS/cm
Silica (SiO_2) ≤ 10 µg/L

24.1.2 CONTROL

The boiler make-up water treatment system adopts auto-control for its operation, backwash and wash, which could ensure the stability and reliability of the system, relieve the labor intensity and decrease the number of operators.

24.1.3 LAYOUT OF BOILER FEEDWATER TREATMENT PLANT AND INDUSTRIAL WASTERWATER TREATMENRT STATION

The boiler feedwater treatment plant shall be arranged with the industrial wastewater centralized treatment station and the laboratory, where the boiler feedwater treatment plant is arranged on the ground floor with ultrafiltration device, reverse osmosis unit, electric desalting and chemical cleaning devices in it; the chemical laboratory is arranged in two floors, operational control room, distribution room, dumping room, operation analysis room, coal sample making room and material depot on the ground floor and oil, water and coal test room on the second floor.

The ultrafiltration water tank, freshwater tank, demeneralized water tank, waste water storage pool and the other wastewater facilities shall be arranged outdoors.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 25 – WASTEWATER TREATMENT AND DISPOSAL

CONTENTS

25 WASTEWATER TREATMENT AND DISPOSAL

25.1 INDUSTRIAL WASTEWATER CENTRALIZED TREATMENT SYSTEM

25.1.1 SYSTEM OVERVIEW

Outside the boiler make-up water treatment plant, there shall be wastewater storage pools for storage of the non-recurrent wastewater from the main building and the drainage from the boiler make-up water treatment system. In regular service, one of them is also used for collecting the ultrafiltration backwash drainage, which has higher suspended solids content and could be transmitted to clean water station or wastewater centralized treatment facility for treatment; one is also used for collecting the concentrated drainage from one-stage reverse osmosis, which almost contains no suspended solids but is high in salinity, and could directly be transmitted to the water reuse system for reusing.

There shall be a drainage pit for collecting and transporting the drainage from the main building, e.g. condensate polishing regeneration drainage, boiler acid cleaning drainage and wash water. The wastewater treatment is completed by the wastewater centralized treatment facility.

Main process of industrial wastewater treatment system shall be as follow subject to Contractor's design optimization: wastewater storage pools→ mixed tank→ clarifier→concentration basin→monitoring pond→ reuse pond→recycle water system.

The sludge water from concentration basin and clean water station is sent to clarifier for concentrating, while that of concentration basin is transmitted to the wastewater centralized treatment system for dewatering treatment, the dehydrated mud is transported to a certain place by truck.

25.1.2 CAPACITY OF INDUSTRIAL WASTEWATER TREATMENT SYSTEM

Capacity of industrial waste water treatment system is the sum of usual waste water discharge of all the units and the biggest unusual waste water discharge treated in a certain time. The whole capacity of waste water storage pits shall be proposed according to total discharge of both usual waste water and the biggest unusual waste water.

25.2 COAL WASTEWATER TREATMENT SYSTEM

The Coal wastewater treatment system is used to treat the drainage of the coal system, especially the wastewater from coal yard, coal trestle and coal unloading wharf. According to the coal contained wastewater quality and water quantity, it is planned to equip three coal water processors, two for operation and one for standby or all the three for operation. In the long term planning capacity, a set of coal water treatment equipment will be increased with the same capacity.

The Coal wastewater disposal facility is planned to be arranged near the sludge settling basin, the effluent water from which is delivered to the coal water processor for treatment. The clear water after treatment is delivered to the reusing water pool for reusing. The coal waste water treatment is planned to adopt the treatment system with electric flocculation unit.

25.3 DESULFURATION WASTEWATER TREATMENT SYSTEM

Considering that the drainage and wash water from the treatment equipments of the desulfuration wastewater treatment system should be returned to the desulfuration wastewater treatment system for treatment.

The desulfuration wastewater disposal facility is planned to be arranged in the desulfuration building with the desulfuration wastewater delivered to the desulfuration waste water treatment station for coagulating sedimentation and dehydration treatment. The clear water after treatment is used for ash yard sprinkling. The sludge from the water extractor is carried by truck to the specified site for disposal.

25.4 OILY WASTEWATER COLLECTION AND TREATMENT

Oily wastewater shall be collected through a system of floor drains and bellups and directed to oil/water separator(s). Each oil water separator shall be provided with two (2) chambers. The first chamber shall contain internal plate separators and oil pump-out provisions. The second chamber shall be a clearwell. The effluent from the clearwell of the oil water separator(s) shall be pumped to the industrial wastewater storage pond by two (2) X 100 percent (100%) capacity submersible transfer pumps capable of operating in parallel.

The treated oily wastewater shall comply with the Bangladesh Environmental Standard or IFC-World Bank, whichever is more conservative / stringent.

25.5 SANITARY DRAINAGE AND TREATMENT

Sanitary waste shall be collected in accordance with applicable national codes and regulations. Sanitary waste shall be collected by gravity drains, with lift stations as required, and directed to the sanitary waste treatment system.

Sanitary lift stations shall be provided where necessary to pump collected sanitary waste to the treatment system. Each sanitary waste lift station shall be furnished with a collection basin. Two (2) X 100 percent (100%) capacity submersible grinder pumps capable of operating in parallel shall be provided in each lift station with parallel operation capability.

The sanitary waste treatment plant shall be sized to treat a minimum of 170 persons at 190 litres per person per shift per day. The sanitary waste treatment system shall produce a treated effluent in compliance with all national and local discharge codes and regulations.

The sanitary waste treatment plant shall utilize an activated sludge process designed to remove organics through biological treatment, remove solids through clarification, reduce fecal coliform through chlorination, and reduce NH_3 reduction through aeration. The aeration basin retention time shall not be less than 24 hours. Filtration equipment may be required as per local requirements.

Notwithstanding the above, the Contractor shall ensure that the limits specified shall meet local environmental discharge limits and World Bank Standards, whichever is lower as applicable.

Sludge generated from the sanitary waste treatment plant shall be suitable for disposal on or offsite. Effluent from the sanitary waste treatment plant shall not be directed to the industrial wastewater storage pond. Vehicle(s) for sludge disposal shall not be required.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 26 – CONDENSATE POLISHING

CONTENTS

26 CONDENSATE POLISHING

The flow diagrams and System Definitions provided for the condensate polishing system in Attachment C of these Employer's Requirements respectively shall be used as guides for design and equipment specification. The condensate polishing system shall remove suspended and dissolved solids from the condensate which may enter due to condenser tube leaks or from cycle piping due to transient load operation and during startup.

The condensate polishing system shall receive water from the discharge of the condensate extraction pumps. The unit's condensate flow from the condensate extraction pumps shall flow through the condensate polisher exchangers. The condensate shall pass through the condensate polisher exchanger beds which shall consist of a mixture of cation and anion resins. The bed serves as both an ion exchange media and as a filter.

The effluent of the condensate polisher exchangers shall be returned to the condensate system upstream of the gland steam condenser.

A bypass line shall be provided around the condensate polishers.

Three (3) x 50-percent (50%) capacity deep bed condensate polisher vessels shall be furnished with flow balancing between in-service vessels. The polisher exchangers shall be designed to treat 100 percent (100%) of the condensate at a maximum flux 2 m^3/min per square meter of cross sectional exchanger surface area.

The condensate polishers shall operate beyond the ammonia break point.

When the ion exchange capacity of the resin is exhausted or the pressure drop across a polisher resin bed becomes excessive, the exchanger shall be taken out of service and the resin regenerated.

Regeneration equipment shall be located in the steam turbine building. A two or three vessel regeneration system design will be acceptable. Exhausted resin shall be sluiced to the resin separation/anion regeneration tank. A spare charge of resin, which has been previously regenerated, shall then be sluiced from the cation regeneration/mix and hold tank to the empty exchanger and the exchanger shall be placed back into service.

The exchanger effluent shall be recycled to the polisher influent header by means of two (2) x 100 percent (100%) capacity recycle pumps per unit following any exchanger outage, including resin transfer operations, prior to placing the exchanger in service.

A resin hopper or similar means shall be provided for loading new resin into the resin separation/anion regeneration tank.

26.1 CONDENSATE POLISHER EXCHANGERS

Internals shall have sufficient mechanical strength and shall be supported or braced as necessary to prevent damage or distortion during shipment or under any service condition specified herein.

The minimum resin bed depth (top of resin to the top of collection headers) in each condensate polisher exchanger shall be approximately 1.2 m. Resin shall be provided in a 2:1 cation:anion ratio by volume. The inlet distributor and underdrain system shall be designed to collect and distribute water throughout all areas of the exchangers. The underdrain shall have sufficient strength to withstand without damage all forces that may be exerted on any of its components when the pressure loss across the resin bed and underdrain is equal to the design working pressure of the exchanger shells.

Each exchanger tank shall be of welded construction, and shall comply with applicable and Regulations and the relevant ASME codes.

The exchanger interiors shall be lined with 5 mm vulcanized rubber extending through and on the flanged faces of all tank connections. The tank lining shall be continuous over all permanently attached brackets and supports.

Inner faces of manholes and blind flanges shall be provided with covering equivalent to the tank lining.

Welding, lining, and covering attendant to each tank shall be completed in the shop prior to shipment.

Linings and coverings shall be warranted for a period of not less than 5 years from the date of receipt of the tanks at the project site. At the end of the Defects Notification Period, the Contractor shall assign the remaining warrantee to the Employer.

Tank internals, including fasteners, shall be constructed from materials that are resistant to the condensate water environment.

The minimum effective resin volumes assume that the resin is in the hydrogen and hydroxide forms. A portion of the resin actually contained in the exchangers will be considered ineffective; the amount of ineffective resin is dependent on underdrain design and shall be defined by the Contractor and acceptable to the Employer.

One basket type strainer shall be provided for installation in the effluent line from each exchanger to protect the condensate system against the accidental discharge of resins in the event of failure of an underdrain in the exchanger. Strainer basket and screen assemblies shall be designed to withstand, without damage, upstream pressure up to that of the condensate pump shutoff head with atmospheric pressure downstream when the strainer screen is completely blinded. Strainer housings shall have double bolt, vertical hinged closures.

26.2 EXTERNAL REGENERATION VESSELS

Regeneration pressure vessels shall be provided in which exhausted condensate polisher resins shall be received, cleaned, separated, regenerated, remixed, and stored.

Resin separation/ anion regeneration vessel and cation regeneration/ mixed and hold vessel shall be provided with all internal piping, distributors, and collectors required for the various regeneration functions as required by the regeneration system design. These functions shall include, but not be limited to, the receipt, air scrubbing, cleaning, separation, regeneration, rinsing, remixing, and all storage and transfers of resins. Other functions shall also be provided, as required by the Contractor, to ensure that the regeneration system will sufficiently prepare the resin to produce the required condensate polisher effluent quality.

Sight ports shall be provided in the side of each regeneration vessel in accordance with the following as a minimum: one as near the internal bottom as practical and one at the surface of the settled resin. Additional ports shall be provided as required by the associated process, which may include one at the resin interface and one in the upper portion of the vessel to observe expanded beds during backwashing. Sight ports shall be flanged nozzles with Lucite inserts that extend at least to the internal surface of the vessel.

Backwash collector systems and regenerant distributors shall be provided in the regeneration vessels.

Tank internals, including fasteners, shall be constructed from materials that are resistant to the regenerant chemicals.

26.3 CATION REGENERATION EQUIPMENT

As a minimum, equipment as shown on the condensate polishing flow diagrams and System Definitions in Attachment C of these Employer’s Requirements respectively shall be provided for use in preparing and applying dilute acid for cation resin regeneration.

For hydrochloric acid cation regeneration, the system will be designed to permit concentrations up to 8 percent (8%) for single step applications.

Hydrochloric acid pumps shall be furnished to supply acid from the acid bulk storage tank for regeneration of cation resins. All wetted pump materials shall be resistant to the hydrochloric acid environment and shall be subject to review by the Employer.

Heavy-duty positive displacement piston diaphragm pumps designed for the intended service shall be furnished. Diaphragms shall be constructed of teflon. Each positive displacement pump shall have an electronic positioner for automatic stroke adjustment. Each pump shall be furnished with a factory set internal pressure relief valve. All positive displacement acid pumps shall be designed for a minimum turndown ratio of 10 to 1. A calibration column shall be provided for each set of pumps. Backpressure valves shall be provided as required. Pulsation dampeners shall be provided

A vent dryer shall be furnished for the bulk hydrochloric acid tank vent line. The dryer shall be furnished complete with two full charges of the necessary amounts of indicating desiccant.

The acid storage tank shall be carbon steel construction with a minimum wall thickness of 13 mm. An overflow with an overflow check valve shall be provided. All piping on the acid storage tank, including fill, vent, overflow, and drain piping, shall be ASTM B729 UNS N08020 Alloy 20 seamless pipe. Piping shall be welded.

26.4 ANION REGENERATION EQUIPMENT

As a minimum, equipment as shown in the flow diagrams and System Definitions on the condensate polishing system in Attachment C of these Employer's Requirements respectively shall be provided for use in preparing and applying dilute caustic (NaOH) for anion resin regeneration.

The design shall allow, through manual adjustment, diluted caustic application at a selected fixed concentration of not less than 3 percent (3%) and not more than 5 percent (5%) to all anion resins.

Caustic pumps shall be furnished to supply caustic from the caustic bulk storage tank for regeneration of the anion resins. The pumps shall be designed to deliver caustic at the maximum head and flow rate required by the regeneration system.

Caustic pumps of the heavy-duty, positive displacement, piston diaphragm type designed for the intended service shall be furnished. Pump wetted materials shall be constructed of stainless steel. Diaphragms shall be constructed of teflon. Each positive displacement pump shall have an electronic positioner for automatic stroke adjustment. All positive displacement caustic pumps shall be designed for a minimum turndown ratio of 10 to 1. A calibration column shall be provided for each set of pumps. Backpressure valves shall be provided as required. Pulsation dampeners shall be provided.

The water heater shall be a vertical cylindrical electric storage. The water heater tank shall be a lined pressure vessel and shall comply with applicable Laws and codes in particular the Factories and Machinery Act, 1967 and Regulations and ASME codes. The water heater shall be designed to provide 49° C caustic dilution water for two complete caustic applications at the design flow rate. The electric water storage heater shall be furnished with mechanically assembled replaceable blade immersion heating elements. The unit shall be complete with electric control panel, adjustable thermostat, starting contactors, float actuated level switch, and pressure relief valve.

The caustic storage tank shall be constructed and complied with ASTM A516, Grade 70 carbon steel and lined with a phenolic epoxy.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 27 – CYCLE CHEMICAL FEED

CONTENTS

27 CYCLE CHEMICAL FEED

Refer drawing no. 10-PM-PAY-14, Diagram of Fresh Water Supply System in Section 5, Attachment B4.

The cycle chemical feed equipment shall provide water conditioning chemicals to the condensate-feedwater-steam cycle. The cycle chemical feed system shall be designed based on the oxygenated treatment (OT) method. Oxygen shall be fed in the range of 30-150 ppb and ammonia solution shall be fed to maintain a condensate pH range of 8.0-9.0. Oxygen gas cylinders and ammonia solutions shall be supplied by the Contractor.

27.1 CHEMICAL FEED PUMPS

Each chemical feed pump shall be of the positive displacement, hydraulically actuated diaphragm type. Each pump shall be capable of a 10:1 feed rate turndown. Pumps with automatic feed rate adjustment devices shall be fully automatic over the entire turndown range. As a minimum, each pump shall be furnished with the following:

1. Single suction and discharge check valves for each pump whose discharge pressure is below 5500 kPag. Suction Check valve maybe integral to pumps to maintain suction head.
2. Suction and double discharge check valves for each pump whose discharge pressure exceeds 5500 kPag. Suction Check valve maybe integral to pumps to maintain suction head.
3. Automatic or manual feed rate adjustment, as required. The automatic feed rate adjustment devices shall accept a 4 to 20 mA dc signal and shall have a manual override. Automatic feed rate adjustment shall be achieved using automatic stroke positioners and/or variable frequency drives.

27.2 CHEMICAL SOLUTION TANK

The chemical solution tank shall be furnished complete with a mechanically sealed hinged charging door with chemically compatible gasket connections and accessories. The solution tank shall be designed and fabricated to prevent fugitive emissions from escaping from the charging hatch and the mixer.

The chemical solution tank shall be furnished with a measuring pot which will be transparent with graduations.

27.3 OXYGEN FEED EQUIPMENT

Oxygen Mass Flow Controller

The oxygen mass flow controller shall have a 20:1 turndown ratio for gas feed rate. Panel mounted mass flow display shall be furnished with the controller.

Oxygen Tubing

Where practical, tubing shall be pitched uphill from the gas source to the corresponding gas feeder. Tubing shall be suitable for the oxygen gas service.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 28 – STEAM CYCLE SAMPLING AND ANALYSIS

CONTENTS

28 STEAM CYCLE AND WATER SAMPLING AND ANALYSIS

To improve the accuracy and continuity of the steam and water sampling and analysis of the thermodynamic system, it is planned to equip the centralized steam and water sampling device, the monitoring instrument matching with the pressure rating of the power units and the steam condenser device that are integrated in the power unit.

The two sets of water and steam sampling devices are centralized and arranged on the ground floor of the main building.

The steam cycle sampling and analysis shall provide a means to monitor the performance and operation of the boiler-turbine-condensate-feedwater cycle, to continuously monitor the quality of various process fluids, and to provide sufficient data to operating personnel for detection of deviations from control limits so that the corrective action can be taken. The system shall provide for sample conditioning and on-line monitoring capabilities.

The sampling system shall be in accordance with ASME codes and standards.

28.1 SAMPLE PANEL

The sample panel shall include a wet section and a dry section. The wet section shall contain sample temperature and pressure conditioning equipment; sample temperature and pressure indication; sample analyzer branch line pressure based flow control and flow indication; a sample trough; pH, specific conductance, and cation conductivity cells; and analyzers, as specified. The dry section shall contain pH and conductivity monitors, a dissolved oxygen monitor, a sodium monitor, a silica monitor, terminal blocks, and recorders, as specified.

The sample trough shall run across the front of the wet section and shall be constructed of stainless steel.

The dry section interior shall be provided with light fixtures and two duplex receptacles.

Doors and equipment arrangement shall be such that all items are readily accessible for maintenance, repair, calibration, and adjustment.

28.2 SAMPLE COOLERS

The cooling coil shall be constructed of stainless steel. Unions shall be provided as required to allow for disconnecting of the cooling water inlet and outlet lines to allow removal of the cooling coil. Design working pressure of the coolers shall not be less than the sample inlet design pressure for the respective sample.

28.3 SECONDARY COOLING

Secondary sample coolers shall be furnished to provide final temperature conditioning of the samples. Secondary sample coolers shall be designed to reduce the sample temperature to 25 +2°C when chilled water is provided. Design working pressure of the coolers shall not be less than the system design pressure. Cooling coils shall be constructed of stainless steel.

28.4 BACK-PRESSURE VALVES

Each back-pressure valve shall maintain a constant upstream sample pressure to ensure constant sample flow rates through upstream cell branch lines.

28.5 FLOW INDICATORS

Each sample rate of flow indicator shall have integral rate set valves and stainless steel construction.

28.6 FLOW SWITCH

A primary cooling water flow switch shall be equipped with alarm contacts to annunciate cooling water low flow conditions.

28.7 SPECIFIC CONDUCTANCE ANALYZERS

Each cell shall be provided with automatic temperature compensators compatible with the monitors.

28.8 CATION CONDUCTIVITY ANALYZERS

The analyzers shall be furnished with ion exchange columns and indicating resin. The discharge from each analyzer shall be piped to a conductivity cell, complete with cell enclosure and automatic temperature compensators compatible with the monitors.

28.9 PH ANALYZERS

pH cells shall be flow-through type with polypropylene flow chamber, cover, and mounting kit. Reference electrodes shall be diffusion type electrodes.

28.10 SODIUM ANALYZERS

Each sodium analyzer shall be automatic, continuous, electrode type analyzer(s) furnished complete, piped, wired, and mounted in the wet section of the sample panel. Shared analyzers are not acceptable. Each analyzer shall be furnished with a calibration kit.

28.11 DISSOLVED OXYGEN ANALYZERS

Each automatic, continuous electrode type dissolved oxygen analyzer shall be furnished complete with the flow cell assembly mounted internal to the panel and the analyzer monitor mounted on the panel face. Shared analyzers are not acceptable. Each analyzer shall be furnished with a calibration kit, calibration shall be with ambient air.

28.12 SILICA ANALYZER

An automatic, colorimetric silica analyzer shall be furnished complete, piped, wired, and mounted in the wet section of the sample panel. Shared analyzers are not acceptable. Each analyzer shall be furnished with a calibration kit.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 29 – GENERATOR

Contents

29 GENERATOR

The scope of supply shall include the furnishing of a 3-phase alternating current cylindrical rotor synchronous machine as specified herein. Work performed under these specifications shall be done in accordance with the following codes and standards.

Work	In Accordance With
Rotating electrical machinery	IEC 60034 and all referenced documents

29.1 GENERAL REQUIREMENTS

Relevant documents in the System Definitions in Attachment C of Section 5 - Employer's Requirements for additional generator related requirements.

The generator shall be a 3-phase alternating current cylindrical rotor synchronous machine. The generator shall have a water-hydrogen cooling system. The generator, and collector rings if used, shall be totally enclosed in a housing. All generator windings shall be copper; hollow conductors may be stainless steel. The rotor shall be machined from a single alloy steel forging. The generator shall be rated for continuous use.

The generator MVA rating shall be based on the turbine MCR condition, design back pressure, and a power factor of 0.85 lagging and 0.95 leading at the generator terminal. The generator's maximum power output should match with the turbine VWO condition.

The generator efficiency shall be at least 98.5 percent (98.5%) at unit rating, including bearing, windage, seal losses and excitation power loss.

The generator winding shall be wye connected and suitable for operation with the neutral resistance grounded through a distribution transformer. Phase terminals shall be brought out separately. The generator shall be designed in accordance with IEC 60034.3 and with Class F insulation limited to IEC "Class B" temperature rises.

A potential-source controlled rectifier excitation system shall be provided, which has high performance, reliability, and response. Self-excitation of the generator shall be provided by a static excitation system using a thyristor rectifier that converts the AC voltage from the generator terminals through the excitation transformer into DC voltage. Thyristors and diodes shall be rated at 200 percent (200%) of the rectifier assembly nameplate RMS voltage rating as a minimum.

The generator shall be capable of continuous non-symmetrical operation with the negative sequence current at 5.2 percent (5.2%) of the rated stator current. The phase current during the non-symmetrical operation will not exceed the rated stator current.

A generator control panel and all necessary and specified protective relaying shall be provided.

The following design features (using redundant protective instrumentation and relays) shall include but not limited to the following generator protection:

1. Overexcitation trip to trip the machine if excessive excitation remains for a predetermined time, both in automatic and in manual operation.
2. An adjustable limiting device to automatically prevent operation above the rated generator overexcitation capability.
3. A volts/hertz regulator to provide a continuously acting limit to the maximum volts/hertz.
4. Automatic and continuous ground detection equipment to detect grounds in the generator field.
5. Underexcitation limitation to automatically prevent operation below the rated generator capability for underexcitation operation.
6. Voltage unbalance detection equipment to transfer the regulator from automatic to manual upon loss of regulator sensing voltage.

The generator shall have a water cooled stator and hydrogen cooled rotor. The generator shall be furnished with the following cooling equipment and systems, at a minimum.

1. Hydrogen and carbon dioxide gas control system and analyzers.
2. Four (4) hydrogen coolers.
3. Stator winding cooling system.
4. Stator and cooling media resistance thermal detectors and thermocouples or RTDs.

The generator shall be capable of producing a minimum of 80 percent (80%) of rated generator MVA with one cooler out of service.

29.2 INSULATION AND MAXIMUM TEMPERATURES

The insulation of the armature windings, field windings, and collectors shall be Class F. The temperature rises and total temperatures shall not exceed those permitted for Class B. The calculated hottest spot temperature shall not exceed 130°C on a machine which is manufactured to IEC standards.

The stator coil insulation shall be a vacuum pressure, resin impregnated, mica type system. Windings shall be insulated for the full rated voltage to earth with no grading of insulation.

As an alternative, the Contractor may offer a machine with Class H insulation with Class F rise.

29.3 SHORT CIRCUIT REQUIREMENTS

The machine shall be designed to withstand without damage a short circuit of any kind at its terminals while operating at any load or voltage within the generator's permissible operating range. Maximum phase current shall be limited by external means to a value which does not exceed the maximum phase current obtained from a 3-phase short circuit.

29.4 CURRENT TRANSFORMERS

The generator terminal current transformers should be furnished for generator and transformer protection, metering, synchronizing and excitation regulator. The current ratio and accuracy should meet the requirements of protection relay, performance test and automatic voltage regulator. The current transformers should withstand short circuit current stresses without damage. The secondary leads of current transformers shall be wired to terminal blocks with shorting capabilities located in the generator control panel.

29.5 NEUTRAL EARTHING ASSEMBLY

The Contractor shall furnish a generator neutral earthing transformer and resistor assembly. The assembly shall include a sheet metal steel indoor cubicle, a neutral earthing transformer, and a neutral earthing resistor. The neutral earthing assembly shall be capable of accepting and connecting to the neutral conductor system.

The neutral earthing transformer shall be of the dry, self-cooled type. The transformer shall have sufficient over voltage capability to prevent saturating on phase-to-earth faults with the generator operating at the maximum generator terminal voltage.

The secondary resistance shall be selected so that the resistor kW dissipation during a phase-to-earth fault is equal to or greater than the generator and generator terminal equipment system charging kVA. In general, the phase-to-earth primary current range should be limited to 4 to 10 amperes.

29.6 EXCITATION SYSTEM

The Contractor shall furnish a static excitation system with a dedicated excitation transformer. The excitation system shall provide adequate field voltage and current to continuously produce generator rated MVA at the maximum rated generator output voltage. Sufficient redundancy shall be provided to allow for device failure and replacement without compromising the required turbine generator availability. The excitation system must withstand, without damage, any faults or abnormal operation of the synchronous machine. A power system stabilizer shall be provided, and shall be in accordance with the requirements of applicable governing authorities. A stability program model of the generation side and data shall be provided. The excitation system shall meet the requirements of IEC 60034-16-1 and IEC 60186.

29.7 CONTROL PANEL

The Contractor shall provide a completely enclosed free-standing sheet metal control panel for the generator. The panel shall contain all required devices, including mounting and wiring of the devices to terminal blocks.

Control switches shall be of the rotary operated type with enclosed silver-plated to silver-plated contacts, and be provided with easily removable protective covers. Switches not arranged for spring return shall be provided with a positive means for maintaining contact position. Handles of different shapes shall be provided as an aid in switch identification. Control switches for electrically operated circuit breakers shall be of spring-return type, with pistol grip handles and separate targets to indicate the after-trip and after-close positions. Control switch slip contacts shall be provided as required.

Meters shall have enclosed cases finished in dull black and shall be of the flush or semiflush mounting type. All resistors, reactors, autotransformers, insulating current and potential transformers, and other auxiliaries required to complete the metering equipment shall be furnished.

The Contractor shall provide the functionality described for the generator control panel via either a hardwired control panel or a turbine-generator control system.

29.8 VIBRATION MONITORING

The Contractor shall provide a complete bearing vibration monitoring system for the generator and collector bearing. The system shall be fully compatible and integrated with the bearing vibration monitoring system provided with the prime mover. The probes for this system shall be installed 90 degrees (90°) apart (XY) at the same longitudinal location along the shaft for each bearing.

29.9 TEST REQUIREMENTS

All equipment and components shall be factory tested in accordance with the equipment manufacturer's standard methods and procedures as necessary to ensure high quality materials and equipment, reliable and safe operation, and long life. Notwithstanding the previous statement, the following tests, as a minimum, shall be conducted.

The generator mechanical tests shall be in accordance with the equipment manufacturer's standard methods and applicable standards as a minimum and such tests shall include but not limited to the following:

1. Rotor overspeed at 120 percent (120%) of rated speed.
2. Rotor mechanical static and dynamic balancing.
3. Mechanical inspection.
4. Air leakage test. The generator frame shall be air tested at 1.25 times the operating pressure.

The generator electrical tests shall be in accordance with the equipment manufacturer's standard methods and applicable standards and shall include but not limited to the following:

1. Stator core iron induction test at 1.0 Tesla or other stator core imperfection test

2. Measurement of cold resistance of armature and field winding.
3. Insulation resistance measurement of armature and field winding.
4. Armature dielectric test.
5. Field dielectric test.
6. Calibration test for all temperature sensing elements.

The power potential transformer tests shall be in accordance with the equipment manufacturer's standard methods and applicable standards and shall include but not limited to the following:

1. DC resistance of transformer windings.
2. Polarity check of transformer windings.
3. Dielectric test of transformer windings.

The static excitation system tests shall be in accordance with the equipment manufacturer's standard methods and applicable standards.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 30 – GENERATOR STEP-UP (GSU) TRANSFORMER, UNIT AUXILIARY TRANSFORMER (UAT) AND STANDBY/STARTUP TRANSFORMER

Contents

30 GENERATOR STEP-UP (GSU) TRANSFORMER, UNIT AUXILIARY TRANSFORMER (UAT) AND STANDBY/STARTUP TRANSFORMER

Refer to the System Definitions in Attachment C of Section 5 - Employer's Requirements for additional transformer related requirements.

The general design criteria shall be in accordance with the applicable IEC codes and standards.

Two (2) GSU transformers of 20/400kV, three, single phase, two-windings transformers with energized tap changers shall be provided. The GSU transformers shall be provided with eight taps, (four (4) x 1.25 percent (1.25%) taps above and four (4) x 1.25 percent (1.25%) taps below the base 400kV voltage). The GSU transformers rating shall be sized to not exceed a 55°C temperature rise for the gross electrical power produced at the MCR of the steam turbine with the generator operating at a 0.85 power factor lagging or 0.95 leading. The generator shall be connected to the GSU transformers with isolated phase bus duct. Taps from the bus duct shall be connected to the unit's auxiliary transformers. The cooling system of the GSU can be OFAF or ODAF. The GSU capability shall be a minimum of 60% full rating in the event of a loss of power to the cooling system. The high voltage winding should be wye connected with solid neutral grounding. The low voltage should be delta connected by insulated bus duct.

Two (2) Unit Auxiliary Transformers ("UATs") of three-windings (20/6.6kV) shall be provided. Each transformer shall be sized to provide the auxiliary power requirements of the Plant without exceeding a 55°C temperature rise. The Contractor shall provide a load flow study for the auxiliary power system. The study shall include system voltage regulation when starting the largest motor on each medium voltage system and the 415/240 V system. The UATs shall be equipped with off load tap changers with the tap range selected based on the load flow study. Connection between UATs and 6.6kV switchgear shall be by Segregated Phase Bus Duct. The cooling system for the UATs shall be ONAN/ONAF. A n+1 fan system will be provided (one additional installed fan will be provided). ONAN power rating will be 60% of ONAF rating.

One (1) Standby/Start-up Transformer of three-windings (400/6.6kV) shall be provided. The Standby/Start-up Transformer shall be equipped with power source from the 400kV power distribution unit as the startup/standby power for the Plant. The Standby/Start-up Transformer shall be sized to provide the auxiliary power requirements of the Plant without exceeding a 55°C temperature rise. The Contractor shall provide a load flow study for the auxiliary power system. The study shall include system voltage regulation when starting the largest motor on each medium voltage system and the 415/240 V system. The transformer shall be provided with on load tap changer with eight (8) taps (four +1.25% and four -1.25% of the 400kV base voltage). Connection between the Standby/Start-up Transformer to the

6.6kV Switchgear shall be of non-segregated phase bus duct. The Cooling system for the Standby/Start-up Transformer shall be ONAN/ONAF.

Transformer components shall be a standard design for items without specific design criteria. The standard design shall be in accordance with accepted industry practices for electrical power generation.

All transformers shall be separated by concrete firewall 300mm thicknesses.

30.1 CORE AND COILS

The current carrying capability shall be limited only by the capacity of the core and coils and not by other components such as winding leads, bushings, and tap changers. Nuts, bolts, and clamps of the core assembly shall be provided with positive locking devices to prevent loosening. For core form transformers, the complete core and coil assembly shall be removable from the tank for repairs.

30.2 COOLING SYSTEM

For forced oil circulated transformers, redundant oil pumps shall be provided; any pump failure shall not result in the transformer being taken out of service. For the forced air cooling radiator and single fan being out of service shall not result in a reduction of the transformer capacity. If all fans are out of service the transformer shall be capable of operation with a minimum of 60 percent (60%) rated capacity.

30.3 LOAD REJECTION

GSU transformer(s) will be directly connected to the generator in such a way that it may be subjected to load rejection conditions that result in an abnormally high voltage from the generator. Therefore, these transformers shall be designed to withstand, as a minimum, the resulting stresses with 1.4 times the rated voltage for 5 seconds, applied at the transformer terminals to which the generator is to be connected.

30.4 THROUGH-FAULT WITHSTAND

Transformers furnished under these specifications shall be capable of withstanding, without damage, the mechanical and thermal stresses caused by short-circuit currents limited only by the impedance of the transformer. System impedance shall be considered equal to zero. System pre-fault voltage shall be equal to the voltage rating of the maximum tap or 1.05 times the principal tap, whichever is greater.

GSU transformers shall also be designed to withstand the resulting forces caused by a surge in terminal voltage and fault current contribution from the generator while coasting to a standstill. Unless additional information is specified about the time/current/voltage characteristics of the generator under fault conditions, assume as a minimum a voltage overshoot of 140 percent (140%) for 2 second time duration.

30.5 TRANSFORMER IMPEDANCES

Transformer impedances shall be industry standard for the size and Max voltage ratings required. The Contractor shall submit calculations for the GSU transformer impedance which verify SIC requirements are met for VAR support. The Contractor shall determine UAT impedances that optimize voltage regulation and minimize switchgear interrupting rating requirements.

30.6 MECHANICAL CONSTRUCTION

Tanks, bases, radiators, covers, junction boxes, and any other attached compartments fabricated from steel shall withstand normal transportation, installation, and service stresses without distortion or damage. The complete tank shall be designed to withstand full vacuum and at least 125 percent (125%) of the maximum operating pressure of the oil preservation system furnished. The tank cover shall be sloped or domed to shed water and to assist with the flow of gas bubbles to the gas detector piping and/or relay. Field installation shall not require any welding.

Holes with automatic drain valves shall be provided at the low point of the bus duct flange enclosures so that condensate and water will not accumulate.

30.7 DE-ENERGIZED TAP CHANGER (DETC)

The DETC of the UAT shall be motor driven and configured for remote controlled by the DCS. A Local/Remote selector shall be provided to allow the DETC to be operated locally.

30.8 ON-LOAD TAP CHANGER (OLTC)

The OLTC should be motor drive and controlled by a voltage regulating relay. It shall be configured to also allow remote control from the DCS.

30.9 AUTOMATIC VOLTAGE REGULATOR

The generator unit auxiliary step-up transformer and the start-up/stand-by transformer shall be provided with an automatic voltage regulator (AVR), for maintaining the voltage on the LV side within adjustable limits.

It shall be possible to select following operation modes:

- local electrical non-automatic
- remote electrical non-automatic

- remote automatic

A digital type AVR of an approved design shall be provided. The set point voltage shall be adjustable between 90% and 110% of the energizing voltage.

The sensitivity of the AVR shall be suitable for adjustment at any value between 0.5% and 6% of the setpoint voltage.

A time delay adjustable between the limits of 10 and not less than 180 seconds shall be provided. This setting shall represent the maximum operating time, which shall be reduced automatically as a function of the amplitude and duration of the voltage deviation.

Additional, the AVR shall be blocked if the energizing voltage becomes too low or too high. The low voltage blocking shall be adjustable between 70% and 95% and the high voltage between 105% and 130%.

The required interfaces for remote control and monitoring through the DDCMIS (e.g. set point, adjustment, tap position indication, alarms, etc.) shall be provided. Remote control shall be included into the plant unit level automatic start up sequence control.

30.10 CURRENT TRANSFORMER (CT)

The necessary current transformers used for protection and measuring shall be provided. The GSU and UAT shall have at least two CTs for unit differential protection in the HV bushing; the CT class should match the generator's CT class. At least one CT in the HV bushing shall also be provided for GSUs and UATs for measuring. For the three phase GSUs, each LV bushing shall be provided with two CTs for GSU transverse differential protection. For the UTs, two (2) CTs shall be provided on neutral bushing. The tank shall be designed so that all current transformers can be removed easily without removing the main transformer tank cover.

30.11 CONTROL CABINET

The control cabinet for each transformer shall be intended for outdoor use with an enclosure protection level of IP56. The control cabinet shall be provided with space heaters capable of preventing condensation of moisture within the cabinet.

30.12 NEUTRAL EARTHING RESISTORS

The transformer neutral (star) points on the 6.6kV windings are to be earthed through earthing resistors (preferably double copper braid type). The earthing resistors shall be of rustless unbreakable material installed in a metal enclosure for outdoor installation. For interconnection with the transformer single core cables with suitable cable terminal boxes (IPW55) shall be provided. The resistor and the enclosure shall be designed in such a way that the surface temperature is not dangerous for personnel.

The bushing for connection to the earthing system shall be equipped with current transformer (2 cores) for over current and ground fault differential protection.

30.13 WIRING

Current transformer leads shall be extended into the control cabinet and shall be terminated on shorting type terminal blocks and ring tongue lugs. The secondary leads of the current transformers shall be stranded copper wire and $6mm^2$ as a minimum. Control cabinet wiring shall be stranded copper, $2.5mm^2$ or larger, with flame retardant PVC or XLPE insulation rated at 600V or above. Splices will not be permitted in control wiring, current transformer leads, or instrument leads, unless screw terminals are provided within a splice box or where current transformer leads must pass through the tank wall.

30.14 TESTING

Testing procedures and techniques are to be in accordance with normal accepted industry practice and the appropriate standards. To minimize potential damage to the transformer during testing, the resistance, polarity, phase relation, turn ratio, no-load loss, percent impedance, temperature rise (when applicable), and load loss tests should precede dielectric tests. In this sequence, the beginning tests involve voltages and currents, which are usually reduced as compared to rated values, thus tending to minimize damaging effects to the transformer. The dielectric test sequence shall be arranged so that lightning and switching impulse tests precede the power frequency tests, and the final dielectric test performed shall be the induced overvoltage test.

30.15 OVER-EXCITATION TESTS FOR GENERATOR STEP-UP (GSU) TRANSFORMERS

Each GSU transformer specified herein shall be subjected to a 12 hour over-excitation test. Top oil temperature shall be recorded during the test. Gas-in-oil tests shall be performed before starting and after finishing each 12-hour run.

In conformance to IEC standards, the Unit shall be subjected to 110 percent (110%) rated voltage at 100 percent (100%) frequency on the input terminals.

30.16 TRANSFORMER HIGH PRESSURE SPRAY WATER SYSTEM

The GSU, Unit Auxiliary and Start-up/stand-by transformer shall be fitted with the equipment specified below:

- one high-pressure water spray system discharging on the transformers

- each transformer shall be provided with one valve station and one control and monitoring cabinet for the water spray system.

The water spray system shall be designed for manual, automatic or electrical remote operation and shall be provided in free-standing and self-supporting design, with the following basic equipment:

- the required number of triggering and fire extinguishing nozzles, with galvanized pipes and mountings

- the necessary galvanized connecting lines from the appropriate valve station to the nozzle pipe network

- the necessary drainage valves, struts, diaphragm sleeve valves, single chamber valve stations with all fittings and connections, pressure-sensitive switches for signaling and air pressure drop

- the necessary tank feed pump

- one brine control and monitoring cabinet with the require interfaces for remote control and monitoring (e.g. manual ON/OFF, alarms, main valve position, etc.) from the central control room through the DDCMIS

- a compressed-air, fire-fighting vessel for maintaining a reserve of fire-fighting water for a minimum spraying time of 10 minutes or as required according to NFPA, whichever is longer

- means for manual initiation shall be provided adjacent to the deluge valve for the system.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 31 – GENERATOR ISOLATED PHASE BUS DUCT

CONTENTS

31 GENERATOR ISOLATED PHASE BUS DUCT

Refer to the System Definitions in Attachment C of Section 5 - Employer's Requirements for additional generator isolated phase bus related requirements.

The isolated phase bus duct (IPB) system shall be provided as a complete sectionalized assembly of rigid insulator supported conductors, housed in individual phase enclosures. The design and construction shall be high current, air-insulated, self-cooled by natural convection and radiation cooling.

The design and construction of the isolated phase bus duct system shall be in accordance with manufacturer and power industry standard practices.

The rated current of IPB shall be 15 percent (15%) above the maximum continuous current rating of the power generator, and withstand the maximum short circuit current form both generator and power grid.

Particular attention shall be given to the necessity for withstanding, without damage or danger, the electromechanical stresses that may arise during normal and abnormal conditions as a result of flexing, vibration, variations in load or temperature, switching, short-circuit, faulty synchronizing, flashover, or other system causes. The design shall be such that any mechanical damage caused by a fault on the connections themselves should be confined as much as possible to the immediate vicinity of the fault.

The Contractor shall consider solar radiation in the bus duct system design.

The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in operation and maintenance.

The isolated phase bus duct supplier shall make all necessary provisions for incorporating the generator breaker into the proposed layout. The isolated phase bus duct supplier shall confirm that all current ratings and temperature rises for the combined assembly shall not be less than the specified ratings as required by the generator breaker supplier.

The Insulated phase bus duct shall include the following components:

1. Generator Voltage Transformer Cubicle
2. Surge Arrester and Capacitor Cubicle
3. Current Transformer Cubicle and Neutral Enclosure

31.1 BUS

The bus conductor shall be high conductivity aluminium with welded joint aluminium shape and shall be provided with expansion joints to prevent undesirable or destructive mechanical strains in the bus supports. Heavy-duty porcelain or epoxy resin insulators shall be used for bus supports within the enclosures.

31.2 BUS ENCLOSURES

The bus enclosures shall be fabricated from aluminium. The bus enclosures shall be electrically bonded to minimize induced currents in the surrounding metal structures. The enclosure design shall include the generator breaker enclosure as part of the bonded enclosure system. Expansion joints shall be provided in the enclosure as required to prevent undesirable or destructive mechanical expansion and contraction strains to the ambient temperature.

31.3 CONNECTIONS, TERMINATIONS AND FITTINGS

All materials, such as flexible connectors, connectors for generator vibration and expansion fittings, fasteners, support plate for main bus wall penetration, seal-off bushings, ground bus, joint compound, and copper-to-aluminium connectors shell furnished. Isolation barriers or seal-off bushings shall be provided at the generator end of the bus duct to prevent hydrogen leaking from the generator into the bus duct.

31.4 PRESSURIZATION

Each phase of the isolated phase bus duct assembly is to be pressurized with dry instrument air. A pressure reducing station, including orifices, valves, manometer, and filters shall be furnished to monitor and maintain the compressed air within the pressure limits of the bus duct enclosures. Seal-off bushings shall be provided for the transition from the indoor portion to the outdoor portion and for carrying the connections through the building wall. Two connection points for air supply, metering and pressure monitoring shall be furnished for indoor and outdoor phase bus enclosure.

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31.5 BUS DUCT SUPPORTS

All supports and fittings for steel fabrication shall be hot-dip galvanized after fabrication. Brackets or saddles factory welded to the enclosure or clamp type shall be provided for attaching the enclosure with bolts to the support steel.

31.6 FIRE WALL FIRE STOP

A fire wall fire stop system shall be provided that is comprised of fire stop materials internal to the bus duct enclosure and fire stop materials sealing the void between the bus duct enclosure and the site-erected fire wall.

31.7 SHORT-CIRCUIT BUS

Supplier shall furnish one set of short-circuiting bus bars in the main isolated phase bus duct run to allow electrical testing and drying of the generator. The short-circuit bus shall have the same continuous current rating as the main bus.

31.8 VOLTAGE TRANSFORMERS

Voltage transformers (VTs) for voltage metering and synchronizing shall be provided. The voltage transformer lightning impulse level shall be equal to or greater than the breaker rating. Voltage transformers shall have a capability of withstanding a secondary short-circuit for not less than one (1) second. The primary current limiting fuses shall be adequately rated for the transformer inrush and load current, and they shall have an interrupting capacity equal to or greater than the specified fuse interrupting rating.

31.9 CURRENT TRANSFORMERS

Current transformers shall be furnished for unit protection and metering. The current ratio and accuracy should be the same as the generator terminal current transformers. The secondary leads of current transformers shall be wired to terminal blocks.

31.10 GROUNDING (EARTHING) SWITCHES

Three phase operated grounding (earthing) switches should be furnished. The grounding (earthing) switches shall be of the no-load break type and shall have the same voltage ratings, closing and latching capability, and rated short-time current carrying capability as the generator breaker.

31.11 SURGE ARRESTERS AND CAPACITORS

Station type gapless metal-oxide surge arresters designed for rotating machine protection shall be furnished, as required. As an alternative, surge capacitors designed for rotating machine protection with built-in resistors can be furnished.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 32 – EMERGENCY DIESEL GENERATOR

CONTENTS

32 EMERGENCY DIESEL GENERATOR

Refer to the System Definitions in Attachment C of Section 5 - Employer's Requirements for additional emergency diesel generator related requirements.

The generator set shall be designed, manufactured, installed and tested in accordance with IEC 60034 - *Rotating electrical machines*, and ISO 8528 -*Reciprocating internal combustion engine driven alternating current generating sets*. The diesel generator set shall conform to performance Class G2 according ISO 8528, or equivalent. The emergency power generation system shall include the following major components:

1. The emergency generator shall consist of a synchronous wye connected 415 volt, three-phase, 50 hertz generator driven by a direct coupled diesel engine.
2. Turbocharged diesel engine with an after-cooler designed to operate at all ambient conditions, complete with an engine cooling system, system, combustion air intake and exhaust system.
3. Individual unit and overall digital synchronizer and load control panels for automatic starting, synchronizing and stopping.
4. Electrically operated circuit breaker with generator and system protection during normal operation and testing.
5. Fuel storage and automatic fuel feed system including a fuel oil tank with 8 hours of storage, fuel oil transfer pumps (if necessary), valves and piping, and control devices.
6. Auxiliary equipment, instruments, and starting system required for start-up and operation
7. Interconnecting piping and wiring
8. Lubrication system.
9. Battery and battery charger with battery capacity for at least 6 consecutive attempted starts.
10. All necessary pipe work, inlet and exhaust ductwork, filters and silencers.
11. Power cable and control cable connections to the 415 volt circuit breakers in the Essential Switchgear.
12. 2-hole earthing pads factory installed: one bronze pad attached to the generator frame adjacent to the main lead terminal housing and two pads on each end of the generator skid frame
13. A weatherproof housing assembly to accommodate the complete diesel generator set suitable for pad-mounting, if necessary.

The specified exciter shall enable the generator to sustain 300 percent (300%) of rated full load current for ten (10) seconds during a fault condition.

The emergency generator shall meet emission requirements of the IFC-World Bank and DOE.

The generator and exciter insulation shall be Class F. The temperature rise of the generator and exciter windings shall not exceed the limit for Class B insulation when the machine is delivering its basic continuous rating over the ambient conditions specified.

The fuel storage and supply system for the diesel generator set is to be located within the confines of the skid, whenever feasible. Secondary containment shall be provided to contain any spills. Drains from this area shall be routed to the oil water separator.

The emergency diesel generator shall be capable of periodical test to confirm its ready-to-start condition. It shall be manually/remote started, brought up to speed and voltage, and synchronized to the 415/240 V essential switchgear. Following completion of the test, the emergency generator shall be unloaded and manually/remote removed from service.

The Contractor shall determine the “essential” and “emergency” loads during detail design as based upon Contractor’s unique system design and provide the emergency distribution equipment including, but not limited to panel boards and MCCs to supply the loads.

Black start capability is not required. The Contractor shall assist the Employer in acquiring a waiver of the black start requirement from the Bangladesh Grid Company (if necessary).

An emergency power supply shall be provided by emergency diesel generator(s) as a complete package, which shall supply AC power to all essential consumers of the plant in case of a blackout. After a defined voltage drop of the 0.415 kV auxiliary busbar the diesel generator(s) shall cut in automatically and shall supply all essential loads so that the required controlled shut down procedure of the plant can be carried out without damaging any of the plant equipment.

In case of a complete blackout of the auxiliary power supply, the emergency diesel generator sets shall be sufficient to meet the electrical demand of:

- all consumers connected to the 0.415kV "essential" distribution boards required for safe shutdown of the plant

- additionally 10% safety margin.

The emergency diesel generator set shall be capable of starting Largest Size of emergency 415V drive(motor) having starting KVA/rated KW ratio of 8 (higher if starting current is more than 8) and starting power factor of 0.2 with terminal voltage drop being restricted to 15%. Generator loading before starting of this motor shall be considered as 50% of generator rating. Each emergency diesel generator set shall preferably be supplied in a container (including acoustic enclosure), fully installed, workshop tested and ready for operation.

The container housing the emergency diesel generator sets shall be suitable weather and corrosion protected.

The emergency diesel generator sets including stack height, acoustics, air emission and fuel oil installation shall meet the statutory Government of Bangladesh requirements.

The necessary lightning protection shall be provided for the stack as per statutory and safety requirements.

Bidder shall provide the sizing calculations for emergency diesel generator including the load demand and load list as well as a diagram showing the overload capacity versus the ambient temperature.

32.1 DIESEL ENGINE AND AUXILIARIES

32.1.1 GENERAL

The engine shall be water-cooled, with a closed circuit radiator and fan and shall be equipped with an exhaust gas turbo-charger for indoor installation. HSD shall be the common fuel.

A suitable electrical heating of the cooling water during standstill of the diesel generator set shall be provided to allow for the specified starting time.

Electrical motor and battery with charger shall start the diesel engine. The capacity of the battery shall be such as to ensure three consecutive starts of the diesel engine within 10 minutes.

The diesel engine shall be directly coupled to the generator and both installed together on a common base frame. Vibration absorbers shall be used to prevent transmission of vibrations to the surrounding area.

BHP Rating of the engine shall be prime power as per ISO 8528-1 considering duration for 50 deg C ambient temperature.

32.1.2 LUBRICATION SYSTEM

The engine and the generator shall be fully pressure-lubricated. The main oil pump shall be gear-driven from the main shaft. Where necessary, a suitable periodic lubrication equipment shall be provided to keep the engine in readiness to start at any time.

32.1.3 FUEL SUPPLY AND INJECTION SYSTEM

An integrated fuel meter shall be installed, suitably connected to the fuel admission and return system, to measure the actual consumption of the engine. For the supply of the diesel engine with fuel the Contractor shall provide a daily tank of adequate capacity and refilling from the HSD common tank.

The Contractor shall provide all necessary means such as pumps, pipes, filters etc. to accomplish the filling of the daily tank from the HSD common tank.

The daily tank shall be fitted with visual level indicator and level alarm devices for remote indication.

The suction of the extraction line shall be arranged at least 10cm above the daily tank bottom or otherwise suitably positioned in order not to take in sludge or water which may have accumulated. Furthermore, a flame trap shall protect the ventilation openings of the tank.

32.1.4 AIR INTAKE AND EXHAUST SYSTEM

The engine shall be fitted with an outdoor installed oil wetted air filter.

Temperature-resistant materials shall be used for the exhaust piping and the required expansion bellows. Exhaust silencers shall be galvanized. Expansion joints in the exhaust pipe shall be made of metal.

Exhaust stack (height) and silencer (e.g. noise level) shall comply with the regulations applicable in Bangladesh.

Flexible connections to the air intake duct, exhaust line and all other external pipework shall be provided.

32.1.5 CONTROL AND MONITORING EQUIPMENT

The engine shall be equipped with all necessary local switches and control equipment for starting, stopping and speed variations etc.

Start-up and shutdown of the set shall be possible from the local control board and from the central control room through the DDCMIS.

The set shall start-up automatically to the required load when the normal busbar voltage (415V AC) fails.

Only overspeed sensing element and shutdown mechanism separate from the regular governor apparatus and governor drive shall be accepted. The overspeed trip shall act on the injection pump independent of the governor link and shall remain operative even if the governor would accidentally be disconnected.

The following control, indication and alarm equipment shall be provided as a minimum on the local control board:

- level indication of the fuel tank with alarm at 20%
- pressure indication of the lube oil with low pressure alarm and trip signals
- temperature indication of the bearings with high temperature alarm
- temperature alarms of the generator winding
- emergency diesel generating set in operation (indication)
- generator overload alarm

- operating hour meter and start-up counter
- speed indication with alarm and trip signals
- generator voltage, current, frequency, active and reactive power indication
- automatic synchronizing equipment
- manual synchronizing equipment such as double voltmeter, double frequency meter, synchronoscope, etc.
- manual/automatic synchronizing selector switch
- start/stop push buttons
- manual/automatic voltage regulator selector switch
- switches for manual adjustment of generator voltage
- generator circuit breaker ON/OFF control switch and indication
- generator protection relays activation (individual alarm and trip signals per each protection relay)
- other alarm and trip signals.

Alarms shall be annunciated individually on the local annunciator unit on the local control board and remotely in the central control room as a group alarms.

After starting of the emergency diesel generator the emergency consumers shall be connected to their switchgears in groups by the DDCMIS.

32.2 GENERATOR

The generator shall be air-cooled with forced ventilation and shall comply with IEC 60034.

A heater shall be provided to protect the generator against humidity during stand-still (automatically initiated when the set is being out of service).

The short circuit ratio of the generator shall be not less than 0.5.

The generator must be capable of continuously maintaining constant Active Power output for System Frequency changes within the range 50.5 to 49.5 Hz. However synchronization with the system shall be possible at all frequency ranges of the Bangladesh system.

The generator winding insulation shall be according to class F. The temperature rise, however, at rated load shall not exceed the figures for class B insulation.

Six Pt 100 temperature sensors shall be provided within the stator windings, wired to terminal boxes.

The generator shall tolerate the sudden application or rejection of 50% of its rated power without unacceptably high voltage fluctuations in excess of ± 5%.

A static or brushless rotating diode rectifier excitation system shall be provided. The rotating diodes shall be easily accessible for maintenance.

A solid state type voltage regulator with automatic and manual control to control the set within a deviation of ± 0.5% from no-load to full load at rated frequency, shall be provided.

The diesel generator set shall be equipped with automatic synchronizing device for parallel operation with the grid. This is for testing the engine from time to time in the load condition and for switch-over to the normal grid after an emergency operation of the diesel generator sets.

The protection relays of the digital type, as indicated below, shall be regarded as the minimum scope, but shall not be limited to the following:

- voltage controlled inverse time overcurrent protection
- reverse power protection
- overvoltage protection
- overtemperature protection (stator windings)
- overcurrent protection
- overload protection.

The emergency diesel generator shall be sized according to the continuous emergency load requirements and the motor starting requirements of a unit shutdown. The emergency loads shall include, but not be limited to, the following:

1. Plant DC system battery chargers.
2. Generator seal oil pumps.
3. Turbine bearing oil pumps.
4. Turbine turning gear.
5. Boiler fans bearing oil pumps.
6. Elevators (if installed)
7. Obstruction lighting.
8. UPS Loads
9. Turbine emergency oil pumps

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 33 – 400kV SUBSTATION

Contents

33 400KV SUBSTATION

33.1 GENERAL

The connection of the Plant to the Bangladesh network shall be materialized with the Plant 400kV substation. The substation shall have 400kV gas insulated switchgears (GIS) due to coastal site and marshy land. The Plant will be connected by means of this substation via two (2) 400kV Over Head Lines (OHL) to the power grid.

However, as the power system analysis has not been approved by Power Grid Company Bangladesh (PGCB) which is the grid authority of Bangladesh, all configurations could undergo changes. Therefore, the Bidders shall fully aware on this and ready to make any changes as required by PGCB.

This specification covers all calculations, design, manufacturing, supply, erection, acceptance testing and commissioning, and handing over of the complete electrical and associated works for the entire 400kV Substation. The configuration shall cater for all units, with number of units and capacities as specified in these Employer's Requirements.

It is to be emphasized, that this specification does not enumerate or describe all the materials and equipment to be supplied and all the services to be performed. However, the electrical and associated works shall be complete in every respect and shall ensure safe and reliable operation of the Plant. This means, all material and equipment shall be provided as required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

The limits of the 400kV substation and the conceptual general layout are as follows:
- terminals of both generator-transformer bushings
- terminals of the start-up transformer bushings
- Both 400kV OHL gantries and the conductors for the 400kV outdoor equipment shall be provided by the Contractor.

Based on the conceptual general layout, the 400kV Substation is foreseen on the west side of the Plant. The 400kV OHL from the GSUT is connected to the substation. The Contractor shall propose a detailed arrangement with various components for the final configuration of the substation subject to the approval of the Employer or the Engineer. In doing so, adequate safety clearances, fire compartments, favorable layout of the plant components for monitoring and maintenance, possibility for extension and any other requirements of up to date for the 400kV Substation construction shall be taken into account.

33.2 BASIC DESIGN DATA FOR THE SUBSTATION

The following data are foreseen for the substation:

Data	400 kV GIS
nominal voltage (kV)	400
highest system voltage	420
rated frequency (Hz)	50
rated bus bar	To consider future provision
rated feeder current (GT and or OHL)	3150
rated feeder current (others)	3150
rated power frequency withstand	650
voltage (kV)	400
lightning impulse withstand voltage (kV)	1425
rated short circuit current 3sec	50
rated peak withstand current	125
creepage distance (mm/kV)	31
ambient temperature range (°C indoors)	Refer to Chapter 1 of Section 5
Auxiliary supply voltage (V AC)	230/415
Control voltage (V DC)	220
Telecomm. aux. voltage (V DC)	48
Seismic conditions (ground acceleration)	0,12g

For the switchgears, housings for electrical equipment and electrical equipment itself must be designed according to IEC 60529.

33.3 SCOPE OF SUPPLY

33.3.1 GENERAL SUPPLIES AND SERVICES

The following supplies and services are to be included in the corresponding section prices.

General:

- material and personnel costs for all tests and inspections including those which are mandated in legislation
- material costs for site inspections
- detailed design of complete supplied equipment including interface coordination
- complete substation primary drawings (Single Line Diagrams and Layouts)
- all as-built documentation
- quality control plan, healthy and safety plan
- complete documentation as set out in the Tender specification
- operating manual in summary form
- a maintenance program for all equipment of the Plant
- housekeeping during construction
- staff facilities during construction
- fire protection during construction.

Mechanical and electrical:

- all connection and adaptation works for tie-in into general supply systems
- all connection elements, screws, bolts, nuts, including gaskets and seals as necessary
- complete installation material, that is wiring, cabling and piping material, all needed fastenings, conduits, brackets and other supports, including the cable trays
- lightning protection
- electrical earthing of the equipment
- clarification of all logic interconnections: sequence, interlocking, protection, safeguarding for coordinated operation/start up/shutdown of individual items of equipment
- cable and cable trays
- all necessary cables and wires for power, AC and DC instrument transformers, control, measuring, signals, etc.
- all necessary number plates for identifying the cables
- all necessary fixing materials
- all necessary fire protection materials for making good the cable openings through walls and ceilings as well as between switchgear and control, measuring, recording and switchgear cubicles, operating panels and desks, etc.
- all necessary plastic protecting tubes for the cable runs
- all necessary materials for laying the cables in the ground
- all necessary cable connections including compression cable lugs, fixing and clamping materials, etc.
- all necessary cable sealing ends and cable connecting sleeves including fixing materials
- all necessary compression connectors.
- all necessary support structures, hangers etc.
- all necessary base frames, mounting plates, grouted in parts, rag bolts, covers etc.
- all required steel parts embedded in concrete

- all necessary lifting equipment and hoists (for repair work where loads exceed 50 kg),
- required safety equipment
- all necessary steel structures, stairs, ladders on platforms weather protection
- all required ventilation or air conditioning equipment for safe operation of the equipment, to be supplied
- all necessary corrosion protection measures for plant components and equipment stored or mounted on site up to the time of reliability test run
- complete primer and top coatings conforming to colour code, clarified with the Employer
- complete labelling of all plant components acc system and in plain language
- all fire protection measures
- all standard accessories and auxiliary equipment which normally form part of the scope of supplies
- all necessary tests, inspections and works acceptances as well as all certificates and reports of these
- removal of any unused material
- scaffolding for all work above ground level

Civil:

- all necessary surveying works, investigations and studies
- preparation of site, demolition works, removal of underground obstacles
- removal of debris and surplus material
- earthworks, drainage, excavation and refilling works
- all necessary temporary works/sheet piling/dewatering
- temporary roads and fencing of construction site
- concrete and reinforced concrete works, masonry and earthing
- water proofing works for pressing and non-pressing water
- facade works/glazing works; non asbestos
- concrete coating/painting/varnishing
- transport of all dumping material to dump locations
- interpretation of soil bearing test
- heating, ventilation, air conditioning

Detail requirements are specified under Chapter 4 of Section 5.

Packaging and transportation:

- suitable packaging and transportation of the entire scope of supplies
- free construction site, on-site transportation and temporary storage including inspections and, if necessary, ensuring the prerequisites for transportation
- transport insurance
- disposal of packing and transportation material
- crane or hoisting facilities at seaport and site
- transportation to site
- unloading and temporary storage at site.

Erection, commissioning and testing:

- Complete erection of the scope of supply up to operational readiness. This includes mobilization and provision of the required supervisory staff, skilled and unskilled personnel, as well as of installation scaffolding, cranes, hoists, equipment and materials, personnel accommodation, prescribed tests and inspections
- commissioning and optimization of all plant components as well as conducting all necessary measurements and supply of the necessary equipment
- supervision of erection, commissioning and Reliability Test Run of complete supplied equipment
- all testing as specified including testing of earthing network before and after rehabilitation of the earthing grid
- All necessary activities for network connections during Test Run of the Plant.

Any additional equipment or works, not specified but intrinsically required for proper operation of the substation, are deemed to be included in the prices quoted in the Price Schedules.

Notification in case of errors or occurrences:

The Contractor shall within fifteen (15) days send:

- notice on any error discovered by the Contractor in his own design, or the Engineer's design
- notice on any errors in test certificates and test reports
- report of non-performance report for any failure of material and equipment
- reports indicating any delays against schedule in the scope of supply and services of the Contractor and any other documents required in other sections of this Bidding Document.

The following equipment shall be under the scope of supply for the 400kV Substation as shown in the Electrical Main Wire Diagram (10-PE-PAY-001).

33.3.2 400KV GAS INSULATED SWITCHGEAR

The 400kV gas insulated switchgear of 1½ breaker configuration outdoor shall include three (3) diameters as shown in single line diagram. Provisions for extension shall ensure that all existing feeders can be kept in operation during installation and commissioning (also during high voltage tests of extension on site) of the new diameters/feeders. Following equipments as show in the Electrical Main Wire Diagram (10-PE-PAY-001) shall be provided:

Each diameter will be arranged with, but not be limited to the following equipments (three-phase sets):

Diameter 1 (Bays 1-A, 1-B and 1-C) for OHL including line reactor feeder and for generator transformer connection:

- Three (3) sets of circuit breakers
- Eight (8) sets of disconnectors
- Eight (8) sets of maintenance earthing switches

- Two (2) sets of high speed earthing switches
- Nine (9) sets of current transformers
- Two (2) sets of SF6 air bushings.

Diameter 2 (Bays 2-A, 2-B and 2-C) for OHL including line reactor feeder and for generator transformer connection:

- Three (3) sets of circuit breakers
- Eight (8) sets of disconnectors
- Eight (8) sets of maintenance earthing switches
- Two (2) sets of high speed earthing switches
- Nine (9) sets of current transformers
- Two (2) sets of SF6 air bushings.

Diameter 3 (Bays 3-A, 3-B and 3-C) for start-up and standby transformer connection:

- Two (2) sets of circuit breakers
- Five (5) sets of disconnectors
- Five (5) sets of maintenance earthing switches
- Six (6) sets of current transformers
- One (1) sets of SF6 air bushings.

Bus bar equipment:

- Two (2) sets of inductive voltage transformers
- Two (2) sets of maintenance earthing switches
- Two (2) sets of lightning arresters.

Local control cubicles:

Local bay control cubicles for conventional control (hard wired) and including bay control units for each bay and bus bar equipments.

33.3.3 400KV AIS EQUIPMENTS AND ACCESSSORIES

The following outdoor equipments shall be provided for the 400kV switchgear:

For the connections to the OHL gantries Line 1 and 2 including line reactors:

- Two (2) 3-phase sets of 400kV capacitive voltage transformers
- Two (2) 3-phase sets of 400kV surge arresters
- Two (2) 2-phase sets of Line Traps
- Conductors, connectors, clamps, insulators and accessories:
- All insulators strings and conductor clamps for final connection of the 400kV OHL to the gantry will be provided and installed by the OHL Contractors.

For generator transformers 1 and 2 and for Standby/Startup transformer connection:

- Three (3),3-phase sets of 400kV capacitive voltage transformers
- Three (3),3-phase sets of 400kV surge arresters
- Conductors, clamps, insulators and accessories.

In addition to the above, there must be 7 (seven) more nos. of unequipped bays for future expansion shall be as follows.

1. 2 nos for Generator Step up transformers
2. 1 nos for Standby/Startup transformer
3. 2 nos outgoing 2 Circuit lines
4. 2 nos as Spare (For future use by PGCB)

Hence in total there should be 12 (Twelve) nos of bays.

The scope of supply and services for all the above mentioned items includes a complete substation with all necessary equipments, cabling, cable trenches, cable channels, functions, gantries, lattice steel structures, conductors, connectors, insulators, clamps, support insulators, foundations etc. on turn-key basis.

33.3.4 400KV SHUNT REACTOR

33.3.4.1 63 MVAR – 400KV SHUNT REACTOR

Both the two (2) 63MVAR line reactors shall be of three phase design based on vector group YN0 and shall be located in the 400kV Substation as shown in the single line diagrams, the capacity should be approved by PGCB. The reactor shall be skid mounted installed on concrete foundation with oil pit and fire walls and connected to the 400kV GIS.

33.3.4.2 NEUTRAL GROUNDING REACTORS (NGR) AND THEIR CONNECTIONS

The two (2) neutral grounding reactors for the 400kV shunt reactors shall be located in the 400kV Substation as shown in the single line diagrams.

The neutral grounding reactor shall be connected conventionally with the line reactors and ground including but not limited to following:

- Foundations
- Two (2) disconnectors (one (1) by bus disconnector)
- Current transformer.

The scope of supply and services of all the above mentioned items includes a complete bay with all necessary equipments, functions, gantries, lattice steel structures, conductors, insulators, clamps, support insulators, foundations etc. on turn-key basis.

33.3.5 SUBSTATION PROTECTION EQUIPMENT

Substation protection system is mainly composed of but not limited to the following sections:

33.3.5.1 400KV SWITCHGEAR AND 400KV OHL

- Line Protection
- Generator Transformer
- 400kV Transformer

- 400kV Line Reactors with NGR

In order to ensure proper coordination with the other end of the 400kV OHL, principally the same protection equipment and facilities shall be installed on the opposite ends, so that at both line ends the protection systems are operating in a coordinated way and ensure selective tripping and security of supply. The scope of supply includes the line protection on the 400kV Substation side only. For this reason the 400kV OHL protection requires licensee's approval. The relays within the principle scope of protection, under the substation package, are listed below.

Integration into the CMS, alarming, signaling, blocking facilities shall be provided and incorporated in all necessary manners to SCADA system, providing monitoring and control from SCADA and NLDC.

The main and back-up protections will be connected to separate CT cores, supplied from different DC supplies (DC 1 and DC2), and will act on different CB trip coils.

Main protection I and II can be installed in one cubicle, but strict separation is required. Main I protection with all related terminals shall be installed in the upper compartment while Main II protection with all related terminals shall be installed in the lower compartment.

All protection relays shall be flush mounted.

33.3.5.2 400KV LINE PROTECTION

Both overhead lines in 400kV Substation shall be equipped in two (2) terminals (Main 1 and Main 2) and shall have, as minimum but without being limited to the following protections:

- Line differential protection (87L) (if fibre optic is in service)
- Distance protection (21/21N)
- Overcurrent protection (50/51, 50N/51N)
- Overvoltage protection (59)
- Undervoltage protection (27)
- Directional sensitive earth fault (67 N)
- Auto reclosing (79) with synchro-check (25)
- Breaker failure protection (50 BF)
- Out of step protection (68/78)
- Disturbance recorder (95DR)
- Event recorder (95ER)
- Dual stub protection (STUB)
- Pole discrepancy protection
- Fault locator (FL).

Main 1 Protection feature 87 L should be possible to be disabled and 21/21N shall continue to operate normally. 21/21N shall not be enabled automatically (emergency distance) when

87 L fails. The 21/21N feature should be possible to set “ON” and 21N, 67N, 59 shall be foreseen as well.

Multifunctional relays shall be used. The functions will be grouped in minimum two multifunctional relays one for Main 1 and one for Main 2 protection.

The Main 1 protection will include the following functions: 87L, 50/51, 50N/51N, 59, 27, 67N, 68, 79+25, 78, 50BF, FL, 21/21N, 95ER, 95DR with teleprotection feature.

The Main 2 protection will include the following functions: 21/21N, 50/51, 50N/51N, 59, 27, 67N, 68, 79+25, 78, 50BF, FL, 95ER, 95DR teleprotection feature.

Two (2) trip coil circuits supervision relays (74 TCCS) shall be provided, using separate TCCS relays, and separately for trip coil 1 and trip coil 2.

The Main 1 and Main 2 relays shall be connected to separate CT cores, supplied from different DC supplies (DC system 1 and DC system 2), and will act on different CB trip coils.

33.3.5.3 400KV GENERATOR TRANSFORMER PROTECTION

Multifunctional relays shall be used. The functions will be grouped in minimum five multifunctional relays, for main and back-up protection. Transformer shall be equipped for Main and Back-up as minimum with, but without being limited to the following protections:

- Two (2) separate differential protection (87T main 1 and main 2)
- Restricted earth fault protections (87 N stand alone and separate from main 1 and main 2
- Two (2) separate differential protection (87LT1 and 87LT2) including directional overcurrent (67/67N): The first protection 87LT1 shall be connected to the CT in the GIS portion of the 400kV substation while the second protection 87LT2 shall be connected to the CT at the low voltage side of the GSU Transformers bushing in order to cover the GSU Transfomers protection.
- overcurrent protection phase and earth fault (50/51, 50N/51N)
- Unbalanced current protection (46)
- Synchro-Check (25)
- volts per hertz (24)
- overcurrent protection (50G/51G)
- overload protection (49)
- breaker failure protection (50 BF.
- directional overcurrent and sensitive earth fault protection (67/67N)
- unbalanced current protection(46)
- overvoltage protection (59)
- breaker failure protection (50 BF)
- overflux protection (59F)
- undervoltage protection (27)
- disturbance recorder (95DR)

- event recorder (95ER)
- dual stub protection (STUB).

In any case, the following functions shall be activated:

The main protection shall include the following functions:

- differential protection (87T), two winding
- restricted earth fault protections (87 N)
- differential protection (87LT)
- overcurrent protection phase and earth fault (50/51, 50N/51N)
- overload protection (49)
- breaker failure protection (50 BF)
- overflux protection (59F)
- dual stub protection (STUB)
- disturbance recorder (95DR)
- event recorder (95ER) .

Back up protection shall include the following functions:

- overcurrent protection phase and earth fault (50/51, 50N/51N
- directional overcurrent and sensitive earth fault protection (67/67N)
- unbalanced current protection(46)
- overvoltage protection (59)
- under-voltage protection (27)
- breaker failure protection (50 BF).

The protective scheme of the transformer shall also integrate the specific protection devices to be provided for the power transformer (for tank):

- Buchholz alarm and trip
- oil temperature alarm and trip
- winding temperature alarm and trip
- oil level alarm
- pressure relief device -trip function.

The free potential output contacts of these relays shall act via back-up protection relay (separate auxiliary signal and trip relays for mechanical protection).

33.3.5.4 400KV REACTOR PROTECTION (LINE BAR)

Multifunctional relays shall be used. The functions will be grouped in minimum three multifunctional relays, for main and back-up protection. Reactor shall be equipped in three (3) terminals (Main and Back-up) as minimum with, but not limited to the following protections:

- differential protection (87)
- restricted earth fault protections (87N stand alone and separate from main 1)
- overcurrent protection phase and earth fault (50/51, 50N/51N)

- directional overcurrent and sensitive earth fault protection (67/67N)
- overvoltage protection (59)
- breaker failure protection (50 BF)
- disturbance recorder (95DR)
- event recorder (95ER).

In any case, the following functions shall be activated:

The main protection will include the following functions:
- differential protection (87)
- restricted earth fault protections (87N stand alone and separate from main 1)
- overcurrent protection phase and earth fault (50/51, 50N/51N)
- breaker failure protection (50BF)
- disturbance recorder (95DR)
- event recorder (95ER).

Back up protection:
- directional overcurrent and sensitive earth fault protection (67/67N)
- overcurrent protection (50/51, 50N/51N)
- overvoltage protection (59)
- breaker failure protection (50BF)
- disturbance recorder (95DR)
- event recorder (95ER).

The protective scheme of the reactor shall also integrate the specific protection devices to be provided for the reactor (for tank):
- Buchholz alarm and trip
- oil temperature alarm and trip
- winding temperature alarm and trip
- oil level alarm
- pressure relief device -trip function

The free potential output contacts of these relays shall act via back-up protection relay (separate auxiliary signal and trip relays for mechanical protection).

33.3.5.5 400KV BUSBAR PROTECTION

The busbar protection shall be of low-impedance type including at least two independent measuring criteria for the release of a trip command and using two separate CT cores. The following features are to be considered minimum requirements:
- selectivity for clearing faults on the respective busbar independent of operational configurations
- fault clearing times under 30ms including own tripping relays
- independent measuring elements for each phase
- automatic testing facility

- extension capability
- teleprotection, trip transfer to the opposite substation.

The busbar protection shall integrate a breaker failure protection with overcurrent supervision.

The bus bar protection shall be equipped with the following relays, but not limited to:
- bus bar protection (87BB)
- breaker failure protection (50BF)
- disturbance recorder (95DR)
- event recorder (95ER).

33.3.5.6 6.6/0.415KV AUXILIARY SYSTEM PROTECTION

The protection of the two auxiliary transformers and their cable connections from the Plant is located within the Plant.

33.3.5.7 EVENT FAULT AND DISTURBANCE RECORDING

Event fault and disturbance recording shall be incorporated in SAS and separate stand alone DFDR (PGCB's or UK) is required for complete 400kV Substation complying all bays, bus bars and bus coupler.

33.3.5.8 DISTURBANCE AND EVENT RECORDING EVALUATION WORKSTATION

For evaluation of the disturbance and event information at the bay level, all recorded data shall be automatically uploaded (event triggered or once per day) on a dedicated workstation situated in the control room of the substation (Service and Analysis System Station). The required hardware is described in the SCMS specification and termed as Digital Disturbance Recorder (DDR).

The scope of supply includes all required equipment, software, communication links and installations to enable the off-line disturbance analysis and the proper connection with the protection units.

The disturbance recording and event file transfer features are described in the protection management specification of the SCMS. Under this function, the capability of reading out and writing information from/to the protection of the 400kV system and in particular parameterizing, setting, visualizing and analyzing disturbance, and event recording through the Service and Analysis System Station are realized, where:
- the SCMS shall use standardized IEC protocols.
- a modem-connected evaluation station situated at a remote location such as NLDC shall be provided (scope includes all required modems and software licenses for the remote evaluation station).

33.3.5.9 PROTECTION SETTINGS AND RELAY SOFTWARE

The Contractor shall perform the protection coordination study and relay settings for the complete 400kV Substation protection and submit to the Employer/the Engineer. The study/relay settings shall be performed for all involved substations considering all relevant substations voltage levels and other protection settings. Adjustment of settings for the neighboring substations shall be considered/proposed as well (adjustment for these stations will be performed by the Employer). The Contractor shall request in due time the necessary data from the Employer. Data not available shall be estimated / calculated by the Contractor.

For each location of the supplied terminals and each terminal type, the Contractor shall deliver a complete set of setup software, manuals and firmware files.

33.3.5.10 INSULATION COORDINATION STUDY

The Contractor shall perform the insulation coordination study for the complete 400kV Substation and submit to the Employer for review and approval. The study shall be performed for all involved substations considering all relevant substations voltage levels and other protection. The outcome of the study shall cover lightning arrestors selection, substation lightning shield protection solutions, etc.

33.4 SUBSTATION CONTROL AND MONITORING SYSTEM (SCMS)

33.4.1 GENERAL

Separate dedicated 400kV Substation Control Room shall be built near the substation area within the Plant boundary providing all the necessary control and monitoring function of the switchgear devices and act as a medium of interfacing between the substation and the Central Control Room.

All circuit breakers and disconnect switches shall be capable of being electrically controlled from the three control positions as follows:

- Local Control: Located adjacent to switching devices, to facilitate maintenance, inspection, and emergency operation.
- Remote Control: Located at the substation control room within the substation area, where all the necessary controlling and monitoring of switching devices are controlled.
- Supervisory Control: Located at the Load Dispatch Centre (NLDC) at Dhaka, for remote control and supervision via the tele-control systems.

All the necessary control-selector switches, position indicating contacts, interposing relays, signals for A, V, W, etc. indications shall be included in the scope of supply.

The Bidder shall offer new SCMS at the 400kV Substation with all equipment as shown in the Electrical Main Wire Diagram (10-PE-PAY-01). The offered system shall fulfill the functional requirements as detailed in this section. The SCMS to be provided shall include as a minimum the following equipment:

- All field equipment such as bay control units and bay protection equipment. The field equipment for the substation shall be interconnected by separate IEC 61850 fiber optic station busses in ring configurations.
- All equipment to control and monitor the auxiliary equipment of the substation connected to the SCMS by redundant fiber optic links.
- Common bay unit / station computers.
- GPS receiver and clock for time synchronization of the individual SCMS equipment and the substation clock system.
- Two (2) operator and one (1) engineering workstations with three (3) 21 inch TFT monitors each and 2 printers to be installed at the substation control room.
- All equipment necessary for the implementation of an OPC server/client architecture between the substation and the Plant control rooms in order to allow supervision and monitoring of the substation from the Plant DCS facilities. The OPC-server configuration shall be redundant.
- The substation control unit shall include the following equipment for each bay:
  - Mimic diagram with position indication for all circuit breakers, disconnectors and earthing switches;
  - Bay Unit;
  - Current value for each phase;
  - MW value;
  - MVAr value;
  - 1-20 alarms with accept/test/reset function
- One (1) maintenance / service laptop which shall also be used for protection and disturbance analysis by respective log-in.
- Data Communication Gateway to the National Load Dispatch Center (NLDC). The type and amount of data to be exchanged between the substation and the NLDC shall be freely programmable. The gateway shall provide for the IEC 60870-5-104 protocol. However, IEC 60870-5-101 shall also be provided.
- Main and backup/check energy meters for active energy (kWh) with accuracy of 0.2 S and for reactive energy (kVarh) with an accuracy of 0.5 S for tariff metering shall be provided for each 400kV outgoing line as well as for each generator transformer and the standby/start-up transformer.

33.4.2 SCMS SYSTEM HARDWARE

- One (1) lot Station computer, incl. panel
- One (1) lot Common bay unit, incl. panel
- One (1) lot Clock System
- Two (2) lots Interface to remote control centers (NLDC and a future control center)
- One (1) lot Station bus, gateway/bridge/router incl. firewall
- One (1) lot Interface (Gateway) to SCMS
- One (1) lot Operator and Engineering workstations incl. three monitors and two hard-copy printers

- One (1) Service/Analysis-Laptop
- One (1) lot OPC server/client with redundant servers.

33.4.3 SCMS SYSTEM SOFTWARE

All necessary software for control and monitoring at the bay level as well as related equipment (Bay control units) shall be provided and installed by the Contractor for:
- two (2) pc 400 kV Line Bay control units
- two (2) pc 400 kV Line Reactor Bay control units
- two (2) pc 400 kV Generator Bay control units
- two (2) pc 400 kV Center Breaker Bay Control units.

All necessary software for protection at the bay level as well as related equipment (Bay protection units-IEDs) shall be provided and installed by the Contractor for:
- two (2) pc 400 kV Line Bay
- two (2) pc 400 kV Line Reactor Bay
- two (2) pc 400 kV Generator Bay
- two (2) pc 400 kV Center Breaker Bay.

33.5 TELECOMMUNICATION EQUIPMENT

The Contractor shall provide telecommunication (communication, telemetry, fiber optical terminal, and tele-protection equipment) equipment for the substation control building.

The Contractor (in consultation with Employer) shall provide suitable interface units for communication links to the Employers SCADA system for communication, control, monitoring and voice channels required for Employers National/Regional Control Center. The wiring of all signaling and control circuits required for the system shall be cabled out to interface marshalling cubicles to be provided by the Contractor. Cabling between the Contractor's cubicles and Employers LDC equipment shall be provided and installed by the Contractor.

33.6 AC/DC INSTALLATIONS

The complete equipped AC/DC installations are included in the scope of supply and services and shall consider for future extensions of the 400kV switchgears, but without limited to the following:

- two (2)sets of auxiliary power transformers 6.6/0.4 kV
- two (2) complete sets of 220V batteries
- one (1) set of 220V DC distribution system
- two (2) sets of rectifiers for 220V DC
- two (2) complete sets of 48V batteries
- two (2) set of 48V DC distribution system
- two (2) sets of rectifiers for 48V DC
- 0.4kV AC distribution system

- UPS suitable for complete substation needs.

For both the sizing of batteries and AC/DC system, the contractor shall perform a calculation

33.7 POWER AND CONTROL CABLES, BUS DUCTS

Complete cabling with accessories, including mainly, but without limited to:

- 6.6kV XLPE cables between power plant and substation control building
- low voltage cables for 0.415kV power and AC/DC supply, control, protection, signaling, lighting, LV power consumers etc. including all accessories as required within the substation and between the Plant and substation.

33.8 TARIFF METERING

Electrical energy shall be delivered at the HV side of the Generator Step Up (GSU) Transformer .

The transferred electrical energy shall be measured by main and backup/check metering systems in the following bays:

- Generator Step-up Transformers
- Standby & Startup Transformer

Electrical meters shall fulfill the requirements in Electricity Grid Code of Bangladesh, and specific requirements spelled out in this Employer's Requirement.

In the room for metering, space for the future extension shall be foreseen.

33.8.1 CURRENT TRANSFORMER (CT)

Following is the specification of the CT:

CT secondary:	1A
A//ccuracy class:	0.2
Knee point:	Vk<40V

The rating of the CT shall be selected based on the connected load (VA). The connected load burden shall be 25% of the CT rating. The main and back-up metering shall have independent CT cores respectively.

33.8.2 VOLTAGE TRANSFORMER (VT)

Following is the specification of the VT:

VT secondary: 110V
Accuracy class: 0.2

The rating of the VT shall be selected based on the connected load (VA). The connected load burden shall be 25% of the VT rating. The VT shall be IVT type. The main and back-up metering shall be from independent VT winding respectively.

33.9 GRID INTERFACE REQUIREMENTS

The Contractor's supply of generator, controls, and equipment shall enable the Plant to meet the following grid requirements:

Grid System Frequency Variations

The frequency of the Grid System shall be nominally 50 Hz. The Contractor shall ensure that variations of the grid frequency can be accommodated by the turbine-generator separately and in combination. Limitations of frequency and excursion durations shall be as per Bangladeshi Grid Code. Further, the turbine-generator shall be designed to operate continuously over the frequency range of 48.5 Hz to 51.5 Hz, and shall be capable of operating at contingency conditions. The Facility shall be capable of continuous operation for the periods defined in the following table:

Frequency Range (Hz)	Minimum Sustainable Operation
48.5 to 51.5	Continuous
47.5 to 48.5	At least 10 minutes
Less than 47.5	Trip Condition
Greater than 51.5	Trip Condition

Grid System Voltage Variations

The operational capability of the Plant shall be subject to reactive power flow level restrictions associated with the Plant. Permissible operating voltage limits shall be as specified in the following table:

System	Operation	Voltage Limits
400kV	Normal	-10%/+5%
400kV	Protection trip settings	110% for 20 seconds

The Contractor shall ensure that variations of the grid voltage can be accommodated by the generator. Limitations of voltage and excursion durations shall be expressly identified in the Bangladeshi Grid Code.

Fault detection and clearing limits

Fault detection and clearing limits for faults cleared by the unit's protective relays. The Contractor shall ensure that the maximum fault clearing time with the Plant in service shall not exceed the following:

For faults detected and cleared by primary protective relays	Estimated at 110 ms for the 400 kV Grid (HV side of GSU) Breaker – Subject to the requirements provided by the Grid System Operator based on power system dynamic analysis for the 400 kV grid breaker
For faults detected and cleared by back-up protective relays	Estimated at 180 ms - Subject to the requirements provided by the Grid System Operator based on power system dynamic analysis for the 400 kV grid breaker
For faults detected and cleared by breaker failure protection	Estimated at 310 ms – Subject to the requirements provided by the Grid System Operator based on power system dynamic analysis for the 400 kV grid breaker

Electrical Relay Protection Systems

As a minimum, the interconnection to the Grid System shall include the Contractor supplied protection equipment required for the Employer to protect the transmission line from the GSU transformer to the substation. The Employer shall provide the line protection relays required for the transmission line and substation alarm points which shall be monitored in the Central Control Room. The Contractor shall coordinate the final interconnection relay protection requirements with the Employer.

Metering Point

The meters for gross electrical energy output of the generator, standby/startup transformer and unit transformer shall be wired to the Central Control Room. Metering accuracy for the current transformers and voltage transformers shall be 0.2 percent (0.2%). Current transformers and voltage transformers shall be outdoor type. The tariff main and backup active power and reactive power meters for plant and standby/startup transformer shall be located in the 400 kV Substation control building.

PGCB's Communications Interconnections

The information interfaces between the PGCB System and the Plant shall be supplied, installed and commissioned by the Contractor and shall be a redundant IEC 60870-5 CS-101 slave gateway for interface with the Load Dispatch Centre. Terminal point will be at a remote terminal unit located in the 400 kV Substation. The Contractor shall coordinate with the Employer and PGCB for the installation and commissioning of the interfacing system at the substation control room. The Employer shall endeavour to facilitate this coordination with PGCB.

The following cabling shall be provided by the Contractor between the Plant and the 400kV Substation:

1. The NLDC AGC signals will be transmitted to the Plant’s Central Control Room through the 400kV Substation Control Building. The Contractor has to provide

fiber optic from CCR to the Substation Control Building and protocol IEC – 101 will be used in compliance with the Grid Code requirement. Converter for the fiber optic is to be provided by the Contractor.

2. Hardwire cabling between the Plant and to both the marshalling kiosk at the 400kV Substation and the relay for the necessary control and protection. Control and relay panels in the control room and marshalling kiosk at the 400kV Substation are to be provided by the Contractor.
3. Hardwire cables (RS485 or MODBUS TCP/IP), for remote reading at the Plant's Central Control Room.

Normal mode of operation

The connection of generators to the Grid System shall be accomplished by closing the HV breaker (at 400kV Substation) dedicated to that unit. Before the breaker is permitted to close, the conditions for safe synchronizing shall be satisfied and the generator will then be synchronized with the Grid System.

Communication of Dispatch Instructions in normal circumstances shall be accomplished as follows:

1. Via telephone contact between the Grid System Operator's dispatch control centre and the Plant Central Control Room
2. Via Fax Message

Gross hourly MW and MVAR readings shall be transmitted to the Grid System Operator's dispatch center by SCADA. In the event of a failure of SCADA, the communication shall be by telephone.

While the unit is in service, all monitoring, control and protection systems, including metering, voltage regulation, governor control and communications systems associated with the unit shall be in service.

Prior to installation, all metering devices shall have passed initial calibration tests as required by the relevant Laws and codes and be in possession of a calibration certificate issued by the Contractor.

The Contractor shall inspect, test, and calibrate the metering system upon installation. The Contractor shall provide the Employer with reasonable advance notice of, and allow a representative of the Employer to witness and verify, such inspections, tests, and calibrations.

The metering system shall be jointly sealed. No Party shall have a right to remove any such seal without the written consent of BPDB and the Employer, except in an emergency.

All testing and calibration performed on metering devices and on the entire metering system shall be conducted in compliance with mutually agreed procedures between BPDB and the Employer, and in conformance with related manufacturer's recommendations.

The Power Station shall connect to the 400kV grid at the 400kV Substation. The transmission line from the HV side terminals of the GSU transformer to the substation shall be provided by the Contractor. The substation shall be of one and half breaker design. The Power Station will connect to a separate, dedicated position at the substation.

The design of the equipment and systems provided by the Contractor shall fully comply with the technical design and operational criteria of the Grid System Operator, relevant portions of the Grid Code, relevant metering and protection codes necessary for the Employer to secure a connection agreement with the Grid System Operator. The Plant shall be capable of operating continuously for faults in the Grid System close to the Plant by the primary protection within the time stipulated in the Grid Code. The Contractor and Employer shall coordinate with the Grid System Operator on an appropriate maximum fault clearing time in case of breaker failure (due to the physical size of the turbine-generator set). In order to make sure that the electrical systems proposed are satisfactory, AC and DC system analysis shall be included. The studies shall include fault levels, load flows, voltage regulation (both steady state and during motor starting) and stability studies. Fault level studies shall take full account of the contribution from motors and the increased fault levels arising from the running of the diesel generator in parallel with the supply system during on-load testing.

33.10 SUBSTATION OUTDOOR LIGHTING

Complete outdoor lighting for 400kV Substation area, roads and buildings including coordination with overall system is part of the scope of supply and works. For detailed requirements on lighting please refer to Chapter 6 of Section 5.

33.11 EARTHING SYSTEM & LIGHTNING PROTECTION SYSTEM

Complete earthing system and lightning protection system for 400kV area, and all substation buildings, incl. coordination with overall system, is part of the scope of supply and works.

33.12 POWER & AUXILIARY SYSTEMS FOR 400KV AREA, INLC COORDINATION WITH OVERALL SYSTEM

Complete power and auxiliary system for 400kV Substation and substation buildings, including coordination with overall system is part of the scope of supply and works.

33.13 FIRE DETECTION, ALARAM AND FIRE FIGHTING SYSTEM

The substation shall be equipped with Fire Detection, Alarm and Fighting System according to the Employer’s Requirements and local requirements.

Additionally fire extinguishers shall be provided to the control building at least one (1) per electrical room and in any case in accordance with local requirements.

33.14 TELEPHONE, SECURITY AND SURVEILLANCE SYSTEM

Telephone, Intrusion detection and CCTV surveillance system shall be provided based on requirements in Chapter 7 of Section 5.

33.15 SUBSTATION OTHER SUPPLY AND SERVICES

For other supply and services related with the substation, the requirements are given in the following Chapters:

- Chapter 4 for Civil, Structural and Architectural works
- Chapter 3 General Specification for Training, Spares Parts, Special Tools, Consumables and shop tests

33.16 PARTICULAR TECHNICAL REQUIREMENTS

33.16.1 GENERAL

The requirements specified is this section as well as further provisions of other sections of this specification, shall apply, where applicable. The specified data of the equipment can be seen from the relevant data sheets. All materials and equipment offered and installed shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according to the latest technological methods, suitable for outdoor operation, under the specified ambient conditions.

The Contractor is responsible that all relevant safety requirements are observed closely during manufacturing, transportation, assembling, erection, tests and trial operation until final handing over.

The project shall be executed on a turnkey basis. In order to match the project scope with the different financial sources of the overall budget and create packages, which are able to attract sufficient international competition leading to reasonable prices it has been proposed and was agreed to handle the project in two packages: substations and overhead lines.

This will create the need for considerable coordination between these different packages, but it is believed that the benefits of such split-up prevail over the disadvantages.

The scope of supply and services will cover the calculation, design, manufacture, assembly and acceptance testing in the Contractor's workshop as well as the supply, customs clearance, delivery, unloading, erection, adjusting, painting, identification, commissioning, acceptance and testing of new equipment to be installed in the existing substations complete in every respect and suitable for satisfactory operation.

33.16.2 BASIC SYSTEM VALUES

33.16.2.1 400KV BASIC SYSTEM VALUES

The basic technical values to be used in the technical specifications will be in accordance with the existing 400kV systems in Bangladesh and with the recommendations of IEC 60038, IEC 60071-1, IEC 60071-2 and other relevant IEC publications.

All equipment shall be designed and constructed so as not to cause interference with radio reception or telephone communication circuit in accordance with most modern practice, and as generally defined in IEC 60694 and CISPR 18-1, CISPR 18-2 and CISPR 18-3. Limits of Radio Interference Voltage are 500 micro-volts for each equipment measured in accordance with IEC 60694.

33.16.2.2 BASIC SYSTEM VALUES 415V AC

For LV installations, the relevant IEC and VDE standards shall apply, in particular IEC 60038 and VDE 100.

For the project, low voltage AC is to be considered only for the extension of the AC supply of the substations.

The following values are applicable:

nominal voltage:	415/230 V
Voltage variation max.:	± 10%
system configuration	3 phase (4 wires), solid earthed (earthed neutral system)
rated current:	250 A
test voltage:	2.5 kV (1 min.)
min. insulation resistance phase to phase:	400 kΩ
phase to earth:	230 kΩ

33.16.2.3 BASIC SYSTEM VALUES LOW VOLTAGE DC

DC voltage for substation control system

nominal system voltage:	110 V DC
type of battery:	Lead Acid
capacity corresponding to a discharge time of:	10 h
test voltage:	1.5 kV (1 min.)
min. insulation resistance:	110 kΩ
DC voltage for communication system	48 V DC

33.16.2.4 BASIC SYSTEM VALUES CONTROL AND PROTECTION SYSTEM

Nominal measuring voltage:	110 V AC
Nominal measuring current:	1 A
Auxiliary voltage:	110 V DC

33.16.2.5 BASIC SYSTEM VALUES LOW VOLTAGE DC FOR COMMUNICATION

DC voltage for substation communication system

- Nominal system voltage: 48 V DC
- Type of battery Valve Regulated Lead Acid Battery
- Capacity corresponding to a discharge time of: 10 h

33.17 BUSBAR, GANTRIES AND CONNECTION

33.17.1 EQUIPMENT SUPPORT, GANTRIES AND OTHER STEEL CONSTRUCTIONS

All equipment supports and other steel constructions have to be designed and erected according to the current editions of EN 50341 parts 1 and 3 and other relevant standards, considering the local conditions and a safety factor of 2.0.

Rolled steel sections, flats and plates used shall not be inferior in strength and quality to those specified as S235 and S355.

33.17.2 GALVANIZING

Except where specified to the contrary, all iron and steel used in the construction shall be galvanized. Galvanizing shall be applied by the hot dip process not less than 610 g/m2 (for all parts except steel wire or bolts which are addressed in the next paragraph). The zinc coating shall be smooth, clean and of uniform thickness and free of defects. The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated materials.

33.17.3 CONSTRUCTION REQUIREMENTS

All members shall be secured by means of bolts and nuts with plain and spring washers. The diameter of bolts and nuts, which are mechanically stressed, shall not be less than 12mm and shall have metric screw threads. Nuts and heads of all bolts shall be of the hexagonal type.

All bolts and screwed rods shall be galvanized (min. 300 g/m2), including the threaded portions. All nuts shall be galvanized with the exception of the threads, which shall be greased. When in position, all bolts or screwed rods shall project through the corresponding nuts but such projections shall not exceed 10 mm.

33.17.4 BUSBARS AND CONNECTIONS

For 400kV OHL gantries and all connections within the substations aluminum-steel conductors shall be used.

All connectors shall be of aluminum-alloy and shall have a current carrying capacity and strength equal to or greater than the buses for which they are used. The material of the connectors for ACSR conductors must be free from copper

33.17.5 POST TYPE INSULATORS (IF ANY)

The insulators shall be of outdoor, solid core station post type. The insulators shall conform as a minimum to the applicable requirements of IEC 60168 latest edition, and other IEC recommendations or equivalent standards.

The maximum force encountered during a full short circuit plus force of own weight of insulators and connected equipment such as clamps and conductors, shall not exceed the minimum cantilever strength of the insulator.

Porcelain shall be manufactured by the wet process and shall be one piece, non-porous, homogenous and free from cavities or other flaws. The glazing shall be uniform in brown color and free from blisters, burns and other defects and shall meet all applicable requirements of IEC 60273 standard.

33.17.6 STRING INSULATORS

For connections of the incoming/outgoing overhead lines to the substations, string insulator assemblies on the dead-end gantries shall suspend the respective conductors.

They shall be long rod composite silicon rubber type string insulator sets assembled from insulator units. The specific creepage distance shall be at least 53.7mm/kV (According to the latest edition of IEC 60815 -USCD).

The insulators shall be assembled with all necessary bolts and fittings. The electrical and mechanical design shall comply with relevant IEC recommendations.

33.18 400KV GAS INSULATED SWITCHGEAR

33.18.1 GENERAL

The design and performance of the switchgear shall comply with this Specification and the latest revision of the relevant International Electro technical Commission (IEC) Standards.

The principle single line diagrams are given in Annexes as well a layout of the switchgear units in Annexes.

Key electrical data are indicated in the Technical Data Sheets.

The design of the SF6 gas insulated metal enclosed switchgear shall comply with IEC Publications 62271-1, 62271-100, 62271-102 and 62271-203.

The switchgear shall be single-phase encapsulated and it shall be designed in such a manner so as to avoid any effects of VFTO (very fast transient overvoltages)

The switchgears shall be supplied complete with all auxiliary equipment necessary for safe operation, routine and periodic maintenance and repairs, as well as for the storage of used SF6 gas prepared for refurbishment.

The switchgears to be supplied shall have rated impulse and power frequency withstand voltages equal to or greater than the specified levels, at the minimum operating SF6 gas density or pressure.

The actual guaranteed withstand voltages, applicable to the maximum filling pressure at 20°C minimum and nominal SF6 gas pressures, shall be given in schedules.

The minimum clearances between phases and from phase to earth at the minimum working density shall be consistent with the specified impulse withstand level. In the event of leakage from any compartment, the equipment shall withstand rated voltage with SF6 at atmospheric pressure.

For performance assessment, the continuous power frequency withstand voltage with the SF6 gas at atmospheric pressure shall be stated in the schedules.

The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for synchronizing operation for breakers.

Dielectric strength curves of GIS shall be submitted (insulation level in relation to gas pressure)

The switchgear shall operate satisfactorily and safely under all normal and fault conditions. Arc faults shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. Routine replenishment of insulating gas shall not be required in intervals of less than ten (10) years.

The thermal rating of all current carrying parts shall be of 50kA for 400kV GIS , for a minimum of 1 second for the rated symmetrical short-circuit current. Bracing of all mechanical components shall withstand the effects of short-circuit currents as indicated, 2.5 times the rated symmetrical short-circuit current.

Bus bar connections and enclosures shall be designed to absorb the effects of thermal expansion without application of stress to the supporting structure.

The layout and arrangement of the switchgears shall fit in the available space. However, the layout may be adjusted as necessary to suit the manufacturer's standard design, subject to the provisions of this specification and the approval of the Employer.

Equipment foundation requirement details, complete with floor and structure fixings and consistent with the switchgear design shall be provided at an early stage in order to be incorporated into the civil works design.

The arrangement of the individual switchgear bays shall comply with the Single Line Diagrams and shall be such so as to achieve optimum space-serving, next and logical arrangement, and adequate accessibility to all external components. Space for the later extensions using cable or GIL connections shall be foreseen. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

For routine inspections and maintenance, all elements shall be accessible without removing support structures. The removal of individual enclosure parts, or entire breaker bays, shall be possible without affecting the adjacent compartments and bays, respectively, obtaining their continuous operation.

The design of the switchgear bays shall minimize assembly work during installation.

The manufacturer shall design an air conditioning/ventilation system for the switchgear systems, if necessary, and submit calculations showing all heat losses of conductors and enclosures to prove the adequate dimensioning considering the most unfavorable operational and ambient conditions.

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance shall be unambiguous.

The following provisions shall be made for control and indications:

- Local Control cubicle placed next to equipment control of circuit breakers, disconnectors and earthing switches complete with electromechanical indications, mimic diagram, gauges or density monitors and alarm annunciator
- PD sensors incorporated in the GIS enabling UHF partial discharge control during site testing, routine and maintenance testing
- remote panel in the control room on the site control of circuit breakers, disconnectors and line side earthing switches with position indication in each instance
- supervisory control from the system control centre provision of control of circuit breakers, disconnector, earthing switches and high speed earthing switches
- all necessary local/remote and remote/supervisory control switches, relays, interposing relays and selector switches are to be provided
- all main and operating parts of the switchgear shall be suitably labeled; this shall include but not necessarily be limited to primary switches, auxiliary switches, gauges and valves
- circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle.

Busbars
Unit (busbars) design will be single-phase enclosed design. The disconnector-earthing switch (three-positioned design) or the disconnector can be situated in the bus bar compartment, having proved ability to withstand heating due to bus bar rated current flow.

Each bay shall have at both ends the barrier spacers for disabling the internal arc propagation over the bus bar. The facilities shall be obtained to enable the evacuation and filling of the maximal bus bar zone in the frame of 8 hours.

The expansion joints will be positioned at every other bay to enable assembling and disassembling work, as well as to cover the thermal dilatation of the bus bars and prevent the stresses on the supporting structure.

End of bus bar will be equipped with barrier spacer, I element and end cover to enable the assembling of the future bay without SF6 gas evacuation under the atmospheric pressure at the neighboring gas compartment.

33.18.2 SAFETY REQUIREMENTS

The switchgears must offer a maximum degree of safety for the operators and bystanders under all normal operating and fault conditions.

It must be impossible to perform operations which may lead to arcing faults.

The primary design goal shall be to avoid any known reasons for internal arcing. Should it occur, nevertheless, the release of pressurized gas into the atmosphere must occur in such a controlled way that personnel standing at the operating position of the switchgear will not be hurt directly by the gas stream or any part of the release device.

Furthermore, no part of the enclosure, or any loose parts, may be blown away in such an event, and no holes may burn through the enclosure as per IEC 62271-203 paragraph 5.102.2, Table 104. The requirements considering the specified 50 kA are the following:

- 200 ms no external effects are allowed, except the activation of pressure relief device
- 500 ms without fragmentation (burn through is allowed).

High speed earthing switches must be able to make full rated fault current minimum 2 times without exchange of contact system.

Maintenance earthing switches must be able to withstand full rated short circuit current for 3s.

Storage springs of breakers and grounding switch actuators must be totally enclosed under normal operating conditions of the switchgear. No moving parts of the switchgear may pose any danger to the operator when standing at his normal operating position.

High speed spring operated earth switches shall be discharged in open/close position, they shall be charged when the command to open or close is given.

All interlocking devices that prevent potentially dangerous and –thus - not allowed operations must be constructed such that they cannot be defeated easily. The actual position of isolators and grounding switches must be positively displayed by mechanical indicators visible from the operating position.

33.18.3 TYPE OF SWTCHGEAR

The 400kV switchgears shall be of the compact SF6 gas insulated metal-enclosed type suitable for accommodation indoors and gas insulated lines (GIL) shall be suitable for outdoors capable of continuous operation under the climatic conditions existing at the site integrating all necessary components for switching, isolating and monitoring as a compact unit.

The arrangement of the switchgear shall be such that particular emphasis is put on the provision of adequate clearance between chambers in order to facilitate maintenance and later extensions.

The spacing of the feeders shall be provided to allow easy installation of the conductors and convenient access to the cable terminations. Intermediate bus sections shall be installed if the standard feeder spacing does not cope with this requirement.

The design shall include all facilities necessary to enable the performance of the specified site checks and tests. The Contractor shall state the test facilities provided and indicate any attachments or special equipment provided for this purpose.

Circuit breakers, isolators, earthing switches, VTs, CTs, cable termination chambers, all and any other chambers and components must be capable of withstanding a gas overpressure of 130% of normal operating pressure continuously.

The welded enclosures have to withstand routine test pressure of 1.3 x design pressure and casted enclosures have to withstand 2 x design pressure. The gas barriers shall withstand maximum possible pressure on one side and full vacuum on the other side. The gas barriers have to withstand routine testing pressure of 2 x design pressure.

33.18.4 POSITION INDICATORS

Position indicators shall be provided for all circuit breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions.

Each pole of the breakers, disconnectors or earthing switches shall have a mechanical position indicator. The device shall be labeled "ON" and "OFF" and shall be clearly visible.

If a disconnector or earthing switch is not in the fully open or closed position, a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

Indicators shall be of a reliable mechanical design and shall be positively driven in both directions by the final drive stage of the contact operating mechanism. Reference marks shall be punched or engraved on the main frame for this purpose. Each indicator shall be clearly visible to operating staff at operating control points and access routes.

33.18.5 400KV CIRCUIT BREAKERS

Operating duty and performance:
The requirements of IEC62271-100 in respect of type tests, service, operation and the making and breaking of fault currents shall be applied to the specified circuit breakers.

Circuit breakers shall be capable of making and breaking short circuit terminal faults in accordance with the requirements of IEC 62271-100 for the specified fault currents.

The temperature rise of current carrying parts shall be limited to the values stipulated above under rated current and the environmental conditions.

All current carrying components shall be capable of withstanding these conditions for a period of three (3) seconds.

The current ratings for the circuit-breakers at ambient conditions shall be as outlined in the Technical Data Sheets.

Evidence shall be provided that enclosures subject to pressures in excess of normal atmospheric pressure during service operation have withstood approved pressure tests without leakage, permanent distortion or any temporary distortion such as might cause mal operation of the circuit breakers. Each circuit breaker shall be equipped with an operation counter to record the number of operations.

Facilities for measurement of circuit breaker contact resistance and timing tests without removal of covers or SF6 gas filling shall be provided. All details of the testing procedures shall be submitted with the Tender.

Means shall be provided to allow access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

Circuit breakers shall use the SF6 gas conforming to IEC as the insulating medium, as well as for arc quenching.

Circuit breakers shall operate on the principle of self-generating gas pressure within the interrupter for arc extinction, e.g. puffer type or auto puffer type. A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with its rated duty.

Gas density switches shall be provided for each phase of the CB, an alarm shall be incorporated to give indication of falling gas pressure prior to the lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by proper equipment.

Circuit breakers shall be complete with spring or hydraulic-operated mechanisms. Where circuit breakers require other services, these shall be included in the supply and erection of the common services installation at the GIS switchgear and shall include alternative back-up facilities.

Emphasis is placed on reliability of design in order to give long continuous service with low maintenance costs.

The Bidder shall include evidence of circuit breakers mechanism reliability on operation in his submission.

Offers of circuit breakers shall include proof (by means of reference lists and end-user certificates) that the type and rating of circuit breakers put forward, a satisfactory period of commercial operational experience of not less than three (3) years in climatic conditions similar to the ones has been obtained.

Test certificates:
Circuit breakers and all other metal-enclosed switchgear modules like bus ducts, disconnectors etc. shall be covered by test certificates and complete test reports issued by an accredited internationally recognized independent short circuit testing laboratory to certify the satisfactory operation of the circuit breakers at duties corresponding to the rated making and breaking capacities of the circuit breakers. The test duty shall not be less onerous than the requirements of IEC 62271-100 or equivalent. Test certificates shall be submitted with the Bid.

Rate of rise of restriking voltage:
Attention is drawn to the transient recovery voltage (TRV) requirements of the BS and IEC Standards. Where not specifically stated in the test certificates submitted with the Bid, the Bidder shall certify that the TRV to which the circuit breaker was subjected during the short circuit tests was the most severe condition that could be imposed by the available test plant for first pole-to-clear factor of 1.5.

Drawings and data with respect to CB operation shall be submitted as per requirement of IEC standards.

Interrupting duties:
Apart from the requirements for interrupting terminal faults, all circuit breakers shall be capable of coping with the interrupting duties produced by the switching of low inductive currents associated with reactors and transformer magnetizing currents, and by the switching

of capacitive currents associated with overhead line, cables and capacitor banks as may be applicable according to IEC 62271-100. Circuit breakers for these duties shall be of the restrike-free type only.

All circuit breakers shall also be capable of interrupting currents associated with short-line faults and the out-of-phase switching conditions that may occur in service.

Fault clearance time:
The overall fault clearance time including relay operating time shall be in accordance with the requirements specified.

Operating mechanism:
The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

Operating mechanisms to be provided shall be for single- and three-phase operation.

The circuit breakers shall be provided with the facility for mechanical and electrical timing of the contacts. Pole discrepancies shall be less than 5ms on closing.

The ability of circuit breakers to perform a rapid open-close-open cycle should be demonstrated. For this purpose, the Bidder shall provide along with the submission of Bid documents, test records with oscillograms for opening (tripping) and closing characteristics.

Anti-pumping relays shall be provided to prevent reclosing if the closing coil remains energized and the circuit breaker fails to latch in the closed position or is tripped during closing.

CB fail protection (CB FP) shall be included in the CB control system with function of CB closing inhibit.

Power closing mechanisms shall be recharged automatically for further operations as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short circuits, circuit breaker operation, or any other cause. Operating mechanisms shall be capable of storing energy for at least one opening and one close-opening operation (O-CO), local to the equipment and without recharging.

Means shall be provided for the local manual "non-electrical" tripping of the circuit breaker, preferably by a shrouded push button and facilities shall be provided for locking off these means of tripping. It shall not be possible to lock mechanically the trip mechanism so as to render the electrical tripping inoperative.

Facilities shall be provided to permit manual slow closing and slow opening of the circuit breaker for maintenance purposes. It shall not be possible to "slow down" or "slow open" a circuit breaker when connected in the normal service condition.

Circuit breakers fitted with DC motor for charging spring-operated closing mechanism shall also meet the following requirements.

When fully charged, the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-O to be performed following the loss of supply to the charging motor.

The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to charge the spring shall not exceed 20s.

The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close whilst the spring is being charged.

Spring closing mechanisms shall be designed in a way that it shall not possible for a fully charged spring to be released inadvertently due to external shock or vibration caused by the breaker opening under short circuit conditions or any other cause.

The mechanisms shall be provided with means for manually charging the spring. This operation may be carried out with the doors of the cubicle opened. During this process no electrical or mechanical operation of the mechanism shall endanger the operator or damage the equipment.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of "spring discharged".

An indicating device shall be provided at the local control panel and the main control room and also over the supervisory system to indicate a spring failing to be charged by a preset time after circuit breaker closing.

Means shall be provided for discharging the spring when the circuit breaker is in the open position without the circuit breaker attempting to close.

33.18.6 400KV CIRCUIT DISCONNECTORS AND EARTHING SWITCHES

Disconnectors and Earthing Switches shall be of the metal enclosed design and shall generally comply with the requirements of IEC 62217-102 and 62271-203.

Isolating and earthing switches shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive. Disconnectors shall be arranged for operation while the equipment is alive, but will not be required to break current other than the charging currents of an open circuit breaker line.

Disconnectors shall be housed in compartments partitioned from the circuit breakers.

It shall be possible with such partitioning and with the disconnector compartments maintained at full gas pressure, to carry out high voltage insulation withstand tests on outgoing circuits, without taking adjacent equipment out of service.

Disconnector and earthing switch operating mechanisms shall comply with IEC 62217-102 and shall be of robust construction, carefully fitted to ensure free action and shall be unaffected by the climatic conditions at site. Mechanisms shall be as simple as possible and comprise a minimum of bearing and wearing parts.

They shall be so designed that the disconnector/ earthing switches cannot be opened by forces due to currents passing through them and shall be self-locking in both, the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be provided suitable for local, remote and supervisory control (supervisory control of earthing switches is not required) and shall be fitted with a removable, manual emergency switch. The mechanisms shall be capable of being locked and secured by padlock in the open or closed position with the motor automatically disengaged.

For supervision purposes the local control panel shall be equipped with position indicators. Nevertheless, local mechanical position indicators shall be provided for all disconnectors and earthing switches and shall be visible from ground level.

The mechanisms shall be electrically operated with provision for local manual operation, if possible. The contacts of these earthing switches shall have the same fault making capability as that of the circuit breaker. The operating mechanism of disconnector and the maintenance earthing switches shall be motor driven.

Slow speed maintenance earthing switches shall be operated from the local position only.

Critical gas pressure drop in the disconnector/earthing switch compartment should block the closing and opening functions.

In the event of driving motor failure, means for hand operation shall be provided which are operable from ground level or walkways provided.

In case, power supply fails in the middle of operation, the driven motor shall not restart upon resumption of power and the disconnector/earthing switch shall be operated, manually only.

All earthing switches shall be assembled so that they may be used to facilitate such tests as CT primary injection, contact timing and voltage drop measurement without the necessity to open gas filled compartments and with a minimum use of tools and special fittings. Detailed means of performing these tests shall be provided.

The earthing cable of these earthing switches shall be fed through a bushing, insulated to at least 2kV DC and connected to earth through a removable earth strap.

Each disconnector/earthing switch shall have its own separate power and control supply.

Disconnectors:
The nominal current ratings of disconnectors shall be correlated to the adjacent circuit breaker ratings.

The disconnectors shall have a short-time withstand current. Disconnectors shall be arranged to permit safe maintenance of any section of the equipment when the remainder is live.

Disconnectors shall be provided with motor driven mechanisms, operated from a low voltage DC supply and shall open and close all three phases simultaneously. It shall not be possible for the disconnectors to open or close inadvertently due to forces which may occur under operational or under short-circuit conditions.

All disconnectors shall be fully interlocked with associated circuit breakers, to ensure safe operation of the equipment under all service conditions. For maintenance purposes, the earthing switches shall be closed and remain locked in this position until the maintenance will be finished. Mechanical and electrical interlocking is required for maintenance and operation.

The insulation level for the isolating distance between disconnector contacts shall be higher than that for the remainder of the equipment as per IEC 62271-203. Disconnectors shall be capable of switching bus charging currents when shunted by a parallel path and capacitance charging currents associated with open bus bar, bushings and capacitor voltage transformers as per IEC 62271-102.

The Contractor shall submit the type test certificate and report to confirm that the disconnectors are able to carry out a load transfer at full load from one bus bar to the other without any reduction or interruption of load.

If the disconnectors are expected to generate fast rising transients during interruption of capacitive currents, adequate protection shall be provided for transient voltage control.

Maintenance earthing switches:
Earthing switches integrally mounted with disconnectors or separately mounted shall be provided for earthing in order to enable safe maintenance. Motor operated mechanisms shall be provided and operated by low voltage DC but it shall be possible to operate the switch manually in emergency conditions.

The earthing switch shall have a short-time withstand current, as specified in the Technical Data Sheets. No burning or welding of contacts shall occur.

Provisions for testing purposes shall be incorporated in the design of earthing switch to facilitate primary current injection tests and other low voltage checks. Fully insulated designs of earthing shall incorporate removable earth links, suitable for the short-time current rating specified. It shall be possible to apply maintenance earths on either side of the test zone for safety reasons.

All earthing switchgear shall be interlocked with associated circuit breakers and disconnectors so that it shall not be possible to close an earthing switch onto a live circuit or to make the circuit alive when the earthing switch is closed.

Facilities for padlocking earthing switches in the open and closed positions shall be provided together with means for isolating the motor drives.

High speed earthing switches:
High speed earthing switches shall comply with the requirements of IEC 62271-104 and IEC 62271-203.

These earthing switches shall be capable of making short circuit current and suitable for high speed power operation. It shall be impossible to slow-close these earthing switches.

High speed earthing switches shall be fully type tested and shall be capable of withstanding the rated peak withstand current and sustaining the rated short-circuit current of the switchgear. They shall be located at all line feeder terminal points and bus bars or other location where there is no certainty that the point to be earthed is not energized. Power mechanisms operated by LV DC shall be self locking in both open and closed positions. High speed earthing switches shall be capable of making and breaking small induced inductive and capacitive currents, as may be necessary to operate the earthing switches for earthing of one out of two or more long parallel lines.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a disconnectable earth strap.

These earthing switches shall otherwise be in accordance with the requirements for maintenance of earthing switches.

33.18.7 400KV CURRENT TRANSFORMER

The current transformers to be supplied suitable for the duty specified and comply with the requirements of IEC 61869 and IEC 61869-2 as appropriate.

Current transformers shall be of the toroidal core type, compatible with the switchgear.

Current transformers shall comply with the requirements of the common sections of this Specification. Where separate terminal boxes are used for current transformer’s secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers including primary conductors shall have a short time current rating and duration not less than that of the associated switchgear. All current transformers shall have sufficient overload capacity to permit continuous operation with currents up to 150% of the rated current of the associated equipment.

Secondary windings of each current transformer shall be earthed through a disconnectable link at one point only, in the relay panel for protection circuits and in the control panel for instrumentation.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments except for protection.

Where double ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer, indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams.

Where multi-ratio current transformers are specified and current transformers with multiple windings are bided, it shall be possible to select either ratio for each winding without alteration to the number of primary turns. All connections from secondary windings shall be led out and taken by means of separate insulated leads to a terminal board mounted in the local control cubicle.

The characteristics of current transformers used for protection circuits shall be fully compatible with the protection relays and shall include the following requirements:

- For overcurrent protection, they shall not saturate, change ratio or produce harmonic voltages in the secondary winding, which will affect the accuracy of the relay with primary currents up to 20 times rate full load current or maximum through fault current, whichever is higher.

- For earth fault protection and balanced forms of protection, when connected as in service, they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable equipment with primary currents up to 20 times rated full load or maximum through fault current whichever is higher.

- Provision shall be made to carry primary injection test of bushing CTs for 100% rating. The partial discharge level permissible shall be less than 10 pC at measuring voltage of 1.2 Um/√3.

The terminal board for CT connection shall have shorting, testing and disconnecting facilities which shall allow tests to be conducted with the circuit on load and which may be operated without disturbing the wiring.

It shall be possible to carry out primary injection rating when the switchgear is fully assembled or re-testing of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits or any part of bus bar. The access for primary injection facilities for site testing shall be clearly stated by the Bidder. Unless otherwise approved, current transformers shall be accommodated separately from to the circuit breaker. Where it is required to accommodate free issue current transformers, the Contractor shall advise the limitations as to types and sizes of current transformers which can be accommodated and material limitations for the transformer to be compatible for use in SF6 gas.

The secondary windings of each set of current transformers shall be capable of being open circuited as per IEC standards with maximum voltage of 4.5kV peak. The secondary wiring of all CTs shall be brought up to a common terminal block located within the local control cubicle.

The magnetization characteristic of all current transformers shall be checked up to 100% current rating to identify the current transformers with reference to the manufacturer's design curve. Special measures may have to be taken to ensure that the core is fully demagnetized before commencing the test.

CTs for protection shall not be used for metering. CTs for protection and metering shall be physically separate.

The rated short time thermal current on all taps shall not be less than the through fault capacity of the associated circuit breakers.

The characteristics of current transformers shall be submitted to the Employer/the Engineer together with details of the protection, instrumentation or measuring equipment with which each current transformer is to be used. Each current transformer shall be capable of providing the necessary output to operate the related devices satisfactorily at the burdens involved.

Current transformers having accuracy classes between 0.1 and 2 may be provided with extended current rating in accordance with IEC 61869-2, up to an equivalent primary current rating not exceeding that of the associated switchgear circuit current rating.

The magnetic characteristics of the CTs of the circuit of each group shall be appropriate for the optimum operation of the protection system.

The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition, labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer winding.

Current transformers shall be located as shown in the Single Line Diagrams.

33.18.8 400KV GIS VOLTAGE TRANSFORMERS

Primary connections shall have the same short time current rating as the associated switchgear.

Each secondary winding of the voltage transformers shall be protected by suitable approved fuses and links. Voltage transformers shall be of dry type, compatible with the switchgear and shall not contain any hygroscopic insulating material which could affect the SF6 gas in either the voltage transformer or in the associated switchgear chamber.

Voltage transformers shall comply with the common sections of this Specification, with the requirements of IEC 61869, IEC 61869-3 for inductive VTs and IEC 61869-5 for capacitive VTs and shall be provided with three (3) secondary windings.

The rated secondary voltage per phase shall be 110/√3 volts in star connected windings and 110/3 in the case of delta connected windings, and the rated voltage factor shall be 1.2 continuously and 1.9 for 30 seconds.

The ratio and phase angle error of the voltage transformers shall not exceed the permissible values specified in IEC standard.

VTs shall be rated for the highest equipment voltage.

Voltage transformers shall preferably be integrated with the compact switchgear system and they shall be compatible with the switchgears. Facilities for isolating the primary connections without having to lift the VT from the switchgear are required. Alternatively, performance VT withstanding high-voltage tests can be supplied.

It shall not be possible for voltage transformer's secondary windings to be connected directly in parallel, except through interposing voltage transformers associated with a synchronizing scheme. To prevent any possibility of back energizing a VT secondary winding via synchronizing circuits, circuit-breaker auxiliary contacts which are of the late make-early break type shall be employed.

Voltage transformers shall be capable of carrying continuously, without thermal damage, 150% of their rated output.

Voltage transformers shall be included in the protected zone afforded by the feeder protection or miniature circuit breakers which shall be located as close as possible to the voltage transformer, preferably within the terminal box. All secondary winding, connections, including both ends of the secondary winding shall be led out to the fuses and links. The fuses and links shall be connected to approved terminal blocks for termination of multi-core cables. A metallic label shall be provided and fixed at the voltage transformer clearly indicating the connections required for each winding. A minimum of 2 main secondary fuses per phase shall be provided to allow the implementation of fuse failure supervision with pre-closing alarm when specified in the scope of work. Protection, synchronizing and instrumentation circuits etc. shall be distributed between the two main secondary circuits and then sub-fused at the local control panel in accordance with the appropriate circuit schematic diagram.

Separate sets of fuse and links or MCBs shall be provided at the VT for:

- each protection scheme

- instruments, disturbance recorder, fault locator etc.
- synchronizing.

VT supply supervision circuit shall be provided.

The circuits for each main protection scheme shall be segregated in separate multi-core cables from the VT to the protection panels. An alarm (VT failure) shall be provided for each set of fuses and MCBs.

The neutral point of each voltage transformer’s secondary circuit shall be earthed at one point only at the local control panel via a separate removable link of approved design. The earth link shall be situated in an accessible position and shall be suitably labeled.

A magnetization and no-load losses curve shall be provided for each voltage transformer up to 110% of rated voltage level for approval by the Employer/the Engineer.

The location of the voltage transformers to be installed on the primary switchgear shall be approved by the Employer / Engineer.

Mechanical shock recorders shall be fitted to VTs prior to dispatch from the factory, to indicate how the VT was handled during transit and to determine if detailed inspection is required at site.

Electromagnetic voltage transformers shall be capable of discharging the capacitance of line, cables and switchgears, which may remain connected to them during switching operations. The Bidder shall declare any limitations of the equipment for this duty.

The Contractor shall ensure that no disruptive overvoltages will be generated due to ferro-resonance phenomena and if necessary, by suitably connecting resistors across the sec Employer/the Engineer.

33.18.9 SF6 LIGHTNING ARRESTERS

For the 400kV GIS bus bars, SF6 lightning arresters are foreseen for bidding purposes. Based on insulation coordination study which belongs to the scope of works, the lightning arresters needed in the bus bars shall be indicated and shall be accordingly selected and designed so as to protect the associated equipment.

The design data shall be proven by calculations and shall be subject to the Employer’s approval.

Lightning arresters shall be of the metal-oxide type without gaps and shall be designed to fulfill requirements of IEC 60099.

A lightning arrester arrangement shall be proposed to suitably protect the switchgear.

The lightning arresters shall be designed as non-linear metal-oxide resistor type without spark gaps.

Each (single-phase) lightning arrester shall be equipped with a suitable lightning counter and an indicator for monitoring of the leakage current.

Lightning connectors shall be designed for continuous operation and shall be capable of passing repeatedly, without distress the maximum discharge current of the arrester. The lightning connector shall be connected to the main earth lead from the arresters. Bolted links shall be provided so that the lightning connector may be short circuited and removed without taking the arrester out of service.

The Contractor shall give evidence about the suitability of the type and location of the employed arresters.

Beside the type tests documented by appropriate certificates attached to the Bid, routine tests shall be performed according to IEC 60099-4 and documented.

The following tests shall be performed as witness tests according to IEC 60099-4 under supervision of the Employer and / or the Engineer:

- Power Frequency Voltage Test on complete arrester
- Lightning Impulse Residual Voltage Test on complete arrester
- Internal Partial Discharge Test
- Thermal Stability Test.

33.18.10 SF6 EQUIPMENT AND HANDLING

Gas compartments:

The switchgear units and bus bar systems shall be divided into several gas-filled compartments, sealed from each other by gas-tight partitions so that any leakage may be quickly localized. The various gas zones shall be further subdivided where necessary to restrict any internal arcing damage, particularly within sections of bus bars and to enable gas handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear. Enclosures shall be designed to minimize burn through in the event of internal arcing.

The number of gas compartments shall be such so as to limit the amount of switchgear which has to be isolated and taken out of service as a result of gas leakages, planned maintenance or internal faults.

Gas section volumes shall be as large as required to minimize the effects of any internal overpressure. They shall be consistent with the need to allow changes in the switching arrangements for maintenance, repair or extension whilst ensuring the remaining parts can remain energized.

The compact GIS bay shall at least consist of the following arc and gas-tight high-voltage compartments:

- busbar per each bay
- disconnector and earthing switch
- circuit breaker compartment
- feeder compartment
- potential transformer
- lightning arrester
- GIL at least each 30 meters.

Each gas compartment shall be provided with facilities for routine checking of moisture content and impurity level in the gas. Gas compartments shall be fitted with permanent connection points for filling, evacuating and gas treatment equipment without moving the switchgear.

Bus bar enclosures shall be segregated into gas-tight compartments of such volumes so as to ensure the minimum necessary time for the SF6 gas evacuation and its subsequent vacuum treatment and refilling

Total time for gas evacuation and filling of the largest chamber shall not exceed 8 hours.

The equipment and connections within each compartment shall be so arranged as to allow easy removal and replacement of any section with minimum isolation and disturbance of adjacent pressurized sections. This feature should also permit the erection and testing of extension units alongside equipment already in service with the minimum of outage time being required for final connections. Outage time requirements shall be clearly indicated in the Tender.

All external gas pipe work shall be connected via vacuum couplings of proven design which will enable joints to be broken and remade without loss of gas.

Suitable arrangements shall be provided for the thermal expansion and contraction of the bus bars and bus bar chambers without detriment to the current carrying capacity or gas volume. Where special tools are involved in the setting up of these arrangements on site, the special tools and full instructions shall be delivered to the Employer by the Contractor.

Special attention shall be paid to the sealing of housing joints so that leakage of SF6 gas is kept less than 0.5% per annum in any single gas compartment.

All metal parts other than those forming part of any electrical circuit shall be connected to the earthing system to create one path for the short circuit current. Any necessary terminals on part of the equipment required for this purpose shall be provided by the Contractor.

The design of the GIS components shall be suitable to avoid the effect of trapped charges generated on the GIS equipment.

To prevent ingress of moisture or leakage of gas during the service life of the equipment, the sealing materials used at all joints and interfaces shall satisfy the following requirements:

- not affected by SF6 gas
- non-hygroscopic, containing no silicon
- non-aging and non-shrinking
- retain resilience for long periods under stress
- stable under all temperature conditions.

Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent extensions. All gas barrier spacers shall be clearly indicated by color banding at each seal.

Expansion bellows, diaphragms and pressure relief devices shall be designed to be free of leakage under the same conditions as stated for seals.

Where the use of cast aluminum is envisaged, the Contractor shall submit to the Employer/the Engineer porosity and extended pressure testing to show the quality of the castings used.

The guaranteed leakage rate of SF6 gas shall be less than 0.5% per annum for each compartment of the switchgear. Initial filling of the equipment must guarantee gas service periods of not less than 10 years. Suitable sensitive leakage tests shall be performed on each shipping unit prior to dispatch from the factory and on all junction points of components assembled at site prior to commissioning.

Pressure relief devices shall be provided for each section of switchgear as appropriate to allow excessive pressure relief. All pressure relief devices shall be located in such a way operation of the devices shall not endanger personnel working on the equipment or in the vicinity of the equipment. Where necessary, the devices shall be fitted with cowls to deflect any gases or fragmented parts away from locations where personnel may be expected to be present. Internal relief devices into adjacent compartments are not acceptable.

Each separate compartment or gas zone must be provided with its own device for monitoring continuously the gas density. This means all phases in case of single-phase design shall have their own gas supervision (no gas piping between the phases. These devices shall be arranged to give individual compartment indication in the local control units and initiation of remote alarms. Means shall also be provided to facilitate the regular maintenance checking of moisture content. Each gas filled chamber shall be fitted with static filters to absorb any moisture which may be present.

In addition, filters for removal of SF6 decomposition products shall be provided in those compartments in which arcing or corona discharge can take place.

The moisture content of the breaker compartment during service shall thereby be kept to a minimum so as to ensure satisfactory operation.

Each gas compartment must have its own independent gas supervision and alarm systems with contact density gauges for alarm and indication. Alarms shall be wired to and indicated in the local control cubicles.

Each compartment must provide the following functions by means of suitable fittings and valves:

- indication of the actual gas pressure by means of temperature-compensated indicators
- monitoring of pressure and alarming of pressure losses in two adjustable stages
- access for evacuating and filling via gas service cart

Especially for the circuit-breaker compartments, the following shall be foreseen:

- Indication and monitoring of pressure and alarming of pressure losses in two adjustable stages and additionally two contacts for blocking of the circuit breaker.

Gas barrier and supporting insulators:

All internal support insulators and gas barriers shall be of a high quality material design to minimize internal and surface electrical stresses. The materials shall be free of voids and partial discharges at the maximum working voltages.

The manufacturer shall submit the proof that all insulators have sufficient margin between Martens point of the insulating material and maximal operating temperature.

Gas barriers shall be gas-tight and of sufficient strength and factor of safety to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions.

Gas seals:

All static and moving gas seals shall be designed to prevent gas leakages and moisture ingress under all normal conditions of service. The materials used for gas seals shall withstand exposure to SF6 gas and its decomposition products without deterioration for the service life of the equipment.

Measures shall be incorporated to eliminate any deterioration of gas sealing surface, finishes and fixings due to the influence of climatic conditions. Seals between different insulating media, sliding or rotating surfaces and those exposed to the risk of deterioration due to their use outdoors shall preferably include multiple seals or other means should be obtained, what is subject of Employer/the Engineer.

The equipment shall be designed to minimize gas leakage which shall not exceed 0.5% per annum by weight for each gas compartment.

Enclosures:

Manufacturers shall take account of the influence of climatic conditions for indoor installation.

Equipment supplied shall be capable of continuous operation at the specified ratings without exceeding the maximum temperature rises stated in the appropriate IEC recommendations. The switchgear room will be vented but not air-conditioned.

The enclosure for the SF6 gas insulated switchgear shall be of aluminum alloy and shall be designed to minimize losses and heating due to circulating currents.

Dimensioning of enclosure shall be such as to safely withstand overpressures caused by internal faults corresponding to maximum fault levels as per IEC 62271-203.

Pressure relief device shall be provided where necessary to prevent excessive pressure rise which could lead to bursting of enclosures and spacers. Circuit enclosures shall be of single phase. All connections and bus bar chambers shall be color-coded to indicate the phase color associated with the connection.

Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes without encroaching on internationally agreed safety factors for this type of equipment. Each enclosure shall be tested and stamped by the inspecting authority issuing the test certificate that shall be independent from the manufacturer.

Ample provision shall be included for access to the circuit breaker, disconnector and earthing switch contacts for inspection and repair.

Voltages induced in the enclosures (touch voltage) shall not be allowed to exceed safe limits of 70V. All enclosures containing discontinuity elements shall be earthed around the discontinuity via two (2) low inductive conductors from each side, having the capacity to withstand the same short circuit current as associated conductive parts inside the enclosures

Each enclosure shall be provided with lifting points to facilitate maintenance or repair works.

SF6 immersed insulation:

Bus bars and items of switchgears shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the gas decomposition products.

Gas barrier insulators and bushings, including gas-oil and gas-air bushings (if any) shall comply with the specified conditions for sealing of enclosures.

The Employer/the Engineer pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature.

The surfaces of insulation in contact with SF6 shall not be glazed or otherwise treated with silica compounds or other materials which may deteriorate in the presence of gas decomposition products due to arcing. Alternative glazing or surface treatment which is compatible with SF6 and its by-products may be acceptable what will be the subject to prove the durability.

The insulation shall be tested for partial discharge free operation at the maximum service voltage according to IEC 62271-203 and other relevant Standards for the equipment.

SF6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

SF6 gas requirements:

All SF6 gas supplied for use in the switchgears shall comply with the detailed requirements of IEC 62271-303 which is the minimum standard acceptable.

The gas systems of the switchgears shall utilize low pressure to minimize leakages and eliminate any possibility of liquefaction at the lowest ambient temperatures.

The GIS equipment shall be designed in such a manner that no heating elements will be required for satisfactory operation within the range of ambient temperatures and pressure encountered under service conditions.

The minimum dew point temperature in unheated SF6 gas filled equipment shall not exceed -20°C at the working pressure.

Gas monitors:

Temperature compensated, digital type, gas density monitors shall be provided for each gas section and gas compartment. Facilities shall be provided to test these monitors without having to reduce the gas pressure.

The gas monitors shall be fitted with density monitors and / or manometers to indicate the gas density / pressure and electrical contacts which shall initiate an alarm to warn that the gas pressure/density is falling to a critical level. In the manometers necessary damping arrangement shall be provided. Manometer and contacts shall be in the same density monitor unit.

For circuit breaker compartments, a lockout feature shall be provided to prevent operation whenever SF6 gas pressure is less than that permitted by the design for satisfactory operation. Contacts shall be included to initiate alarms to warn of this condition.

Two sets of voltage-free electrical changeover contacts shall be provided for every alarm for remote SCADA and repeat alarm facilities in addition to alarm facias, incorporated in the local control panel/marshalling kiosk associated with each primary circuit.

SF6 gas handling:

SF6 is the gas with the highest molecular weight. It is an inert gas, colorless, tasteless and non poisonous. It is heavier than normal air so it will gather at the lowest point, will displace air and oxygen and can cause death by asphyxia. Once inhaled, it can be exhaled only by making a headstand. Locations in which SF6-handling takes place are strongly recommended to have facilities for efficient ventilation to prevent from accidents.

SF6 can absorb a high amount of energy and thus is the ideal insulating and arc quenching gas available. However, SF6 is not a natural gas but man-made. Once released to the atmosphere it takes 3,200 years for neutralization by means of high energy ultra-violet radiation. The impact to the atmosphere caused by 1 kg of SF6 is as high as that of 22.8 tons of CO2 and thus it is a very efficacious greenhouse gas. Therefore, provisions have to be taken to minimize the release of SF6 to the atmosphere.

SF6 Pollution:
During switching operations, SF6 will be subject to decomposition due to the switching arc. It has to be assured by appropriate means that the gas will be held as pure as required for its employment as insulating / arc quenching medium. For this purpose, the content of decomposition products should be as low as possible during service life. Appropriate filters have to be employed where applicable or formation of these decomposition products should be reduced to a minimum. The Bidder shall describe measures considered and provide evidence of effectiveness.

SF6-Recycling:

Measures shall be taken at the GIS to facilitate complete removal of the SF6 for maintenance / repair / extension works. Respective tapping points for all gas compartments shall be easily accessible. The gas shall be stored in containers suitable to serve for the gas of the entire switchgear in its final extent plus 10% spare capacity.

Suitable filtering and handling devices shall be supplied to purge the gas from moisture, decomposition products and other impurities so that the gas can be re-used after completion of the maintenance / repair / extension works. The said equipment shall be handed over to the Employer upon completion of installation and commissioning works.

Temperature rise:
The temperature rise limits shall be in accordance with IEC 62271-203. The switchgear shall be capable of carrying the specified rated current at rated frequency continuously in accordance with normal service conditions as defined in IEC 62271-1.

Any derating to meet site ambient conditions shall be taken into account and declared in the schedules.

Every part of the switchgear shall also withstand, without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the circuit breaker. Rated duration of short circuit shall be taken as one (1) second.

The design of sliding type, current carrying connectors and joints shall be such that they meet the afore-mentioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on site, full details of alignment procedure, together with any necessary alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

The maximum temperature of the external surface of enclosures accessible during normal operation shall not exceed 70°C.

Arrangement/testing facilities:

The switchgears shall be installed in buildings with cable basements suitable for accommodation of all HV and LV cables, both rooms being maintained at a slight positive pressure of filtered air such that any SF6 gas released in the building will be discharged externally via pipes from the lowest point.

The Contractor shall supply the necessary ladders and galleries for access to all levels of equipment during normal operation or maintenance.

The Contractor shall include in his supply power operated lifting appliances as appropriate to the size and weight of component parts of the switchgears which require to be lifted in the course of installation, maintenance or repair.

Testing flanges for connection of testing devices shall be provided where relevant on each circuit for HV withstand testing of switchgears. Each testing flange shall be positioned in a separate gas zone compartment which shall be independent of adjacent disconnector and earthing switch gas sections.

Suitable links shall be provided to allow disconnection of voltage transformers and cable heads without dismantling.

All test equipment and erection tools for the GIS shall be submitted before the end of the commissioning period.

Anti-condensation heaters:

Anti-condensation heaters of an approved type shall be provided inside each cubicle provided for all parts of the project. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall have individual thermostatic control and shall be arranged to cut off when the cubicle internal temperature exceeds between 30 to 35°C. A master heater circuit switch shall be provided on the switchboard or panel with an indicating lamp to show whether the supply is on or off. The location of the heater circuit switch and indicating lamp shall be in such a location that it does not require moving when extensions are provided. The heaters shall be operated from the specified AC supply.

Gas handling equipment:

A gas handling plant shall be provided at each installation to permit emergency topping up of gas in the switchgears in the event of leakage.

In addition, mobile gas handling units, the size of which shall allow full mobility within the switchgear rooms, shall be included for the complete sampling, testing, filtering, drying, extraction and refilling of SF6 gas.

These units shall be self-contained and comprise of a wheeled trolley housing all necessary compressors, gauges, piping and controls, etc., together with gas storage tanks with usable capacity compatible to the design of the switchgear. The capacity of the tank shall be such that at least the content of the biggest three phase gas compartment can be stored. The storage may be gaseous or liquid. Filters shall be provided in order to clean gas taken out of the switchgear or tanks to eliminate impurities such as decomposition products or moisture. The units shall be capable of evacuating air from the switchgear compartments and replenishing them with gas at the end of a maintenance period. They shall also be capable of being used for all gas (SF6, nitrogen and air) operations necessary if replacement of a gas enclosure is undertaken. Facilities shall also allow for circulation of the gas from a compartment through filters in order to extract moisture present.

Additional mobile or static storage shall be provided for use in combination with the gas trolleys and to extend storage facilities.

All necessary pipe work, flexible hoses, couplings, valves, pressure and vacuum gauges shall be included to enable interconnection between the switchgear compartments, gas trolleys and storage tanks and the cylinders provided by major producers of SF6 gas.

An approved SF6 gas leakage detector, oxygen analyzer and moisture meter shall be provided.

To enable safe maintenance to be carried out on any portion of the switchgears when all electrical supplies to the local control units are switched off, a portable gas alarm unit shall be provided. The alarm unit shall be self-contained and capable of giving clear audible warning should the gas pressure in any adjoining gas-filled chamber become unsafe.

Compact GIS manufacturer shall recommend adequate and user friendly recycling equipment for SF6 reuse, provide instruction and technical support.

SF6 gas that cannot be reused on site shall be transported to a specialized Company in appropriate containers with a label according to the contamination level.

The gas handling units shall be suitably sized so as to enable gas evacuation and filling of the largest chamber to be carried out in not more than 8 hours.

33.18.11 ACCESSORIES

Accessories for proper operation of the switchgear shall be included in the base price.

Following accessories for maintenance and repairs shall be included in the scope of supply:

- complete gas service cart, including vacuum pump, compressor and gas pressure vessel for liquefying of SF6-gas, all fittings, connections gauges and hoses
- set of special tools
- breaker withdrawal and maintenance parts
- portable SF6 gas detecting equipment

- SF6 purity (indication of O2 content, dew point, moisture content).

The Tenderer shall describe all accessories in detail to enable an evaluation of the proposal.

33.18.12 TEST OF 400KV SF6 SWITCHGEAR

33.18.12.1 INSPECTION AND TESTING

In addition to the General Specification of Chapter 3, which shall be applied in relation to the general test requirements, the following requirements shall also be applied:

- All relevant documents, test plans and drawings are to be submitted and approved by the Employer/the Engineer prior to the test is carried out.

- Tests shall be carried out in order to determine whether the material and apparatus comply with the specifications. All tests shall be arranged to represent the working conditions as closely as possible. All test results shall be subject to the approval of the Engineer.

- All tests of the equipment both at the Manufacturer's factory and after completion of erection at the site shall be made in accordance with IEC standards if not otherwise agreed by the Engineer. If the IEC standards are not available for the particular test, the scope, standards and methods applied shall be specified by the Contractor and shall be subject of approval by the Engineer.

- Any additional tests apart from those specified below, as may be needed to confirm guaranteed data or to ensure the completeness and safety of the equipment, shall be performed as requested by the Engineer.

- Appropriate standard instruments and other measuring equipment, necessary to carry out the tests, shall be provided by the Contractor.

- A written notice of the time and place of all shop tests shall be given to the Engineer at least four (4) weeks in advance, in order to enable the latter to be present if he so desires. The Contractor's records of all tests shall be furnished to the Engineer immediately on conclusion of each test.

- Following failure of tests, the Contractor shall, at his own expense and within the terms of the Contract, rectify and defect and replace any defective part, as directed by or to the satisfaction of the Engineer.

33.18.12.2 TYPE TESTS AND SPECIAL TESTS

Type test certificates will be accepted for the equipment used in the similar applications if the proposed equipment does not deviate in the relevant technical characteristics and if the type tests are made in an internationally recognized test laboratory and if the reports are not older than 5 years.

33.18.12.3 ROUTINE TESTS

At least the following measurements and tests shall be carried out on the equipment:

- gas insulated switchgear 52 kV and above Test as per IEC 62271-203
- circuit breakers Tests as per IEC62771-100.
- isolating and earthing switches Tests as per IEC62771-102
- current transformers Tests as per IEC 60186, IEC 60186-2
- voltage transformers Tests as per IEC 60186, IEC 60186-3.
- lightning arresters Tests as per IEC 60099-4.

33.18.12.4 SITE TESTS AND OTHER/SPECIAL TESTS

Field acceptance tests after installation of the complete switchgears shall be made according to IEC 62271-203 and shall be subject to agreement between manufacturer and the Employer/the Engineer. The Bidder shall state in his offer, specify the type of tests to be conducted on site. The dielectric tests shall comprise at least a power frequency voltage withstand test and partial discharge test according to IEC 62271-203 Procedure A for 170kV and below and Procedure B for 220kV and above, where partial discharge test shall include UHF or acoustic method. Voltage transformers shall also be tested, erected and assembled to GIS.

Other tests:
The following checks and test measurements shall be made during erection and commissioning in accordance with agreed standards, but not limited to:

- measurement of insulation values
- verification of earthing grid neutralization conditions (e.g. step and touch voltage) in accordance with VDE 101 / IEEE80
- phase rotation
- polarity checks in the case of DC voltages
- protection circuit tests which will be not limited to CT polarity and magnetization curves
- insulation resistance tests of relays, wiring and CTs
- primary injection of all Cuts to prove CT ratio and correct connection of 50, 51, 50 N, 51 N, 67, 67 N, 87 relays
- secondary injection tests for proof of timing tests on the relays and pick-up/drop off values of important auxiliary relays shall be tested
- stability tests and in-zone fault test for differential protection schemes
- operation of tripping elements at reduced DC voltage
- measurement of the end-to-end HF teleprotection channels transmission times
- combined logic tests of HF signaling /protection /autoreclosing /schemes under various simulated fault and operating conditions
- fuses, overcurrent trips, short-circuit trips, time settings, relay settings

- safety signs and warning signs
- setting indicators
- checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- high voltage test on cables and switchgear
- functional test on equipment.

All defects detected as a result of routine or on site testing shall be repaired by the manufacturer and tests repeated at his own expense.

Acceptance of any equipment by the Engineer shall not relieve the manufacturer from any of his performance guarantees, or from any of his other obligations resulting from the Contract.

Where no tests are detailed for items of equipment, a full program of tests shall be agreed with the Employer/the Engineer prior to tests as it may be necessary to prove compliance with the Employer's Requirements.

33.19 INSTALLATION / DISMANTLING

In accordance with the General Specification (Chapter 3 of Section 5), the Contractor shall furnish and install all specified equipment and accessories.

33.19.1 PACKAGING, SHIPPING AND TRANSPORT

Packing, shipping and transport shall be arranged according to the requirements in the General Specification (Chapter 3 of Section 5).

33.20 TRAINING

Works to be done under this section include training of Employer's personnel to operate and maintain equipment efficiently and safely. The main requirements for training are described in the General Specification (Chapter 3 of Section 5). There shall be no constraints on the number and category of Employer's personnel to be person trained.

33.21 DOCUMENTATION

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals and other information in accordance with the General Specification (Chapter 3 of Section 5).

33.21.1 DOCUMENTATION WITH TENDER

The Bid shall contain at least the following information and documents:

- general arrangement, construction and overall dimension drawings of the overhead travelling cranes
- manufacturing specification of the overhead travelling crane

- catalogues, literature and reference lists of proposed equipment
- type test certificates from an independent testing authority or independently witnessed
- Quality Management System Manual and ISO Certificate of the equipment manufacturer.

33.22 OUTDOOR HIGH VOLTAGE EQUIPMENT

33.22.1 GENERAL

This paragraph refers to the following items related to 400kV outdoor equipment:

- coupling capacitive voltage transformers
- current transformers
- lightning arresters
- Line traps and Line Matching Units
- post insulators.

33.22.2 COUPLING CAPACITOR VOLTAGE TRANSFORMERS

Capacitor voltage transformers shall be used for measuring and protection purposes, as well as coupling capacitors for PLC coupling. All capacitor voltage transformers shall comply with the Specifications and IEC 60186, in the same order of precedence. Type test certificates of renowned laboratories have to be submitted with the Bid. For Technical Data please refer to the Technical Data Sheets.

Series-connected capacitor elements shall be housed in insulators of brown glazed porcelain. The units shall be hermetically sealed, and means shall be taken to allow for thermal expansion of the oil contained. The HV terminal shall be suitable for accommodation of an adapter (to be included in the supply) for the bundled phase conductor.

A sealed and oil-filled enclosure at the base of the HV unit(s) shall enclose an inductive circuit with a transformer, secondary terminals, a ferro-resonance suppression device, an overvoltage protection device, earthing switch, draining coil. The ground pad shall be suitable for connection of a cable shoe for the earthing conductor of up to 120 mm^2.

The CCVT shall be mounted on a pedestal of galvanized steel lattice, to be included in the supply. The top fitting shall be suitable to carry a line trap.

Coupling Capacitors shall be tested in accordance with IEC 60186.

Additional to the tests required therein the following test shall be performed:

- measurement of capacitance
- measurement of dielectric dissipation factor.

33.22.3 LIGHTNING ARRESTERS (CONVENTIONAL OUTDOOR TYPE)

Lightning arresters shall be selected and designed to protect the associated equipment.

The design data shall be proven by calculations and shall be subject to the approval.

Outdoor lightning arresters shall be of the metal oxide type without gaps and shall be designed to fulfill requirements of IEC 60099.

A lightning arrester arrangement shall be proposed to suitably protect the switchgear. The switchgear will be connected via strung bus and overhead lines to the network system.

The lightning arresters shall be designed as non-linear metal-oxide resistor type without spark gaps.

Each lightning arrester shall be equipped with a suitable lightning counter and indicator for monitoring of the leakage current.

Lightning connectors shall be designed for continuous operation and shall be capable of passing repeatedly without distress the maximum discharge current of the arrester. The lightning connector shall be connected to the main earth lead from the arresters. Bolted links shall be provided so that the lightning connector may be short circuited and removed without taking the arrester out of service.

Outdoor arresters shall be supplied complete with supporting steel structures. The material used for terminals shall be compatible with that of the conductors to which they are to be connected.

The Contractor shall give evidence about the suitability of the type and location of the employed arresters.

Beside the type tests documented by appropriate certificates attached to the Bid, routine tests shall be performed according to IEC 60099-4 and documented.

The following tests shall be performed as witness tests according to IEC 60099-4 under supervision of the Employer and / or the Engineer:

- Power Frequency Voltage Test on complete arrester
- Lightning Impulse Residual Voltage Test on complete arrester
- Internal Partial Discharge Test
- Thermal Stability Test.

33.22.4 LINE TRAPS

33.22.4.1 GENERAL

The line traps shall be constructed and tested in accordance with the guidelines stipulated in IEC 60353. There shall be two types.

Each line trap shall be provided with a shunt connected protective device in the form of a lightning arrester of the non-linear resistor type in accordance with IEC 60099.

Where the tuning device comprises two circuits via a series resonant circuit and a capacitor circuit for shut resonance with the main coil, then each circuit shall be housed in a separate enclosure.

Each of the enclosures shall be adequately supported so that undue vibration does not occur during transport.

The connections to each end of the enclosures, where these are not directly bolted to the spiders, shall be multi stranded flexible cable.

The tuning device circuits shall be so constructed that the voltage gradient is in one direction only, preferably parallel to the cylindrical axis of the main coil.

The rated band width and rated blocking impedance as defined in IEC 60353 will be advised by the Employer based on the frequency allocations made.

At any frequency within the specified rated band width, the resistive component of the blocking impedance shall not be less than 600 ohms.

The rated inductance of the main coil, measured in accordance with IEC 60353, shall be as outlined in the Technical Data Sheets.

The temperature rise of any part of a line trap under rated continuous current conditions shall not exceed the limits specified in IEC 60353, Table 1.

Where Mylar is used as an insulation material, the maximum hot spot temperature (including ambient temperature and black body sun temperature) shall be less than 110°C. Full details of how this hot spot temperature is calculated and measured shall be supplied with the Bid.

For maximum ambient temperature, when carrying rated continuous current the final temperature rise on the terminal palms shall not exceed the following:

- for bare aluminum or copper terminals 90°C
- for tin-plate aluminum or copper terminals 105°C
- for silver-plate aluminum or copper terminals 105°C.

The line traps shall be designed and constructed to withstand the electro-magnetic forces and thermal effects of the specified rated short time current after previous operation at rated continuous current at the maximum specified ambient temperature.

Maximum permissible average temperature in degrees Celsius shall not exceed the limits specified in IEC 60353, Table V.

All components shall be adequately rated for carrying maximum strength carrier frequency signals.

The self-resonant frequency of the main coil shall always be higher than the highest frequency of the rated bandwidth.

Construction –windings and insulation - Soldered joints are not acceptable.

Insulating materials shall be impervious to moisture, shall have high resistance to abrasion, and shall not be affected by continued exposure to bright sunlight, heavy sub-tropical rains or high humidity.

Insulating materials shall be capable of withstanding rapid changes of temperature and shall not be detrimentally affected by heavy industrial or salt pollution.

33.22.4.2 INSPECTION AND TESTS

The line traps shall be tested in accordance with all the requirements laid down in IEC 60353 and this specification.

33.23 BUSWORK

33.23.1 GENERAL

For 400kV OHL bay gantries and other connection within the 400kV Substation, the Contractor shall calculate the required cross section of conductor to be used and submit calculations for approval

33.23.2 STRAIN CONDUCTOR

The strain conductors shall be in accordance with IEC 60105, IEC 61089. IEC 60889 and other relevant IEC standards as well as ASTM B-339, if not otherwise required in these Employer’s Requirements.

The conductors shall be greased internally (all layers) with a suitable and approved grease, having no adverse effect in contact with the aluminium of the conductors, according to relevant Technical Schedules. The steel core shall be covered with grease, too.

The wire and conductors shall comply with the IEC 60207 and IEC 60209 standards. The outermost layer shall be right-handed.

The stranded conductors shall be supplied on drums so as to enable the conductors to be run out smoothly, and in lengths as long as can be conveniently handled and erected.

The Contractor shall present appropriate calculations to justify the dimensions and configurations offered, on stranded conductors, jumpers and fittings.

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

All tests on the materials and equipment shall be made in accordance with IEC 60208 standard.

On arrival at site and during and after completion of erection, all items of equipment shall be inspected in order to check correct installation of the equipment.

33.23.3 CONNECTORS AND FITTINGS

The connectors and fittings shall be in accordance with IEC 60383, and other relevant IEC standards.

All connectors shall be designed to avoid any possibility of deforming stranded conductor and separating the individual strands.

Tension clamps shall be of the compression type. The mechanical efficiency of such tension clamps shall not be affected by methods of erection involving the use of auxiliary erection clamps before, during, or after assembly and erection of the tension clamp itself.

Tension insulator sets and clamps shall be arranged to give a minimum clearance of 150 mm between the jumper conductor and the rim of the live end insulator units.

Fittings made of steel or malleable iron shall be galvanized.

All bolt threads shall be greased before erection.

All tests on the materials and equipment, type and routine test, as well as the site tests shall be performed in accordance with the relevant IEC standards.

On arrival at site and during and after completion of erection all items of equipment shall be inspected in order to check correct installation of the equipment.

33.23.4 SUSPENSION AND TENSION INSULATORS

The insulator strings shall be in accordance with IEC 60383, and other relevant IEC standards.

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to the development of defects. Insulating material shall not engage directly with hard metal. Where cement is used as fixing medium, cement thicknesses shall be as small and even as possible, and proper care shall be taken to centre and locate the individual parts during cementing.

Each insulator shall be legibly and indelibly marked as required by the appropriate IEC together with such other marks as may assist in the representative selection of batches for the purpose of routine tests. For glass insulators these marks may be applied by sand blasting.

Disc insulators shall be of toughened glass and together with their metal fittings shall comply with the requirements of IEC 60383. Their mechanical characteristics and dimensions shall comply with IEC 60305, whilst the ball and socket couplings, retaining pins and locking devices shall comply with IEC 60120 and IEC 60312.

The pin shank of the suspension and tension insulators shall incorporate a sacrificial zinc sleeve to protect the pin from corrosion.

The locking pins shall be of stainless steel. A common design of retaining pin or locking device shall be used for each complete insulator set.

Tension and suspension insulators shall be equipped with arcing devices in order to minimize the possibility of damage to conductor, clamps, fittings and the insulators themselves under all flashover conditions. These devices are not required for insulation co-ordination purposed, thus the length of gap shall ensure that the specified BIL is obtained.

The arcing device and its fixings shall have sufficient mechanical strength to withstand a mass of 90kg applied at the periphery.

All ball and socket joints of insulator sets shall be lightly coated with grease.

All tests on the materials and equipment, type and routine test, as well as the site tests shall be performed in accordance with the relevant IEC standards.

On arrival at site and during and after completion of erection all items of equipment shall be inspected in order to check correct installation of the equipment.

33.24 POST INSULATORS (IF ANY)

33.24.1 EQUIPMENT REQUIREMENTS

33.24.1.1 GENERAL DESIGN

Outdoor porcelain post insulators shall be applicable to three-phase systems up to rated maximum system voltage, and shall be of outdoor, solid core station post type. They shall comply with the requirements of IEC 60273, IEC 60507, IEC 60815 and other relevant IEC standards.

Porcelain shall be manufactured by the wet process and shall be one piece, non-porous, homogenous and free from cavities or other flaws. The glazing shall be uniform in brown color and free from blisters, burns and other defects and shall meet all applicable requirements of IEC 60273 standard.

The post insulators with associated equipment shall be designed in such a manner as to meet the properties required in this Section, Technical Schedules and Drawings at ambient site conditions.

33.24.1.2 ELECTRICAL CHARACTERISTICS

The post insulators are to be designed for a standardized value of the lightning impulse withstand voltage given in IEC 60071-1. The minimum height to be chosen is determined by dry lighting impulse withstand voltage, wet power frequency withstand voltage and wet switching impulse withstand voltage as applicable and according to the relevant insulation coordination requirements.

It should be noted that the operating voltage is specified in spite of the fact that it cannot strictly be correlated with the height of the post insulator and that it is depending on service conditions, especially contamination.

The minimum creepage distance requirements associated with a few other geometrical parameters generally do not limit the design of the insulator itself. The requirements of the creepage distance are based on insulators having an acceptable risk of flashover when operating under such polluted conditions.

33.24.1.3 MECHANICAL CHARACTERISTICS

Post insulators are to be standardized in mechanical strength classes based on values of the specified failing load in the bending test.

The maximum force encountered during normal service (own weight + wind load + switching load of insulator and connected equipment) shall not exceed 40% of the minimum cantilever strength. IEC 60865 standard shall apply.

The maximum force encountered during a full short circuit plus force of own weight of insulators and connected equipment such as clamps and conductors shall not exceed the minimum cantilever strength of the insulator.

The specified strength class is based on the minimum failing load in the bending test with the post insulator mounted upright and the load applied horizontally at the top surface of the insulator. However, the strength class as well as the bending strength is subject to arrangement in the substations that should be confirmed by the calculation, and consequently the more stringent values shall be applied.

The radius of conductor's grooves m conductor that an abrasive contact be produced on the current-carrying connector components.

The bearings of conductors in the clamps of support require thermally stable friction bearings of low coefficient of friction. A permanent and reliable transmission of charging current to the support must be ensured.

The angle of deflection of conductor in the suspension clamps must be 8 degrees in all directions.

The expansion of conductor in expansion clamps must not be impeded. In case that the provided expansion is exceeded, the locking device must prevent the conductor from falling out of the suspension clamp.

33.24.1.4 DIMENSIONAL CHARACTERISTICS

The nominal dimensions of an insulator shall be in accordance with the specified values in the Technical Schedules, subject to the appropriate tolerances as per Clause 24 of IEC 60168.

33.24.1.5 FIXING ARRANGEMENTS

The fixing arrangements of post insulators shall be in accordance with the IEC 60273.

Fixing holes shall be equally spaced on the appropriate pitch circle, which shall be concentric with the axis of the insulator. Holes in top and bottom fittings shall be in line and they shall be so arranged as to permit the use of normal hexagon bolted heads and nuts.

33.24.1.6 INSPECTION AND TESTS

Tests shall be carried out in order to determine whether the material and equipment comply with the specified requirements. Testing shall be carried out in accordance with IEC standards.

33.25 SHUNT REACTORS

33.25.1 GENERAL

This section of the Specification covers the technical requirements for shunt reactor(s) to be installed in the substation.

33.25.2 REQUIRED TECHNICAL DATA

The required technical data for the shunt reactor is specified in the schedule of technical data Section.

Test requirements:
The test requirements for the shunt reactor are specified in the schedule of technical data Section (Standards). The reactors shall be skip mounted. Further technical requirements for Magnetic cores, Windings, Tank, Bushings, Cooling, Reactor oil and Noise limits please refer to requirement for Transformer in this specification.

Protection:
Beside the protection relays installed in the control room, the reactor shall be protected by the following devices mounted on the reactor:

Buchholz relay for the reactor. The pipes connecting the Buchholz relay with the tank shall have slide valves to enable dismantling of the relay without oil leakage.

Dial type thermometer for oil temperature measurement equipped with two adjustable maximum contacts (range of maximum adjustment to be from 60°C to 120°C). The oil temperature thermometer shall be so placed that accurate reading is possible from ground level.

Oil level indicators equipped with low oil-level alarm and trip contacts. The oil level indicator shall be so placed that accurate reading is possible from ground level.

Resistance type thermometer, R = 100 Ohms, for winding temperature control installed on the cover plate at the place where the highest temperature is expected. The winding temperature thermometer shall be a 2-stage device having alarm and trip contacts and shall be so placed that accurate reading is possible from ground level.

The reactor bushings shall be equipped with current transformers. The current transformer data please refer to data sheets.

Reactor neutral:
The neutral of the reactor shall be brought out to bushings.

Reactor losses:
A guarantee must be given that the reactor losses to be indicated in the Schedule of technical data are not exceeded.

For the guarantee data mentioned hereinafter the tolerances in accordance with specified IEC shall apply and only if these tolerances are exceeded a penalty shall be applied as follows:

Rejection:
The Employer shall have the right to reject any transformer if, the actual values are in excess of the guaranteed values, including the tolerances according to IEC 60076.

Indicating plates:
The following plates shall be mounted on the low voltage side of the transformer tank at a height of about 1.5 m above ground:

- rating plate as specified in IEC 60076, including also a space for the Employer's plant identification number,
- diagram plate with the internal connections of the windings,
- general plan of the reactor covering the locations of terminals, control devices, lifting points and valves.

The inscription shall be written in English.

For the following:
- piping and valves
- cabling and wiring
- external cabling
- marking and labeling
- corrosion-protection, painting
- transport
- proof of compliance

Please refer to technical requirements for Transformer in this specification.

As proof of compliance, the Bidder shall submit the following with the bid documents:
- Schedule of technical data duly filled in
- Outline drawings of the reactor.

33.26 NEUTRAL GROUNDING REACTOR (NGR)

The Neutral Grounding Reactor will be specified based on the result of the Network Study.

33.27 OUTDOOR DISCONNECTORS FOR NGR

The Disconnectors for Neutral Grounding Reactor will be specified based on the result of the Network Study.

33.28 STATION AUXILIARY TRANSFORMER

The station auxiliary transformers shall be dry type, transformers suitable for indoor installation.

Off-load tapping shall be provided by means of tap change switch for the range specified in the following table and shall be conveniently located for easy access.

The terminal numbers corresponding to the tapping position shall be cast or engraved on a metal indication plate fixed to the transformer enclosure. The technical data and vector group of the station auxiliary transformers shall be according to the technical data sheets.

The design of the magnetic circuit shall be such as to avoid static discharges development of short circuit paths internally or to the earthed clamping structure, and the production of flux components normal to the plane of the laminations. Each lamination shall be insulated with a material, which is stable under the operating conditions.

The magnetic circuit shall be grounded to the clamping structure through one removable core-insulation-test link only, placed in an accessible position.

The transformers shall be provided with high conductive electrolytic copper windings. Insulation material shall be of Class A (IEC 76-2).

33.29 0.415 KV INSTALLATION

The 0.415kV indoor switchgear shall be provided in metal-clad and compartment design with fix-mounted units.

In the individual switch units the necessary instruments, control switches and switch drives are to be fitted on the front panel.

The 0.415kV distributions will be fed from the station service transformer(s). The cable connections from the power transformers will be implemented with single-core plastic-insulated cables.

The complete installation shall be designed for continuous operation at 40°C ambient temperature.

The Contractor must ensure that, after handing-over of the plant, a minimum of 5% of fully equipped and 15% of not-equipped reserve capacity is available in the switchgear installation.

The switchgear shall fulfill the following minimum requirements:

- switchgear cabinets, metal-clad and partitioned
- single busbar system with the necessary current transformers
- busbar earthing pins, including earthing fittings
- compartments for busbars, breaking units and cable connections, each separately partitioned
- fire bulkheads below switchgear cabinets
- electronic or electro-mechanic protection relays, MCBs for monitoring and protection, circuit breaker position indicators, warning and control devices, mimic diagram, complete terminal strips
- a heating system for each cabinet which must be controlled by the relative air humidity, with the possibility of by-passing the control device by a switch
- all CBs, isolators, MCBs with minimum spare auxiliary contacts: 2 "on" and 2 "off".

The following basic equipment shall be included:

- circuit breaker unit for infeed
- the necessary outgoing units with fuses, contactors, MCBs, instrument transformers, measuring instruments, etc.

- relay recess with protection and monitoring relays, complete terminal strips, etc.
- in the partitioned cable connection part, the necessary cable connection fittings protected against accidental contact, including the necessary attachment components for the cable end fittings
- one 230V/10 A single-phase three-pin convenience outlet
- ventilation slots
- voltage measurement on infeed.

All circuit breakers shall be designed for local control with the necessary control and position indicating contacts.

The switchgear cabinets shall be installed with the rear side to the wall and a sufficiently large gangway must be provided at the front for operating purposes.

Transformers with cast-resin insulation are to be used. The current transformers must withstand dynamic and thermal short-circuit stresses. Intermediate transformers shall be avoided.

For motors and consumers with the following outputs, suitable connection terminals shall be provided. Terminals at the contactor tee-offs for motors and consumers up to 5.5kW must be suitable for cable cross-sections of $4mm^2$. Dito, for motors and consumers from 7.5 - 11.0kW = $10mm^2$.

Plug connections are to be provided for all auxiliary contacts. Plug contacts shall be so located that the circuit breakers are universally interchangeable without altering the wiring.

The individual instrument transformer secondary circuits must be wired to the circuit breaker cubicle terminal strip. In the case of current transformers the necessary terminals must be fitted with short-circuit bridges.

If the voltage is used for various purposes (e.g. measurement, metering), separate MCBs with auxiliary contacts shall be provided. Tripping of the MCBs shall be indicated in the control room by a group signal.

Only square shape measuring instruments shall be used. The incoming feeder fitted with circuit breaker shall be equipped with a triple moving iron ammeter and with single voltmeter with four-way change-over switch for measurements between phases and phase to neutral.

The relays shall be suitable for panel mounting behind the doors or glass fronts of the individual chambers. Indicating devices must be provided in such a manner that a relay trip could be seen without opening the door.

Electro-mechanic protection or electronic relays shall be used. Each circuit breaker shall be equipped with:

- three-phase over current (thermal overload) protection, continuous adjustable
- three-phase short circuit protection continuous adjustable with instantaneous tripping

equipped with adjustable time delay relay.

The circuit breaker operation will be by commands given at the front panel of the distributor by "on-off" buttons covered in normal operation.

All signaling, monitoring and other contacts must be wired to the associated terminal strip of the switch unit and are to be processed by the Contractor in the control system used.

Each 0.415 kV circuit breaker and contactor shall be equipped with three indicator lamps or position indicators to show the following switching conditions:

- circuit breaker/contactor "off"-open position
- circuit breaker/contactor "off"-due to fault
- circuit breaker/contactor "on"-operating position.

All switchgear cabinets must be installed on base frames provided specially for this purpose supplied by the Manufacturer of the 0.4 kV switchgear.

33.30 DIRECT CURRENT INSTALLATIONS

The DC distributions and the rectifiers shall be installed in metal-clad, partitioned cabinets with fixed equipment and a single busbar system, in the control building.

The necessary instruments and control switches shall be fitted on the front of the individual circuit breaker and equipment compartments.

In the lower part of the switchgear cabinet the terminal strips and the attachment components for the cable end fittings shall be arranged.

The main distributor will be fed by a alkaline battery (Ni-Cd) or Lead -Acid battery and two rectifiers.

The infeed switch shall be a manually operated circuit breaker, the outputs shall be equipped with load switches preceded by fused isolators. The busbar voltage shall be indicated by voltmeter.

The complete equipment, such as load switches, fuses, contactors, shunts and measuring instruments, are to be neatly arranged and fixed in the appropriate switch or instrument compartment. The cable connections from the rectifiers and batteries respectively shall be single-phase cables.

The complete installation shall be designed for continuous operation at 40°C ambient temperature.

The alkaline battery shall be equipped with the necessary counter cells and/or regulator cells and chargers to enable it to cope with all operational shock loads within the given voltage tolerances.

Suitable heaters arranged in the switch cabinets must prevent any condensate formation.

The Contractor must ensure that after handing over, each switchgear installation still has a minimum of 5% fully equipped and 15% not equipped reserve capacity for the terminal strips of the switchgear.

The DC distributions shall fulfill the following requirements:

- busbar compartment with busbar protected against accidental contact
- infeed circuit breaker
- manual load switches preceded by isolators with fuses
- automatic MCB for output circuit preceded by main fuse
- contactors with fuses, bimetallic strips, control voltage MCB etc., for motor circuits
- in the partitioned cable connection compartment the necessary contact-proof cable connection components and the plug-in connection combinations including the required attachment components for the cable end fittings.

Colored mimic diagrams shall be provided on the front of the DC switchgear cabinets with the necessary position indicators, equipment symbols and signaling lamps. The mimic diagram should show at least the following:

- 0.415kV busbar with position indicator for the rectifier input circuit breakers
- rectifier and battery symbol with Y-connection
- DC infeed circuit breaker with position indicator and the necessary controls
- DC main distribution
- earth fault supervision.

The switchgear cabinets shall be installed with rears nearest the wall. In front adequate space must remain to allow access by operating personnel.

The degree of protection of the switchgear must be at least IP 41.

An "emergency off" push button in the event of failure of the control voltage shall be foreseen.

Battery charging equipment:

Each battery charger shall be suitable for the charging and floating of the battery and for supplying the DC consumers at the same time.

The rectifiers shall be provided by the Contractor as thyristor controlled devices with current voltage characteristic for standby parallel operation.

The following control and monitoring equipment shall be provided by the Contractor for the individual battery chargers:

- radio interference suppression of the battery chargers according to the appropriate IEC regulations
- monitoring the charging circuit for interruption

- voltage monitoring of the incoming three phase supply, with an overvoltage of + 15% and an undervoltage of - 15%, automatic disconnection of the battery charger shall occur. However, voltage surges shall not cause periodic interruption of chargers.

With an undervoltage of - 15%, a fault alarm shall be given and indicated on the front door of the device.

All cases of disconnection shall be indicated as a fault alarm in the front door of the unit.

The fault alarm and disconnection shall be combined as a collective alarm - "rectifier fault" - and wired up as potential free contact to the terminal strip for remote alarm (if applicable).

The battery chargers shall be equipped by the Contractor with automatic boost charge stages which shall be adjustable between 1 to 8 hours after input failure.

The chargers shall be equipped with filter units having a ripple content of less than 2 percent.

A warning lamp "boost charge" shall be installed and wired up outside the battery room (if applicable).

On the front of the rectifier cubicles, the Contractor shall provide all the necessary monitoring equipment, measuring instruments, other devices, switches, indicator lamps and corresponding fixings for the cables.

Batteries:

For the DC system, a battery of the alkaline or lead acid type shall be provided.

The battery shall be mounted on insulated wooden or metal frames with consoles, and all interconnections and fixing material as necessary. The capacity of the battery shall be matched to the requirements of the control and protection circuits.

The capacity of the battery shall be justified by the Contractor, considering a discharge time as specified in the data sheets.

A complete set of test and maintenance accessories suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Battery cases shall be of high impact polystyrene translucent plastic.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Further detail requirements for 48V batteries is given under Telecommunication Power Supply Equipment section.

33.31 POWER AND CONTROL CABLES

33.31.1 GENERAL

Cables having a cross section greater than 16mm2 are to be of XLPE cable type, LV cables of smaller size of PVC insulated type. All cables have to be suitable for an ambient temperature given in Chapter 1 of Section 5.

For cables, which are subjected to ambient temperature above 60°C, teflon-or silicone-insulated cables must be provided.

All cables laid on the surface of walls, steel frames etc., must be protected against mechanical damage by galvanized steel tubes or robust PVC pipes. In all areas where the cable conduits can be damaged, e.g. walk-ways, only steel tubes shall be installed.

For running out power cables, heavy screw jacks and spindles shall be used. The cable has to be continuously pulled from the upper side of the drum in the same direction and runs over rollers. The rollers shall be placed into the trench at intervals of 1m max. At corners or when pulling cables into ducts, special rollers have to be used. Sharp edges in the trenches or at the ends of the cable ducts have to be covered in such a manner that no damage of the cable occurs.

During the approval procedure, the Contractor shall provide a cable schedule listing all cables and their destination including details with regard to number of cores, core size, cores in use and spare cores, cable length etc. for each substation.

All control cables which have to be laid between the outdoor substation and the existing control building have to pass the new control building via marshalling kiosks to be installed in the new control building including associated terminals for future connection of new control and protection equipment.

33.31.2 MV POWER CABLES

MV voltage connection from power plant to substation auxiliary transformers, please refer to Chapter 6 of Section 5.

33.31.3 LV CABLES

33.31.3.1 GENERAL

The LV Cable system installed in the substation shall be designed to support auxiliary power, monitoring and control functions of the substation. The selection of materials, design and installation shall ensure a high level of availability, minimize damage or disruption to other systems in the event of a fault and minimize the risk to personnel.

33.31.3.2 SCOPE OF WORKS

The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of Employer's personnel an

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

33.31.3.3 TECHNICAL DATA

The main technical data for all LV power, control and signaling cables are listed in the Technical Data Sheets. All parts of the cable installation shall comply with this Specification and the latest revisions of the relevant IEC standards except where otherwise stated.

33.31.3.4 GENERAL DESIGN REQUIREMENTS

The low voltage power and multicore cables shall comply with these specifications and the requirements of the latest revision of the following IEC Standards, except where otherwise stated:

IEC 60189-1/1986, IEC 60189-2/1981 and 60189-3/1988 "Low Frequency Cables and Wires with PVC Insulation and Sheath".
IEC 60227 "PVC Insulated Cables on Rated Voltages up to and including 450/750 V.
IEC 60228 "Conductors of Insulated Cables".
IEC 60287 "Calculation of the continuous current rating of cables (100% load factor)".
IEC 60724 "Guide to the Short-Circuit Temperature Limits of Electric Cables with a Rated Voltage Not Exceeding 0.6/1 kV".
IEC 60811 "Common Test Methods for Insulating and Sheathing Materials of Electric Cables and Optical Cables ".
IEC 60885 "Electric Test Methods for Electric Cables ".

All cables shall be suitable for continuous operation under climatic conditions prevailing on site. All transient and abnormal conditions, such as overload and short circuits shall be withstood without detrimental effects. The cables shall have copper conductor with PVC insulation and PVC over. The cables shall be identified at both terminations with plastic ferrules showing the cable number and the designation of the opposite end.

At those points of interconnection between the wiring carried out by separate contractors where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.

The Contractor shall provide a complete set of cable schedules listing all cables required for connecting the equipment supplied in the Contract.

Cable schedules listing all cables and their points of termination including details of cable, number of cores, core reference, core size, number of cores in use and cable length etc. shall be provided.

The Contractor shall ensure that the core identification at their terminals corresponds to the above mentioned schedule.

The cables shall be laid on trays in single layers in such a manner that they can be replaced or added to without difficulty.

In general, the cables for double in-feeds from the switchgear, transformers, distribution boards and cubicles shall be laid separately so that in the event of short-circuit in one in-feed, the other is not affected.

All AC and DC control and power circuits shall be segregated from one another and the circuits to main protective gear shall be segregated from those for back up protection.

The cable sheaths must be resistant to solar radiation, the effect of oil, bacterial action, insects and rodents. They must be suitable for being laid indoors, outdoors, underground and in water.

The screen of the shielded cables shall be brought out and earthed at one end. The armoring of the cables shall be earthed at both ends.

When laying the cables on trays, vertical runs, in cable ducts, etc. and when choosing the sizes of cables, care must be taken to ensure that adequate ventilation is guaranteed and that there is no risk of thermal overloading, undue pressure or distortions of the cables.

33.31.3.5 LOW VOLTAGE POWER CABLES

The conductors for power supply cables at voltages up to 600/1000 V AC shall be plain annealed copper wire complying with IEC 60228 as applicable, with circular or shaped conductors. All cores shall be identified by phase colors.

During motor starting or re-acceleration in groups, the voltage at the motor terminals shall not fall below 80% of the rated voltage. Cables and systems shall be sized to meet these criteria. The basis of voltage drop calculations shall be for worst case, i.e. minimum fault level and outage of supply feeders or transformers.

The maximum permissible volt drop in cables shall be:

- feeders and sub-feeders 1%
- motors branch circuits 2.5% (from power centre to load terminals)
- lighting sub-circuits 2.5% (from lighting switchboard to furthest fitting).
- A derating factor shall be applied to cable vendors stated current capacities, taking into account grouping factor, ambient temperature and environmental conditions.

Cable shall be sized by consideration of:

- nameplate full load current of equipment,
- current carrying capacity after de-rating,
- voltage drop,
- short circuit rating.

The minimum cross-section of standard conductors shall be 2.5mm². The low voltage power cables shall consist of single, two, three and four core-cables. On the low-voltage side, the cable connection between the station service transformers and the 0.4kV infeed cubicles shall consist of single conductor power cables. The connections between batteries or rectifiers respectively and the DC distribution board shall generally consist of single core power cables.

33.31.3.6 LOW VOLTAGE MULTICORE CABLES

The conductors for power supply cables at voltages up to 600/1000 V AC and for all 220 V DC protection, control, alarm and indication as well as 48V Telecommunication equipment shall be plain annealed copper wirecomplying with IEC 60228 as applicable or equivalent and all cores shall be clearly identified by printed numbers at regular intervals.

The minimum conductor size of stranded conductors shall be not less than seven strands of 0.52mm diameter wire and the minimum cross-sectional area shall be not less than 1.5mm².

All multicore cables except where used for instrument transformer circuits shall have stranded copper conductors.

Multicore cables of 7 cores and above shall have a minimum of ten percent (10%) spare cores over the original design requirements.

The number of cores in multicore cables shall be selected from the following numbers: 2, 3, 4, 7, 12, 19, 24, 27, 37 and 47.

The multicore cable tails shall be so bound that each wire may be traced to its cable without difficulty.

The screens of screened pairs of multipair cables shall be earthed at one end of the cable only. The position of the earthing connections shall be shown clearly on the diagram.

All spare cores shall be earthed at both ends of the multicore cable. The Contractor shall submit full details of all cable loads and in the case of interposing current transformer connections, the loop resistance of each circuit.

An instrument transformer cable may transmit the current or voltage from only one transformer. If the same voltage is required for different purposes (e.g. protection, measurement, metering) each voltage transformer circuit must be wired via a separate MCB to the switchgear control cabinets.

33.31.3.7 TERMINATION OF CABLES AND WIRES

All cables shall be terminated in a recommendations and the cable cores shall be long enough to be terminated to any terminal in an enclosure without extension. All cables shall enter cubicles and boxes from bottom side.

PVC sheathed cables shall be terminated by compression glands or cable lugs complying with BS 6121 (or equivalent). Where cable cores are liable to be in contact with oil or oil vapor the insulation shall be unaffected by oil.

The Contractor must terminate all power and control cables inside the appropriate cubicle. The spare cores of all multicore cables shall be numbered and terminated at a terminal block in the cubicle. AC terminals shall be clearly color coded and shrouded.

Colors shall be marked on cable box, cable tail ends and single core cables at all connecting points and/or any positions the Employer may determine. Cable boxes shall be marked with stamped stainless steel labels indicating the purpose of the supply where such supply is not obvious.

33.31.3.8 INSTALLATION REQUIREMENTS

The following requirements shall apply:

- LV Power Cables shall be routed in separate cable troughs.
- LV power cables, multicore cables and telecommunication cables shall each be routed in separate trays, racks, ducts, troughs or compartments separated by steel sheet barriers.
- Fiber optic cable shall be routed and installed such that they are protected from deformation or damage by auxiliary power or control cables throughout their installed length.
- Sufficient space shall be allowed to run in each duct or compartment the necessary draw wires, being of non-corrosive metal and having devices for securing the conductors.
- A spare capacity of 20% shall be provided on cable trays, ladder racks, ducts, compartments, or openings in walls and floors.
- Openings in floors and foundation pads shall be large enough to permit free movement of cables during installation.
- Channels and ducts shall be sealed where they enter a building to prevent the ingress of moisture, gases and vermin.
- Openings in walls and floors shall be sealed after the cable installation with a fireproof barrier.
- Cabling and wiring installations shall be arranged to minimize the risk of fire and damage which might be caused in the event of fire.
- Only one layer of cables shall be laid on one tray or in one cable channel.
- All cables leaving buildings for outside plant shall be laid in cable ducts.
- Where cables emerge from grade they shall be protected by a section of steel pipe

extending 150mm above grade.

- Cables above ground shall be run on galvanized cable racks, trays or supports, suitably clipped to prevent movement. Care shall be taken to provide for differential movement between the structures.
- Protection from direct sunlight shall be provided by means of suitable sunshades continuously covering the cable and of the same materials as the rack/tray. Cable straps shall be made of stainless steel.

33.32 INSPECTION AND TESTS

33.32.1 GENERAL

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

All tests on material and equipment shall be carried out in accordance with IEC Standards if not otherwise approved by the Employer

33.32.2 WORKSHOP TESTS

Routine test shall be performed at each item of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of a test object or reduce its lifetime. The following routine tests shall be performed on all lengths of cables and all accessories to be supplied:

- general inspection
- examination of sheath, armor and protective coverings, as well as examination of insulation, to be performed after bending test
- measurement of conductor resistance
- high voltage test
- high voltage test on outer sheath.

33.32.3 SITE TESTS

On arrival at site, during installation and after complete installation, all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment. The following tests shall be performed:

- general inspection of the cable routes, verification of proper installation, fixing to the racks, bending radius, etc.
- verification of proper earthing of the screen
- measurement of cables insulation resistance
- verification of proper condition of external surfaces.

33.32.4 SPECIAL EQUIPMENT AND TOOLS

Supplies to be effected under this section include the delivery of special equipment and tools for erection, installation, maintenance, setting to work and other purposes. Requirements for special equipment and tools are described in the General Specification (Chapter 3 of Section 5). Specified special equipment and tools to be delivered by the Contractor shall be listed in the Tender.

33.33 CONTROL EQUIPMENT

33.33.1 OUTDOOR TERMINAL CABINETS

Each high voltage switchgear bay shall be equipped with a outdoor terminal panel where all high voltage equipments shall be connected (see capacitive voltage transformers).

33.33.2 INDOOR LOCAL CONTROL CUBICLE

33.33.2.1 FUNCTIONS

Each circuit-breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and status indication of the circuit-breaker and all associated disconnectors and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously. Closing of the circuit-breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Local control cubicles shall be suitable for installation in a separate place - preferably in a separate building, if present - and not attached to the switchgears.

Circuit-breaker control position selector, operating control switch and emergency trip push button shall be installed in the Local Control Cubicle. In case that local operation has been selected with the control position selector, remote manual operation is excluded and vice versa if remote operation (normal kind of operation) has been selected. Circuit-breaker control from this position will be used under maintenance and emergency conditions only.

Local manual release facilities shall be provided for closing and tripping the circuit-breaker. The operation of both releases shall be subject to lockout if insufficient stored energy is available. Local manual releases shall be provided with locking off facilities.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies.

Where control cabling between the local control cubicle and the switchgear are connected by plug and socket boxes, the plugs and sockets shall not be interchangeable.

A Mimic Diagram with circuit identifying labels on a suitable plate shall be provided in the switchgear rooms.

The color of the mimic diagram shall be "light grey" as per RAL 7055.

Circuit devices/instruments identifying labels shall be fitted at the front and rear of each individual device and on the remote/local control cubicle. A Single Line Diagram shall be marked along each bay showing location of all items of the switchgear.

There shall be at least 20% spare capacity in terminal blocks.

33.33.2.2 DESIGN

Operating mechanism, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles. Local control cubicles shall be provided to be free standing with front access, and shall be equipped with anti condensation heaters. A suitable thermostat shall be included in the heater circuit. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation. Similarly the contractor has to provide adequate cooling of the control cubicles at very high temperatures in summer. Temperature within the cubicles shall stay ≤40°C if electronic modules are installed unless these can cope with high temperatures that have to be expected.

Cubicles shall be of rigid construction, the thickness of the steel sheets shall be minimum 2 mm, preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steelwork necessary for mounting on the circuit-breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors. All fastenings shall be integral with the panel or door and provisions made for locking. Doors and panels shall be fitted with weatherproof sealing material suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvers.

Taking into account the aggressive environment conditions in Ash area, all new cubicles for SS Ash shall be made in tropical export version.

An interior lamp suitable for the local LVAC supply, controlled by a door operating switch, shall be fitted at the top of each section.

The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus.

All local electrical control selector switches, together with a mimic diagram of the bay complete with semaphore indicators to show the status of each primary device shall be mounted behind a metal framed glass panel, dust proof door in the front of the cubicle.

The single bay control selector switch shall determine either local electrical or remote control of all devices and prevent simultaneous operation from both points. Local electrical operation of devices shall be for maintenance purpose only.

The voltmeter, where required, associated voltage selector switch and a circuit-breaker electrical emergency trip button shall be mounted on the front of the cubicle and not behind the hinged door. Arrestors shall be provided for bus section and bus couples cubicles. The emergency trip button must be conveniently placed. It shall operate both trip coils from electrically separate contacts for local indication and remote operation alarm. The button shall be colored red, either recessed or shrouded, protected by a discrete hinged cover and be clearly labeled. A facility shall be provided to enable a wire seal to be used on the cover.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, and protection and local ring main supplies.

All connections to the supervisory system shall be wired to a separate terminal block labeled accordingly. The connections to this block shall be cabled to the marshalling cabinets.

Where control cabling between the local control cubicle and the switchgear are connected by plug and socket boxes, the plug and sockets shall be discrete for each duty and shall not be interchangeable with other plugs and sockets within the substation.
Hydraulic/spring drives and SF6 operation equipment necessary for the correct functioning of the circuit-breaker, disconnectors and earth switches shall be located in a separate rack of the SF6 circuit breaker cubicle.

33.33.3 AUXILIARY SWITCHES AND CONTACTORS

Auxiliary bi-stable switches for purposefully actuated operation in both directions shall be provided for all circuit-breakers, disconnectors and control, interlocking and repeat relays, if necessary observable for local and for remote operation. All necessary auxiliary switches, contactors and equipment for indication, protection, metering, control, interlocking, supervisory etc. shall be supplied together with every circuit-breaker, isolating and earthing device and they have to be installed in a. dust free housing. Not less than six (6) spare auxiliary contacts shall be installed for each circuit-breaker and not less than four (4) for all other devices. All of them shall be wired up to a terminal board in the local control cubicle of the switchgear. These spare contacts shall be arranged in the same sequence for all other switchgears.

Automatic switches shall be provided to interrupt the supply of current to the actuated tripping mechanism of the circuit-breaker after completion of its operation. All such switches and mechanisms shall be mounted in accessible positions clearly separated from the operating mechanism and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Direct acting auxiliary switch contacts shall be used in conjunction with busbar protection schemes.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by the auxiliary switch arrangements and multiple contactors and relays will not be accepted in lieu of auxiliary switches except as specifically approved by the Employer. Control, protection and interlocking circuits, where it is necessary to use more than one relay (a repeat relay) for a certain action due to the limited number of auxiliary contacts for one relay their operation shall be carefully monitored particularly related to the operation of in parallel working relays and their contacts. It is stressed that such construction shall be an exceptional solution.

Bi-stable devices for approval of the may be accepted, but only where it can be shown that extra contacts are not required on critical circuits and direct contacts are not available.

Related to current auxiliary switches shall be designed to prevent undue heating of this associated circuit. In addition to that a current of 2A at 220V DC shall have a circuit time constant of not less than 20ms in order to limit peak current after switching on the system.

33.33.4 INTERLOCKING

An interlocking scheme shall be provided on the lowest control level which takes into account the following basic requirements:

Safeguard maintenance personnel who may be working on one section of the equipment while other sections are live. This may be a mechanical detent in combination with a table switch any switch or circuit break prevent incorrect switching sequences which could lead to a hazardous situation to plant, equipment and personnel.

Interlocking shall be done by electrical systems for all operational interlocks, but preferably be of the mechanical/key type for maintenance safety interlocks, Interlocking for maintenance purposes shall be effective when the equipment is being controlled locally under emergency off condition or from a supervisory position.

All mechanical interlocks shall be applied nearby the point at which manual operation will be performed, so that stress cannot be transferred to parts remote from that point.

All electrical interlocks shall function in that way that power supply for normal operation will be interrupted. A system of interlocks shall be provided, which shall cover the manual emergency off operation of apparatus, which are normally power-operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation.

Electrical bolt interlocks shall be energized only when the control levers to operate the appropriate mechanism is set to its working position. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided. So the bolt can be operated in the emergency case of a failure of interlock supplies.

As long as key interlocking is engaged tripping of the circuit-breaker shall be prevented as consequence of pulling the key from the lock. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

Interlocking of circuit breakers shall be designed, that a circuit-breaker cannot close, unless the associated busbar and circuit disconnectors are in closed position, except under controlled maintenance conditions with deenergized adjacent systems. In addition to that it shall not be possible to close a circuit breaker unless all trip relays of the concerned circuits are reset.

That means as well disconnectors stay interlocked and not operable unless the associated circuit-breaker is open.

In cases with double busbar arrangements on-load transfer of a feeder from one busbar to another with the associated circuit breaker shall be made possible by interlocking which ensures that the associated bus-coupler and its relevant disconnectors are closed.

The bus-coupler circuit breaker shall be interlocked in such manner that opening the bus-coupler circuit breaker shall not be possible while on-load changeover on the relevant side of the breaker is in progress.

Both busbar disconnector pairs of a circuit that are affected by the load switching shall not remain closed after completion of load transfer. Only the new circuit shall stay to be a closed loop. The other disconnector to the busbar shall be opened. An alarm shall provide a warning if both busbar disconnectors of a transferred circuit are left closed.

Earthing switches shall be interlocked in that way that they cannot be operated unless the associated disconnector is open.

All busbar isolators and earthing switches shall be interlocked with the associated circuit breakers (standard safety interlock).

For double busbar configurations where on-load change-over of feeders is foreseen, the closing of busbar isolators of individual feeders, if the related CB is closed, shall be prevented, unless the bus-coupler breaker and associated isolators are closed. Interloading scheme, subject to detailed design, will be approved by the Employer.

33.33.5 LOCKING FACILITIES

Locks and locking facilities shall be provided for all safety relevant parts of the switchgear as detailed below and shall be additional to the mechanical interlocking devices specified in the above clause.

If a mechanism is to be locked in a specific position, preferably the power supply of this mechanism shall be considered.

The following interlocking functions shall be provided:

- circuit-breaker mechanism in the open position and any associated manual operating device in the neutral position
- isolating switches in both positions open and closed position
- control position selector switches in all positions as specified
- operating cubicle access doors
- air or gas system isolating valves in inacceptable positions (open/closed)
- It shall not be possible to open the bus-coupler during the process of feeder transfer from one busbar to the other.

The following locking facilities shall be provided:

- Synchronizing selector switch:
  - Cylinder lock such that switch can be operated by inserting and turning the key. Key removal in off-position only.
- Protection on/ off switch:
  - Key removal in either position

Locks shall be designed, constructed and located on the equipment so that they will remain serviceable in the climatic conditions specified without operation or maintenance for continuous periods of up to two years and with suitable maintenance shall be fit for indefinite service.

33.33.6 TARIFF METERING

It shall be provided programmable microprocessor based digital type for indoor application, offering outstanding measurement accuracy and reliability, communication capability, event storage, suitable for operating in harsh environment.

The meter shall be designed and tested in such a way that long life time and stability is guaranteed for at least 20 years under severe conditions.

The meter must be capable to display and record meter ID, program, CT ratio, VT ratio, total kWh, kVarh, kVah, kW, kVar, kVA, PF; per phase (voltage, current, phase angle); load profile having minimum 16 channel storage data for minimum 90 days; event log; power failure etc.

The following main features are required:

- Power Polarity:
  Meters shall be full quadrant (four quadrant) type for measuring power flow in any direction without variation of accuracy.
- Measurement Options:
  Provisions for measuring two-directional active and reactive energy, voltage and current, active and reactive power, frequency, power factor.
- Data Storage:
  Should be capable of storing all critical data, including calibration, configuration and time of use etc. in battery backed up when no auxiliary supply is available.
- Alarms:

Auto-diagnostic alarm facilities for loss of memory, problems with batteries, including VT failure/tolerance, unbalanced power and advanced anti-tampering features etc.

- Security:
  Provisions for highest security in communications, storing the data measured, overall operation of the meter, preventing unauthorized configuration, saving the data in non-volatile memory in the event of power failure and extended alarm function with self diagnostic features.
- Configuration Software:
  The tariff meters shall be configured and calibrated via the optical port using a PC. Configuration software of relevant tariff meters shall have to provide.
- Memory Storage:
  Load profile interval (kWh &kVarh received and delivered, phase voltage, phase current, power factor with 30 minutes interval)
- Number of Digit:
  Minimum 5 Integer with 3 decimals (programmable)
- having LCD display showing the values in a selectable scroll mode
- meter must have an LED test output for active energy
- interfaces for communication
- battery backup for minimum 72 hours to allow meter operation in case of power supply failure
- programming facilities
- event log
- tariff system with energy and demand tariffs
- internal real time clock with an accuracy within IEC338 backed up by a battery
- self read features for at least 12 month’s billing history
- monitoring functions

33.34 SUBSTATION CONTROL AND MONITORING SYSTEM

33.34.1 GENERAL REQUIREMENTS

The Substation Control and Monitoring System, which is detailed below, shall be provided for the 400kV Substation. Additionally, OPC client/server architecture shall also be provided between the 400kV Substation and the Plant as to allow the supervision and control of the substation from the 400kV Substation.

33.34.1.1 GENERAL SYSTEM REQUIREMENTS

The SCMS shall comprise full station and bay protection as well as control, monitoring and communication functions and provide all functions required for the safe and reliable operation of the Substation.

It shall enable local station control via an operator workstation by means of a human machine interface (HMI) and control software package, which shall contain a comprehensive range of system control and data acquisition (SCADA) functions. Additionally, it shall include communication switches and gateways, station-bus as well as intelligent electronic devices

(IED) for bay control and protection as shown in the general system architecture. Furthermore, the SCMS shall also include an engineering workstation for configuration as well as parameterization tasks.

All materials and parts which are not specifically mentioned hereinafter but are necessary for erection, assembly and operation of the equipment shall be furnished and are deemed to be included in the scope for this subsection.

The minimum requirements for the SCMS are as follows:

- proper and trouble free operation and support maintenance of the substation through the corresponding operator control station
- proper and trouble free operation from the bay control and / or protection units (IEDs) with position indicators for all circuit breakers, disconnectors and working earth switches
- all alarms and indicators associated with protection and remote control activation and tripping
- all items for the control, monitoring, remote control, protection and interlocking circuits
- communication links to remote control centers via standard protocols
- protection and remote control management
- event recording
- disturbance analysis

In order to meet the requirements of this specification the detailed design of the SCMS as well as the OPC-client/server architecture is within the supplier's responsibility subject to approval by the Employer.

Only experienced and technically capable manufacturers of digital control and protection systems for electricity generation and transmission and distribution applications will be accepted. In order to establish their technical capabilities, the supplier is required to present the following documents with his tender:

- block and functional diagram showing the proposed control, protection and monitoring schemes,
- technical specification and description of system,
- digital control and monitoring system layout,
- catalogues of equipment and devices to be used,
- material list of equipment contained in the cubicles,
- certificate of conformity with the communication protocol IEC 61850 for each type of the components
- brochure and references of manufacturer supplying the control, protection and monitoring system.

Preferred manufactures will be those who have experience in deliveries of the full scope of station automation systems and services. This experience has to be substantiated by means of reference installations having been in service under similar functional requirements and environmental conditions for at least 2 years.

33.34.1.2 SYSTEM DESIGN

Design principles:
The SCMS shall be a digital control and monitoring system to supervise and operate the switchgears in the substation complete in every respect for monitoring and control inclusive all facilities, e.g. of the power transformers which will be equipped with OLTC (on-load tap changer) and AVR (Automatic Voltage Regulator).

SCMS shall be suitable for supervision, operation and maintenance of the complete substation including future extensions.

Design and arrangement of the system offered shall be state-of-the-art based on IEC 61850 for operation under electrical conditions (including electrical discharge and disturbance level) prevailing in high voltage and medium voltage substations, follow the latest modern engineering practice, ensure optimum continuity and reliability of supply and ensure the safety of equipment and the operating staff. The highest degree of uniformity and interchangeability shall be provided.

Design of the hardware and software shall be suitable for all voltage levels used by the Employer to enable a standardized technical concept.

SCMS shall be designed such that personnel without any computer back-ground shall be able to operate the system with ease and shall incorporate user-friendly features without causing undue operational delay.

The whole equipment shall be pre-assembled and pre-programmed at the supplier’s workshop. Facilities / devices and services necessary are to be provided, i.e. for generation of data base, of displays, programming and for testing, adjustments, parameter settings etc., even if not specified in detail.

The whole equipment shall be designed for indoor installation, installed in steel sheet cubicles with hinged frames and glass door having a protection degree.

All components shall be suitable for the local climate and environmental conditions.

The SCMS shall be designed for easy modification of hardware and software and for easy extension of the substation. Maintenance, modification or extension of components may not force a shut-down of the whole SCMS. Self monitoring of single components, modules and communication links shall be incorporated to increase the availability and reliability of the equipment and minimize maintenance.

Failure of any component of the system may not force a total system failure.

The supplier shall ensure that after handing over, a minimum of 35% spare function capacity (hardware and software) and 20% spare parts for future extensions are available (for each type of component at-least one).

Reliability:

The SCMS system shall be designed to satisfy the very high demands for reliability and availability concerning:

- solid mechanical and electrical design
- security against electromagnetic interference (EMI)
- high-quality components and boards
- modular, well-tested hardware
- thoroughly developed and tested modular software
- easy-to-understand programming language for application programming
- detailed graphical documentation, IEC 1131-3, of the application software
- built-in supervision and diagnostic functions
- after-sales service
- security:
- experience of security requirements
- process know-how
- select-before-execute at operation
- process status representation as double indications incl. indication of intermediate state
- distributed solution
- independent units connected to the station bus
- back-up functions
- cubicle design appropriate to any harsh electrical environment and ambient conditions
- cubicle grounding immune to transient ground potential rise

The SCMS shall provide an MTBF (mean time between failure) and a MTTR (mean time to repair) rate as defined in the technical data sheets.

The availability shall reach at least the value stated in the technical data sheets. In order to provide this availability, some main (or weak) components shall be of redundant design e.g. the power supply of the fiber-optic coupler.

The outage of one communication link from an individual device to the central components shall not affect any other communication link between the central components and all other device.

The supplier shall clearly define how the offered architecture meets the availability requirements. A system block diagram shall therefore be submitted with the offer.

System capabilities:

SCMS shall provide full operation of each station corresponding to projects requirements.

Security of control selections is of paramount importance and every precaution shall be taken in the software and hardware design to ensure that false selection or execution of a control is rejected. Failure of a communication, either partial or total, intermittent or permanent, shall not lead to a false control action. Noise, either spuriously occurring or injected manually into the communication link shall not lead to a false control action.

The system software shall be standard software as offered to other customers. The software structure shall be specially designed for the important requirements of switchgear and substation operation.

The system hard- and software shall consist of basic modules and standardized supplementary function modules, which are parameterized depending on the layout and operation concept of the substation.

The system shall restart automatically after halt or loss of supply voltage, all necessary information shall be kept in memory in case of supply voltage outage.

After automatically restart the displays shall present the same displays like before system hold, operator workstations (H level.

It shall be possible to test the system without any hazard of unwanted influence to the substation. Test facilities shall include both function and data.

System performance:
The updating times on the operator workstation in the substation shall be as follows:

Function	Typical values
Exchange of display (first reaction)	< 1 sec
Presentation of a binary change in the process display	< 0.5 sec
Presentation of an analog change in the process display	< 1 sec
From order to process output	< 0.5 sec
From order to updating the display	< 1.5 sec

Table 33.34-1: System performance

System behavior:
When DC voltage is restored after a DC auxiliary voltage failure, the entire system shall perform automatically a start up on its own (automatic restart time < 5 min).

After each restart, an automatic general interrogation with old / new comparison shall be carried out and changes shall be communicated to all functional modules that require the new information.

In addition to securing the parameter values in each functional module, the process data base including manual entries shall also be secured against failures in order to avoid new inputs during restarts.

Each action by the operator shall be logged as event and result in a reaction from the system. The latter may be visible or audible, and either confirms the operator input or rejects it. Rejections shall contain an explanation with easily understandable error messages. The starting and ending of an operator input shall be user friendly at all control levels.

If a local / remote transfer switch is operated, an acknowledgment and cancellation procedure shall automatically be initiated.

Compliance with standards:

Technical data, dimensions, quantities etc. shall be given in the SI-System of units (International System of Units). Protection designation shall be carried out in ANSI.

For design and type testing of the protection and control equipment, the following standards shall be applicable.

General:

- IEC 60038: IEC Standard voltages
- IEC 60068: Environmental testing
- IEC 60255,IEC 61810-1 and IEC 62246-1 : Electrical relays
- IEC 60664: Insulation coordination for equipment within low-voltage systems
- IEC 61000:Electromagnetic compatibility (EMC)
- IEC 60073: Basic and safety principles for man-machine interface, making and identification-coding principles for indication devices and actuators

CE-marking:

- EN 61000-6-4 Emissive (Industry)
- EN 61000-6-2 Immunity (Industry)

General for Substation Automation:

- IEC 61850: Communication Networks and Systems in Substations
- IEC 60870-5-101: Communication with remote control centres
- IEC 60870-5-103: Communication with third party devices having no
- IEC 61850-Interface
- IEC 60870-5-104: Communication with remote control centres

Data Integrity:

The data integrity classes apply to the information transfer from the source to its destination and refer to:

- the probability of undetected falsification of information and
- the probability of undetected information loss.

The SCADA / EMS system shall comply with data integrity class and residual information error probability.

33.34.1.3 SYSTEM ARCHITECTURE

For safety and availability reasons, the SCMS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information shall be stored in distributed databases.

Principally the architecture of the SCMS is structured in the following levels:

- Remote level:
  System control operations shall be possible from the remote control centers
- Station level:
  System control operations shall be possible from the operator workstations
- Bay level:
  System control operations shall be possible from the bay control and / or protection units (IEDs)
- Apparatus level:
  System control operations shall be possible by local control from the individual equipment

The substation shall be controlled and supervised from up to two remote control centers or from the operator workstations while individual bays are supervised and controlled from the bay level devices in the control cubicles.

Interlocking between the levels shall be possible by customization. SCMS shall prohibit carrying out the control at the same time from different control levels.

It shall be possible to control and monitor the individual bays from bay level, in case the communication link fails. The station wide interlocking shall also be available when the station computer fails.

At station level, the entire substation shall be controlled and supervised from the operator workstations (HMI).

The station level contains the station-oriented functions, which cannot be realized at bay levels, e.g. alarm list or event list related to the entire substation. Communication with remote control centers via a gateway shall also be a part of the station level.

To provide highest reliability, the station computer, the operator workstations (HMI) and the gateway shall work completely independent, meaning retrieving the process data directly from the bay level devices.

A dedicated master clock for the synchronization of the entire system shall be provided for the complete substation. The master clock shall be independent of the station computer and of the gateway, and shall synchronize all devices via the station bus. The deviation of the different internal clocks shall not be more than 1ms.

The master clock shall be synchronized by a satellite receiver (GPS).The master clock in the substation shall be battery buffered.

Data transmission between the devices on station and bay level shall take place via the station bus, realized by using fiber-optic cables in a ring configuration, thereby guaranteeing disturbance free communication.

To increase system performance and availability, the system shall support several physically separated networks for the station bus e.g. separate networks for different voltage levels.

At bay level, the bay and / or protection units (IEDs) shall provide all bay level functions regarding control, monitoring and protection, inputs for status indications and outputs for commands. IEDs shall be directly connected to the switchgear without any need for additional interposition or transducers.

IEDs shall be installed in the local control cubicles independent of each other and the operation shall not be affected by any fault occurring at the station level or in other IEDs of the substation.

The SCMS shall contain the following main functional parts:

- station computer system
- Human Machine Interface (HMI) with process data base
- gateway for remote supervisory by control centers
- master clock (e.g. GPS receiver)
- protection fault processing
- service, analysis and engineering system
- data exchange between the different system components via serial bus utilizing fiber-optical links
- collection of the relevant data concerning the substation and distribution of the data where needed
- bay and station level devices for control, monitoring and protection
- process interface parallel wired or connected by a process bus.

IEC 61850 communication profile

The definition of the IEC 61850 communication profile shall ensure that the offered solution complies with the minimum requirements requested in the international standard of the IEC 61850. Additionally, it shall also ensure that the offered architecture can be realized with the offered products and their implemented services.

For interoperability, not only data shall be standardized but also the access to these data called services. The relevant areas to be covered by the profile are:

Communication services:
Abstract Communication Services (ACSI) (7-2)

Data modeling
Common Data Classes (7-3), Nodes (7-4).

The data modeling is not specifically listed but the supplier shall comply fully with the logical nodes described in the standard for the devices where they are required. As a minimum all the mandatory data of the used logical nodes shall be supported.

The system architecture of SCMS shall be based on a completely distributed approach. In order to support this distributed approach, the following communication services between the particular system devices shall be supported as a minimum:

1. Time synchronization
2. GOOSE-Communication between bay level devices (Interlockings)
3. File transfer
4. Reporting
5. Commands execution.

Ethernet Topology

The station bus according IEC61850-8-1 nowadays mapped to MSS / Ethernet (with priority tagging and with 100 MBit/s). The standard is not making any provision on the Ethernet communication infrastructure.

Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply in accordance with data sheets suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection. To ensure a certain level of quality, performance and availability at lea be fulfilled concerning the Ethernet switches and the ring topology:

- The switches shall be equipped with a double supply input. If there is an existing redundant DC system in the station (2 different batteries with 2 supply systems), the switches shall also be redundant, for example each switch’s input has supply to be connected to a different supply system.
- compliance with the IEC 61850-3 standard for high level of immunity to electromagnetic interference
- compliance with IEEE 1613 (power substations) standards for error free communications performance under EMI stress.
- a rapid network fault recovery (less than 20 milliseconds) and redundant power supplies for higher network availability (ideally isolated redundant power inputs with universal 24/48VDC or 110/220VDC/VAC power supply range).
- fanless design in order to enhance the overall reliability of devices.
- extended temperature tolerance to withstand climate extremes (within -40 to +85°C)
- RSTP/STP for network redundancy
- compliance with IEEE1588 for a precision Clock synchronization protocol for networked measurement and control Systems to synchronize real-time clock.

- configuration recovery adapter
- sufficient number of optical ports as specified in the datasheets
- Port Monitoring RMON (Remote Monitoring).

Additionally, the compliance of the Ethernet switches with IEEE802.1x is preferred. In this case, if some of the network components are not able to authenticate on the network using IEE802.1x, the MAC-Bypass functionality shall be provided as a minimum solution.

The use of Ethernet hubs is not permitted as they do not provide collision free transmission. The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g. for later system extension utility has not to rely on one switch supplier only. External switches are preferred as they have the advantage that there is no interruption or reconfiguration of the Ethernet network if one or several bay devices are taken out of service.

The system architecture shall be based on completely distributed approach also concerning the connection of any device to the system. Meaning any device, control as well as protection and station level devices shall be connected to the Ethernet network via a corresponding switch (one switch for one bay).

The distribution of the IEDs on the switches shall be designed by the supplier so that the IEC61850 properties of the station bus are not compromised.

To ensure maximum performance also for large systems it shall be possible to have more than one physical separated network. The network shall be designed that the number of switches used keeps the latency for time critical applications to a minimum.

OPC Client/Server Architecture

OPC Client/Server architecture shall be provided in order to allow the information exchange between the SCMS and the DCS.

The OPC Client shall allow the supervisory and monitoring of the substation apparatus from the DCS control room at the Plant.

For availability reasons, the OPC servers shall be provided in a redundant configuration.

The OPC client shall be a high performance workstation, based on high performance and maintenance-free computer system equipped with two LCD monitors. The LCD monitors shall comply with the TCO standards. Color graphics with high resolution are required.

OPC data security shall be provided.

OPC server connectivity to the IEC61850 compliant IEDs is preferred but the final method for translating the data from the native format of the data source in an OPC format is left to the discretion and the responsibility of the Contractor.

All equipment necessary to connect the OPC client (slave) located in the power plant control room with the servers (masters) in the substation control room shall be provided and installed by the Contractor in order to ensure a disturbance-free communication between both devices.

Furthermore, the Contractor shall be responsible for design, manufacture, inspection, testing, packing for export, shipment, insurance, transport and delivery to site, commissioning and maintenance during the guaranty period.

The Contractor shall also explain in detail how potential conflicts in the applications (in connection with the use of redundant OPC servers) can be neutralized (in case this would lead to problems during operation).

33.34.2 FUNCTIONAL REQUIREMENTS

All control and monitoring functions required for a secure and reliable operation of the substation shall be provided.

The minimum functions required are as follow:

- acquisition of binary signals (single and double indication)
- acquisition of analog signals
- monitoring of execution of commands
- automatic chronological control of standard switching routines
- station and bay interlocking
- tap changer control of power transformers inclusive automatic voltage regulator AVR
- supervision of the entire substation
- station control via operator workstations
- alarm handling
- event recording
- tagging
- analog value processing
- display of trend values
- evaluation and archiving of historical data
- fault indication
- all hardware, software and telecommunication facilities for remote control
- emergency control of each bay from the related bay units and local control cubicles.

The different high voltage and medium voltage apparatus within the substation shall be operated from different places:

- from the National Load Dispatch Centre (NLDC)
- from the operator workstations
- from the bay control and / or protection units (IEDs)
- from the individual equipment.

It has to be ensured, that operation is only possible by one operator at the time. Clear control priorities shall prevent operations of a single switch being initiated at the same time from more than one various control levels, i.e. remote level, station level, bay level or apparatus level.

The priority shall always be on the lowest enabled control level. However, it shall be possible to adopt other philosophies by parameterization.

33.34.2.1 STATION LEVEL FUNCTIONS

At least two station computers and one operator workstation (HMI) shall be installed in order to ensure the proper supervision of the entire workstation. The latest shall be expandable to multiple operator workstations (HMI).

The position of the switching devices (e.g. circuit breaker, disconnector, earthing switch, transformer tap changer etc.) shall be supervised permanently. Apparatus positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO).

An alarm shall be initiated if these position indications are inconsistent or if the required time necessary to operate the position changing mechanism exceeds a predefined limit.

Every detected change of position shall immediately be displayed on the single-line diagram of the operator workstations recorded in the event list. Additionally, a hard copy printout shall be generated. Alarms shall be initiated in the case of spontaneous position changes.

The Contractor shall provide complete operation workplaces (including desk, chair, etc.) for each operator and engineering workstation.

Station computer:

The station level of SCMS shall include a redundant station computer system for superior functions to achieve advanced availability, each of them equipped with a high performance microprocessor and real time operating system. The storage technology of the station computer shall be RAID (redundant array of independent disks) to allow higher data availability in case of failure of individual hard drives and/or higher data throughput than a single physical drive.

The station computer shall have access to all subsystems at the bay level, collect signals and information, issue commands and perform the signal processing required for the connected substation.

LEDs shall indicate the status of the respective circuits on the front of the station computers.

The station computers shall be placed together with all necessary input / output equipment in cubicles in the control room. The station computers shall be supplied from the station battery power supply.

Operator and Engineering workstations (OWS and EWS)

The engineering workstation shall be able to act also as an operator workstation. In normal cases it shall be used for system configuration and software implementation. The specifications of the engineering and operator workstation are given below.

The operator workstation (OWS) is emblematic for Human Machine Interface (HMI) and shall provide supervision of the substation on station level:

- presentation of user defined displays (switching status and analog values), standard displays, trend curve displays and reports
- effective and safe dialogues for manual control of the substation and for release of control sequences including select-before-execute
- tagging
- presentation of alarms and events on the operators video display units and printouts on the printer.

The OWS and EWS shall be high performance operator workstations, based on high performance and maintenance-free computer systems equipped with two LCD monitors each. The LCD monitors shall have a size of at least 20” diagonal and comply with the TCO standards. Color graphics with high resolution are required.

The system software shall be loaded from a transportable medium (e.g. CD, DVD) and shall be stored in a dynamic read / write memory with error correction and battery backup power.

One high speed color printer shall be supplied for graphic hardcopies of the displays and for reports.

Additionally a black and white printer shall be supplied that logs all events and alarms in which they are reported from the bay control units.

Printers which are supplicants for IEEE802.1x are preferred.

The AC power for the EWS and OWS, the monitors and printers shall be supplied by the station UPS power supply.

The operator shall have access via the operator workstation to the distributed intelligence. For control of the substation the operator will use a functional keyboard and a graphical locator (track-ball, mouse, etc.). The keyboard shall be designed to meet Employer’s specific requirements. Furthermore, the keyboard shall be exchangeable with an extended keyboard for substation and display modifications.

The operation procedure needs to be easily used and understood. Switching status of the substation in terms of actual measured values (currents, voltages, active and reactive power) as well as positions of transformer tap changers shall be displayed. The OWS and EWS shall give the operator and/ or engineer access to the equipment of the high voltage levels.

Display selection, parameter setting, alarm acknowledgment, selected printouts of reports and command outputs shall be performed from the operator/engineer's keyboard.

The system has to distinguish between alarm lists and event lists selectable on the monitor by the operator. Beside of these lists on the screen, there shall be a chronological print out of any alarm or event in an event log.

In addition, a historical archive-file including the events of at least the past 30 days shall be generated and stored on the hard disc.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be presented on any screen selected by the operator.

As a minimum, the following items shall be presented on the operator workstation:

Status diagrams showing the switching status and measured values of:

- the entire substation
- each voltage level of the substation
- each busbar section of the substation
- user authority levels
- command procedures
- control dialogues
- tagging
- control inhibit
- removed from Operation
- permit to work
- grounded
- event list:
- station –oriented
- bay –oriented
- SCMS-internal
- alarm list:
- station –oriented
- bay –oriented
- SCMS-internal
- event and alarm log
- system status diagram
- reports
- trend values.

Status diagrams

The station diagrams displayed on the operator workstation shall include as a minimum a diagram of the entire substation, an individual diagram for each voltage level of the substation and individual diagrams for each busbar sections of the substation.

A diagram shall be able to show a single line with all relevant data (at least 50 switching devices like circuit breakers / disconnectors / earthing devices, 20 measuring values, 40 additional indications).

New displays shall be designed in an interactive dialog without taking the total substation control system off-line.

Layouts of the displays are subject to the approval by the employer.

User authority levels

It shall be possible to restrict activation of the station diagrams within a certain user authorization group. Each user shall then be given access rights to each group of objects:

- display only
- normal operation (e.g. open / close apparatus)
- restricted operation (e.g. by-passed interlocking)
- system administrator.

For maintenance and engineering purposes of the station HMIs, the following authorization levels shall be available:

- no engineering allowed
- engineering / configuration allowed
- entire system management allowed.

The access rights shall be defined by passwords or alternatively by key card readers etc. assigned during the log-in procedure. Only the system administrator shall be able to add / remove users and change access rights.

Command procedures

To ensure a high degree of security against unwanted operation, a special operation procedure select-before-execute shall be provided.

After selection the operator shall be able to recognize the selected device at the screen and all other switching devices shall be blocked.

The operator shall only be in a position to execute a command if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

Control dialogues

The operator shall give commands to the equipment of the high voltage and medium voltage via mouse clicks on soft keys located on the diagram. Data entry shall be performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- circuit breaker and disconnectors
- transformer tap-changers
- device of control sequences
- device of load shedding.

Event list

The substation event list shall contain events that are important for the control and monitoring of the substation. The time shall event be in real display time with a resolution of at least 10ms.

The operator shall be able to call up the chronologically ordered event list on the monitor at any time for the entire substation or sections thereof.

A printout of each displayed event list shall be possible on the printer. Features for page-sensitive printing shall be provided.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the operator workstation. The information shall also be retrievable from a printed event log.

The chronological event list shall contain:

- position changes of circuit breakers, disconnectors, earthing devices and tap changer operations
- indication of protective relay operations
- fault signals from the switchgear
- indication when analog measured values outside upper and lower limits
- loss of communication
- operators commands and taggings.

Filters for selection of a certain type or group of events shall be available.
The filters shall be designed to enable viewing of events grouped per:

- date and time
- bay
- device
- function
- alarm class.

Alarm list

Faults and errors which may occur in the substation shall be tabulated in the substation alarm list and shall be available to be simultaneously transmitted to the remote control centre. The alarm list shall replace a conventional alarm tableau and shall constitute an actual evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults.

Date and time of the occurrence of alarms shall be indicated. The time shall be displayed corresponding to the alarm in real time with a resolution of at least 10ms. The sequence of alarm indication in the alarm list shall coincide with the occurrence of the alarms.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- the date and time of the alarm
- the name of the alarming object
- a descriptive text
- the acknowledgement state.

The operator shall be able to select displays which contain only a section or subsection of the substation overall alarm list.

The operator shall be able to acknowledge alarms at the keyboard, acknowledged alarms shall be marked in the list. An unambiguous distinction (e.g. in color) of acknowledged and unacknowledged alarm shall be ensured in the alarm list.

Faults which appear and disappear without being acknowledged shall be specially marked in the alarm list.

Filters for selection of a certain type or group of alarms shall be available as for events.

The alarm list shall be presented on the display screen. It shall be possible to obtain hardcopies of the alarms on the printer. Features for page-sensitive printing shall be provided.

SCMS internal alarm list

The SCMS shall constitute an actual evaluation of internal SCMS alarms, e.g. of defect SCMS input / output boards or defect SCMS communication nodes.

It shall contain unacknowledged alarms and persisting faults as mentioned before.

Event and alarm log

The event and alarm log shall be the spontaneous listing of events and alarms displayed on the monitor.

This log shall contain the same alarms and events as mentioned above, but chronologically listed as soon as they occur.

Each alarm shall be configurable in a way that a second message can be listed if the alarm disappears.

System status diagram

The SCMS shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations.

The system status diagram shall cover the entire SCMS configuration and the status of all devices of the SCMS including bay level devices, substation level devices and communication links.

Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak).

Historical reports:

- Day
- Week
- Month
- Year.

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

It shall be possible to print out the report on request and automatically at pre-selected times.

Trend display (historical data)

A trend is a time-related follow-up of process data. It shall be possible to illustrate all types of process data as trends (binary and analog data). The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen.

It shall be possible to change the type of value logging (direct, mean, sum or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

Common bay unit

The station level shall include a common bay unit for acquisition of inputs / outputs not assigned to dedicated bays.

The common bay unit shall be placed together with all necessary input / output equipment in cubicles in the control room. The common bay unit shall be supplied from the station battery power supply.

Substation Gateway

The Substation Gateway shall be based on high performance and maintenance-free computer system equipped with a real time operating system. The access to all subsystems at station level shall be guaranteed. The computer shall also collect signals and information, issue commands and perform the signal processing required for the connected substation.

System service and analysis

For fault evaluation and monitoring as well as integrated disturbance monitoring and analysis a service and analysis system shall be implemented in the SCMS.

Automatic disturbance file transfer

For the bay level devices with integrated disturbance recorder as well as for dedicated disturbance recording systems, all recorded data shall be automatically uploaded (event triggered or once per day) to the station computer or a dedicated computer and be stored on the hard disc.

Disturbance analysis

The SCMS shall provide all relevant information for faultfinding, analysis, and troubleshooting on a dedicated disturbance analysis system. Suitable and user-friendly fault evaluation software shall be included in the scope of supply, providing short fault summaries and automatic printouts of the fault history and fault location.

The protection engineer may have his own PC-based system or use the Operator workstation to evaluate all the required information for proper fault analysis, independent of the network control centers.

If a separate disturbance analysis system is provided, it shall be a work-station, based on a high performance and maintenance-free computer system equipped with one LCD monitor. The LCD monitor shall have a minimum size of 20” color graphics diagonal with high resolution are required.

The disturbance analysis system software shall be loaded from a transportable medium (e.g. CD, DVD) and shall be stored in a dynamic read / write memory with error correction and battery backup power.

The scope of supply includes all required equipment, communication lines and installations to enable the disturbance analysis workstation for the proper connection and communication with the protection units.

Parameter Setting

Under this function it is understood the capability of reading out and writing information from / to the IEDs, in particular parameterization, setting, visualizing and analyzing disturbance and event records through the service and analysis system:

- from the operator workstations (HMIs), by use of standardized IEC 61850 protocols
- from the remote control centre
- from a modem-connected evaluation station connected at a remote location.

Setting of parameters or activation of parameter sets shall only be allowed after entering a password.

It is proposed to include under the scope of this project all required modems and software licenses for the remote evaluation station.

Service, analysis and engineering unit

A portable service, analysis and engineering unit based upon a standard personal computer shall be foreseen for on-site modifications of the control and protection devices for the SCMS. This service unit shall be used for documentation, testing and commissioning.

The service unit shall permit the user to study changes in the substation. The service unit shall be able to monitor data in the running SCMS and to present changing variables on the display screen, selectable in tabular form or in graphic representation.

The service unit shall be used for the following purposes:

- system configuration
- system testing
- help functions
- program documentation
- down and uploading of programs
- system commissioning
- data base management
- changing peripheral parameters program entry
- on-line parameter setting features
- other subjects depending on the requirements during engineering stage.

The service unit shall be used for detail engineering of the SCMS.

As the result of the design process for IEC 61850 based systems shall formally be described in a SCD (System Configuration Description) file, which contains the logical communication connections between IEDs within sub-networks and routers between sub-networks. The detail engineering on system level has to determine the communication addresses and the detailed data flow between the IEDs in terms of data sets and signal inputs to clients. This signal-level data flow engineering replaces to a big extent the engineering of the conventional wiring. Due to the inherent semantics of the IEC 61850 data model, this step can also be supported with object based or even automated signal engineering. The resulting SCD file contains individualized IED descriptions for the system under design. These descriptions shall be downloaded via the service unit to the IEDs to make them aware of their place in the system and their connections to other IEDs.

The service unit has to be supplied at the beginning of the commissioning period and shall be available for training of the Employers personnel.

The service unit shall be supplied with all necessary tools and licenses in order to fulfill the planned tasks.

Software development tools and maintenance

Program development editing, compilations and linking shall be available on the workstation and laptop.

This implies that all source files containing source programs shall be supplied to enable future software development and modification.

All program development and support functions to be supplied shall be described in detail to enable the trained personnel to use the system.

The programming languages supported by the system shall be stated.

Any apparatus that enables testing, configuration and diagnosis of bay control units, gateway and substation LAN e.g. laptops, communication devices is to be included in the offer.

Interface to the remote National Load Dispatch Center

Communication to the National Control Centre shall be provided by data communication, utilizing both, the IEC 60870-5- 104 and the IEC 60870-5-101 protocols. Settings shall ensure interoperability with the remote National Load Dispatch Center.

For possible future extensions, it shall be possible to interface with two remote control centers simultaneously by using dual port capability.

From the National Load Dispatch Center, all related high voltage apparatus of the substations shall be remote controlled and monitored.

All signals of the substation required for the control and monitoring from the remote National Load Dispatch Center shall be made available for data transmission via the gateway. Additionally the signals from/ to Power Plant shall be passed through to/ from NLDC. Reference is made to Chapter 7 of Section 5 where at least these signals are defined to be exchanged for AGC capability of the Plant.

The scope of supply includes all required equipment and installations to enable the substation for the proper connection of the required control and monitoring signals.

Station protection functions

The protection system is described in a separate subsection. However, the following items are also important for SCMS as the protection functions are an integral part of the SCMS.

Station protection functions are protection functions which are normally not allocated to the particular bay. This concerns essentially busbar and breaker failure protection schemes (by busbar protection a part of equipment can be allocated in the particular bays, which are connected with a central unit via a proprietary bus. The connection of the central unit to the station bus is under the entire contractor’s responsibility).

All protection functions realized in the station level shall be based on numerical technology. Remote access to the protection devices shall be made available.

The station protection units shall be serial integrated for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various station protection units shall be compatible with the overall system communication and data exchange requirements.

The operation shall depend on the conditions of other functions, such as interfaces, local HMI, event and disturbance recording; data-storage, self- supervision, etc. (see description

33.34.2.2 BAY LEVEL FUNCTIONS

In a decentralized architecture the functionality shall be as close as possible to the process.

In this respect, the following functions shall be allocated at bay level:

- bay control functions
- bay protection functions
- data collection functionality.

In application for high voltage levels bay control functions and bay protection functions shall be carried out in separate units.

All bay internal programs, command sequences, collection of signals and information, outputs of commands and signal processing required for the different switchgear units of the corresponding bays shall be performed by the IEDs.

The IEDs shall be based on a microprocessor technology and real time operating system.

Power supply to the IEDs shall come from the station battery and shall be redundant.

The IEDs are placed together with all necessary input / output equipment in the local control cubicles in the control room of the control building. The bay level devices shall be supplied from the station battery power supply.

Bay control functions

Control mode selection

The different high voltage apparatus within the substation shall be operated from different places:

- from the remote control centers (National Load Dispatch Center)
- from the operator workstation
- from the bay control and / or protection units (IEDs)
- from the individual equipment.

It has to be ensured, that operation is only possible by one operator at a time. Clear control priorities shall prevent that operation of a single device can be initiated at the same time from more than one various control levels, i.e. remote level, station level, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

OFF mode:
It is not possible to operate any object, neither locally nor remotely.

EMERGENCY mode:
The position indication shall be retrieved directly from the primary equipment circuit breaker.

On the mimic board, the selection push button and either the ON or OFF push button has to be pushed simultaneously in order to close or open the circuit breaker.

To control in the emergency mode requires a special key. Control operation from other places (e.g. from REMOTE) shall not be possible if the emergency select key is in the emergency operation position.

LOCAL mode:
The related object has first to be selected on the local HMI. In case of blocking or interlocking conditions, the selection will not be possible and an appropriate alarm annunciation shall be generated. If a selection is valid the position indication will show the possible direction and the appropriate ON or OFF button shall be pressed in order to close or open the switching device.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

REMOTE mode:
Control authority in this mode is given to a higher level (station or remote level) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

It shall be possible to adopt other philosophies by parameterization.

Interfaces
All IEDs shall be provided with an optical interface for connecting the station bus and communication to station level devices and remote level devices according to IEC 61850.

Additionally the IEDs shall be provided with an optical front interface for connecting a personal computer or a laptop.

The monitoring, controlling and configuration of all input and output logical signals, all binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

Local HMI

A local HMI at the IEDs shall permit controlling and monitoring the individual bays from bay level.

The local HMI shall be front-mounted and based on a user-friendly, menu-structured program and performed with the use of a permanently installed HMI-unit, type tested together with the IED.

The diagram of the individual bay shall indicate the switching status as well as the measured values.

Service values of current and voltages as well as active and reactive power shall be available. Also characteristic analog values related to the activated functions (e.g. impedance in case of distance protection) shall be available.

Additionally an alarm annunciation for bay alarms shall be included in the local HMI.

Command supervision

Perfect collection and processing of all switchgear positions of the entire substation must be ensured at all time. Unclear information, such as intermediate switchgear positions, switchgear fault, faulty data transfer etc. must never allow switching operations.

Control, regulation and synchronizing functions shall require perfect collection and processing of all information of the substation. The information has to be up to date and valid.

Mal-operation of control and regulation facilities such as on-load switching of a disconnector, switching on in asynchronous state etc. shall be avoided. If remote and / or station level control and regulation facilities are failing, back-up control shall be possible.

Interruption of drive latching in case runtime is exceeded. When the runtime is exceeded, the command has to be cancelled.

Pole discrepancy monitoring

A pole discrepancy function, based on the measurement phase over currents and current differences between phases shall be provided.

Select-before-execute-procedure

Select-before-execute-procedure shall be applied for the operation of circuit breakers. For safety reasons the command is always given in two stages: selection of the object and command for operation. These two stages are realized with one contact each and the final command will be executed only when both contacts are closed.

Station interlocking

Interlocking facilities shall be installed in the switchgear to prevent damages and accidents in case of false operation.

Within the bay itself, software interlocking controlled via bay control units shall be used. The station interlocking systems shall be provided via station bus. The tender shall describe the scenario while an IED of any bay is switched off or fails.

The primary interlocking of the substation feeders shall be provided via hardwire parallel cabling as specified.

The station interlocking system shall make it easy to add new feeder (lines, transformers etc.) and future modification and extension of the station control shall be possible without interference to the operation of other parts of the installation (e.g. moving of existing feeders including all parameters and settings to enable installation of new feeders).

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. Modifications shall be possible to be carried out by the Employer‘s staff without compromising operation and safety.

The function and design of the switchgear interlocking systems shall be a hardware interlocking with parallel copper cabling as specified and shall be extremely reliable and safe.

For the switching and operation of the substations, the following interlocking concept shall be applied:

- The disconnector shall be operable only when the relevant circuit breaker is in the off-position and all relevant earthing switches have been removed.
- The earthing switch is operable only when the disconnectors have been opened and the relevant location is free of voltage.
- Closing of circuit breaker shall only be possible when the relevant earthing switches have been removed and the protective relays and corresponding lock-out relays are not actuated or if they are actuated, the faults have been cleared and the respective lock-out relays have been reseated.
- Busbar change-over shall be possible with the busbar disconnectors and bus coupler in closed position without power supply interruption.
- When a pressure drop signal is received from gas monitoring device for a SF6 circuit breaker, the tripping and the closing signal shall be locked out.
- Other interlocks as found necessary during engineering stage.

An override function shall be provided which can be enabled to bypass the interlocking function.

Service interlocks shall be provided for future remote operations and maintenance interlocks shall be provided for local operations.

The interlocking system is to be designed in such a way that testing is possible during normal operation.

Synchrocheck

The synchronism and energizing check functions shall be distributed to the control and / or protection devices and have the following features:

- Adjustable voltage, phase angle, and frequency difference.
- Energizing for dead line-live bus, live line-dead bus or dead line–dead bus.
- Settings for manual close command and auto reclose command shall be adaptable to the operating times of the specific switchgear.

Synchrocheck function shall be applicable for all breakers.

Voltage selection

The voltages relevant for the synchrocheck functions are dependent on the station topology, i.e. on the positions of the circuit breakers and / or the disconnectors. The correct voltage for synchronizing is derived from the corresponding voltage transformers or from bus voltage image with special relay control and shall be selected automatically by the control and / or protection IEDs.

Auto reclosing

The auto recloser should be settable for the following modes of operation:

First auto reclosure sequence:

- Three-phase auto reclosure
- Single / three-phase auto reclosure
- Single-phase auto reclosure

Further auto reclosure sequences:

- no further auto reclosure sequences
- further auto reclosure sequences (totally 2, 3 or 4 sequences), always three-phase sequences

It shall be possible to perform all three-phase auto reclosure sequences with or without synchrocheck with respect to voltage check.

Transformer tap changer control

Voltage regulation for transformers with on-load tap changer shall be either included in the numerical control unit for the power transformer bay or located in a separate on-load tap changer control device which is associated with the power transformer. If a separate tap changer device is used, it shall be considered as an integral part of the SCMS like any other bay-oriented device.

Event and disturbance recording

Each IED shall contain an event recorder capable of storing at least 256 time-tagged events.

Having bay protection functions, the IEDs shall provide the user, either locally or remotely, with complete information on the last ten disturbances.

A disturbance recorder with a minimum of 5 seconds recording time for at least 10 disturbances shall provide the user with time-tagged disturbance records. At least the analog inputs as well as 16 binary signals must be recorded with a sampling rate that guarantees the presentation of a fifth harmonic component of any recorded analog signal. The pre-fault and fault currents and voltages shall be recorded for each disturbance and be made available for further evaluation purposes.

Data-storage

Data storage of at least 500 events (cyclical buffer) shall be provided.

Self-supervision

The electronic system shall be provided with functions for continuous self-supervision and test. Each circuit board shall contain circuits for automatic testing of its own function. These circuits shall interact with a test and diagnostic program controlled by the central unit.

Faults in a unit shall be indicated by the illumination of a red LED on the front edge of the unit and reported to the higher operation levels. The error indications / messages to be generated shall allow fault localization down to the card level.

Time for fault tracing and replacement of a faulty unit shall be reduced to a minimum.

Self-supervision shall also comprise the power supply system, the internal system bus and the ability of the central unit to communicate with different circuit boards.

Bay protection functions:

The protection system is described in a separate subsection. However, the following items are also important for SCMS as the protection functions are an integral part of the SCMS.

All protection functions realized in the bay protection units shall be based on numerical technology. Remote access to the protection devices shall be made available.

The bay protection units shall be serial integrated for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various bay protection units shall be compatible with the overall system communication and data exchange requirements.

The operation shall depend on the conditions of other functions, such as interfaces, local HMI, event and disturbance recording, data-storage, self- supervision, etc.

Data collection functionality:

Generally the following basic data collection functions shall be performed by the IEDs:

- signal acquisition
- acquisition of measured and counted values
- monitoring of execution of commands
- calculation of derived operational measured values
- generation of group signals.

The position of each switching device (e.g. circuit breaker, disconnector, earthing switch, transformer tap changer etc.) shall be supervised permanently.

Every detected change of position shall be immediately visible in the single-line diagram on the local HMI and reported to the station and remote level.

Alarms shall be initiated in the case of spontaneous position changes.

The positions of each switching device shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO).

An alarm shall be initiated if these position indications are inconsistent or if the required time necessary to operate the position changing mechanism exceeds a predefined limit.

Analog inputs for voltage and current measurements with high-accuracy of 0.5% shall be provided. The values of active power (W), reactive power (VAr), frequency (Hz) and the rms values for voltage (U) and current (I) shall be calculated.

The measured values shall be displayed locally on the station HMI and reported to the higher level. Threshold limit values shall be selectable for alarm indications.

Additionally digital inputs for acquisition of active and reactive power in line and transformer bays shall be ensured.

IEDs shall be provided within a process interface for acquisition data directly from the high voltage and medium voltage apparatus:

- binary inputs and outputs
- analog input and outputs:
- 0 –100 (110) V
- 0 –1 / 5A
- 0 / 4 –20 mA.

The provided quantity of inputs and outputs in the tender shall be based on the single line diagrams of the substation to consider the quantity of binary and analog inputs / outputs as indicated in the IEDs.

The quantities of binary and analog inputs / outputs as indicated are minimum requirements. Any further requirements as per the Substation manufacturer and identified during engineering stage, site testing / commissioning stage shall be included.

33.34.2.3 DESIGN REQUIREMENTS

In order to meet the requirements of this specification, the detailed design of the SCMS is within the contractor’s/supplier’s responsibility to submit for the Employer/Engineer review and approval. The following important requirements should be guaranteed in any case:

- Distributed architecture that allows the placement of bay level devices in a cubicle and the station equipment in a central building.
- Bay level devices like IEDs are directly connected to the station bus also the protection equipment of other manufacturer
- In the case of main1 / main 2 protection schemes, the two protection terminals shall be of different hardware and software.
- Back-up protection functions can be allocated in the bay control unit.
- Station-oriented protection functions (busbar and breaker failure protections) may be integrated into one system.
- Reclosing and associated synchrocheck rspt. Voltage check functions can be considered as control functions.
- A separate control unit has to be associated to each circuit breaker.
- In case of a 1½ breaker scheme, three control units are requested per diameter.
- The supplier shall present the layout of the different cubicles used in the project, following a bay-oriented arrangement.

33.34.2.4 STATION LEVEL DESIGN

Station level devices such as switches, gateways, station computer, operator workstations, etc. are directly connected to the station bus. The Contractor shall present a detailed schematic and the drawings of the station level and the bus connections

33.34.2.5 BAY LEVEL DESIGN

For each type of bay (line, transformer and coupler bay) the supplier shall present the principal arrangement of the cubicles within type of hardware units and associated functions.

The protection scheme is an integral part of the SCMS system, and the protection relays shall therefore be directly connected to the station bus, in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters remotely. Back-up protection schemes can be allocated in one or the other units already mentioned.

In some applications or voltage levels a higher degree of integration is acceptable, e.g. integration of control and main protection functions or integration of busbar and bay protection functions.

A high integration of functions and a low number of units is permitted under consideration of the method of fulfilment of the reliability requirements.

Line bay:
Cubicle with:

- already mentioned control unit per breaker with the associated bay mimic (control, recloser, synchrocheck), and depending on voltage level also with protection schemes
- already mentioned main and back-up protection schemes for the line

- protection unit for the busbar and breaker failure protection functions per set of current transformer (in the case of a double-busbar scheme, the breaker failure protection may be associated with the line protection)
- dedicated disturbance recorder unit (depending on the required sampling rate).

Transformer bay:
Cubicle with:

- control unit per voltage level
- already mentioned main protection for the power transformer
- protection unit for the busbar and breaker failure protection functions (in the case of a double-busbar scheme, the breaker failure protection may be associated with the line protection)
- back-up protection in one separate unit or in the control unit
- units for dedicated disturbance recorder (depending on the required sampling rate).

Coupler bay:
Cubicle with:

- control unit per breaker with the associated bay mimic (control, recloser, synchrocheck)
- protection unit for the busbar and breaker failure protection functions. Normally one set of current transformer is sufficient, because the busbar protection is designed to work correctly even if only one set of current transformer is available
- protection functions (normally overcurrent functions) can be mounted in one of the units already mentioned or in a separate unit.

33.34.2.6 QUANTITY OF INPUTS AND OUTPUTS

The bidding shall be based on the single line diagrams of the substation to consider the quantity of binary and analog inputs / outputs as indicated in the bay control units.

The quantities of binary and analog inputs / outputs as indicated are minimum requirements.

Any further requirements as per the substation manufacturer and identified during engineering stage, site testing / commissioning stage shall be included.

Minimum binary inputs (single indications):

- 8 per circuit breaker
- 5 per disconnector
- 4 per earthing switch
- 16 per line feeder from protection
- 6 from busbar protection
- 50 general / auxiliaries for the whole substation
- status of transformer operation

Minimum binary outputs (single commands):

- 2 per circuit breaker
- 2 per disconnector
- 2 per earthing switch
- 2 per tap changer lower / raise
- 2 per tap changer automatic / manual
- 2 per AVR

Minimum analog inputs (11 bits + sign bit measuring):

- 3 voltages per busbar section
- 3 voltages per transformer bay
- 3 currents per coupler bay
- 3 currents per transformer winding
- 1 active power per transformer
- 1 reactive power per transformer
- tap changer position per transformer
- winding temperature per transformer
- oil temperature per transformer

33.34.3 PROJECT MANAGEMENT

33.34.3.1 GENERAL

During the project management phase the following activities shall be considered:

- Engineering
- FAT
- Site installation
- Commissioning
- SAT
- Training
- Operation
- Service, after sales and maintenance.

33.34.3.2 ENGINEERING

The specific functionality and boundary conditions of the SCMS shall be adapted to the requirements which are related to the particular voltage level and specific substation layout.

During the engineering phase at least the following items are very important and shall be supplied for approval by the Employer:

- overall single-line diagram, including position of the different objects (CT’s, VT’s, isolators, etc.) for the engineering work
- general system architecture of the entire SCMS for each substation
- functional design specification of SCMS, which describes in details the equipment and the functionality’s

- layouts of the displays at station level and bay level as single-line diagram, event list, alarm list, etc.
- lists of events and alarms (including their names) with the indication of the particular signal to be sent (station event list, remote, etc.)
- transmission to the remote control centres
- station interlocking cubicle layout.

33.34.3.3 FAT AND SAT

The supplier shall submit a test specification for the factory acceptance test (FAT) and the site acceptance tests (SAT) of the SCMS for approval. For the individual devices applicable type test certificates shall be submitted.

The manufacturing phase of the SCMS shall be concluded by the FAT. The purpose is to ensure that the supplier has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the Employer.

The general philosophy shall be to deliver a SCMS to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the same parts of SCMS are already installed on site, the FAT shall be limited to subsystem tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

33.34.3.4 COMMISSIONING

The commissioning of the primary equipment and the wiring between the primary equipment and cubicle terminals of the SCMS system is not part of the commissioning of the SCMS and has to be finished before commissioning of the secondary equipment.

33.34.3.5 TRAINING

During erection, commissioning and operating staff is to be familiarized with the functions of the SCMS. The Contractor shall arrange appropriate training on the operation and maintenance of the SCMS equipment for the Employer.

A tentative training program shall be submitted by the Contractor. The training program shall consider the avail shall be structured accordingly. The training shall be performed during installation as well as during commissioning.

The training sessions shall be conducted by for this purpose specially trained personnel of the contractor.

The training sessions shall be performed in language specified in General Specification (Chapter 3 of Section 5).

The focus of the training shall be on the general and basic structure of the SCMS and its components as well as configuration and setting of parameters respectively the maintenance and error correction.

The training shall include as a min maintenance staff in the operation setting and testing of the SCMS. Training shall be regularly performed during the erection and commissioning of the equipment in the substation. Before energizing, training sessions of at least two weeks, separated into different sessions shall be performed. The Contractor shall provide comprehensive training documents. Furthermore, particular attention shall be paid to maintenance and repairs.

33.34.3.6 SERVICE, AFTER-SALES AND MAINTENANCE

In order to reduce maintenance, training and commissioning costs, it is required to use the lowest number of different hardware platforms as possible.

A guarantee period including replacement of defective material for a period of 24 months, starting from the date at which the system has been taken over or for a period of 30 months after the last delivery by the factory shall be agreed upon.

The supplier shall provide spares considered necessary for the bay control units, gateway and other equipment that the Employer may require to replace damaged components in order to bring the system to full operation. All special tools and test equipment required for maintenance of the system shall be included in the offer. The complete spare parts list recommended and submitted by the supplier shall be subdivided into:

- Short-term spare parts that are necessary for two (2) years of operation as mentioned above. These spare parts shall be included in the contract and shall comprise at least one spare module for supplied equipment and basic tools for system maintenance.
- Long-term spare parts necessary during the lifetime of the SCMS (not less than ten (10) years of operation).

The complete system shall be accessible for the manufacturer via modem after permission of the user.

33.34.3.7 DOCUMENTATION

The hardware and software documentation shall comprise but is not limited to the following:

- list of drawings
- control room layout
- assembly drawing
- single line diagram
- block diagram
- circuit diagram

- list of apparatus
- list of labels
- Functional Design Specification (FDS)
- test plan and specification of factory acceptance test (FAT) and of site acceptance test (SAT)
- standardized IED capability description (ICD) files written in SCL (Substation Configuration Language) according to IEC 61850-6
- standardized substation configuration description (SCD) file written in SCL according to IEC 61850-6
- front view and side view of all different cubicles
- circuit diagrams for cubicles
- connection tables for cubicles
- logic diagram
- list of signals
- product manuals
- operator’s manuals

The size of all documents and drawings shall conform to ISO standard, and be of size of A1, A2, A3 or A4.

Larger sizes than A1 shall be avoided. All documents in size A3 and A4 shall bound in hard covers. The schematic diagrams, apparatus and cable lists shall be size of A3 or A4.

All drawings shall be carried out in the latest version of AutoCAD or a similar aided drafting software package. Scales to be used shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

All system hard- and software documentation and the application hard- and software documentation shall be written in English Language, especially where the text refers to operational and warning labels.

During the project, the contractor shall maintain a list of documentation to be updated whenever needed. This list of documentation shall include the date of the original issue of each document submitted as well as the date of each revision. A time schedule for the submittal of the documentation shall also be included in this list.

33.35 PROTECTION

33.35.1 CURRENT AND VOLTAGE TRANSFORMER REQUIREMENTS

The rated burden of the protection cores indicated in the data sheets are to be considered as minimum requirements for all possible ratios; the Contractor may select either primary reconnection or secondary taps in achieving the specified ratios.

The Contractor is responsible for defining the final characteristics of the CT's and VT's cores for protective relaying functions (dedicated or combined measuring / protection) so as to satisfy the performance requirements of the offered relays. The compliance of the CTs and VTs shall be documented and submitted for Employer's approval prior to their manufacturing.

Current transformers shall be preferably of the low reactance type (for all secondary taps in case of multiple ratios). The performances shall not be inferior to that defined in the IEC Publications.

In case class “X” type cores, the knee point voltage recommended (defined as the point on the excitations curve at which a 10% increase in the r.m.s value of the applied voltage results in 50% increase in the r.m.s value of the secondary exciting current) shall be for each of the possible ratios above the secondary voltage for maximum short-circuit conditions, actual secondary winding resistance at 75°C and 150% of the anticipated external burden.

The following minimum requirements apply:

- magnetizing current at knee-point voltage not higher than 5% of the nominal secondary rated current
- maximum secondary resistance so as to not exceed 50% of the secondary rated burden.

For the high impedance protection, scheme specific requirements shall be taken into consideration for selecting knee-point voltage and magnetizing current.

Means for checking the integrity of the CT and VT circuits shall be foreseen, either automatically or manually. This check must be performed on-line without inhibiting or jeopardizing the protection function. The Bidder shall explain his method of performing these checks.

For easy commissioning, the CT and VT terminals of the relay panels shall be equipped with links for interrupting or shorting as well as measuring points. Each current transformer circuit shall be earthed through a link at one point only. By interrupting of any current transformer circuit at the place before his earthing (e.g. at the measuring point) it shall be foreseen the automatic shorting of remain circuit and the earthing of this circuit at other point.

33.35.2 AUTO RECLOSING CONCEPT

All protections for 400kV OHLs described in these nodes shall be designed for operations in conjunction with one three phase auto reclosing cycle. Additionally all protections for these OHLs shall be designed for operation in conjunction with one one-phase auto reclosing cycle + one three phase auto reclosing cycle after unsuccessful one-phase auto reclosing cycle.

33.35.3 REFERENCES

The provided protection equipment supplied under this contract and its associated software shall have a conclusive number of reference installations at similar voltage levels and at least two years of operational experience in a HV substation.

33.35.4 HOUSING, WIRING, IDENTIFICATION

The provided protection equipment shall be grouped in the necessary number of fully wired, floor mounted, steel sheet cubicle type panels. The cubicles shall meet the requirements of the IEC Publication 60529, classification IP 52.

The Contractor has to provide adequate cooling for the cubicles at very high temperatures in summer. Temperature within the cubicles shall stay if electronic modules are installed unless these can cope with high temperatures that have to be expected.

Basically each protection cubicle shall be dedicated to one single protected element.

The sequence of the cubicles shall be defined in detailed design. Cubicles shall be fitted with window type (flame-retarding) protective full doors.

By installation of protection cubicles in the relay room of corresponding control building, these rooms shall be air-conditioned. Protection cubicles shall be of the self ventilated type and complying with all construction requirements of the above mentioned sub-section of the Specification. The Contractor shall ensure that in the event of failure of the air-conditioning system the protective relaying systems and their associated signaling, monitoring, control and alarm equipment must remain in full operating condition, during minimum 24 hours the outside ambient temperature and the maximum possible for region humidity. Due to aggressive environment the cubicles shall be made in tropical export version.

Suitable heating elements in the relay cubicles, controlled by humidity detectors, must prevent in this case any condensation form while keeping the cubicle internal temperatures within the operating limits of the devices.

The internal wiring of the cabinets must be carried out according to the provisions of specification. Within the cubicle, wiring associated with each functional assembly shall be as far as possible segregated.

The final paint cover shall comply with the requirements of General Specification (Chapter 3 of Section 5) the color shall be subject of Employer's approval.

Equipment identification shall include:

- feeder (bay) labels
- individual relay identification (device, ANSI designation numbers and functions)
- terminal identification of external relay connections to CTs, VTs, DC and AC alarms, trips and communication equipment
- control cable labels.

33.35.5 TESTING FACILITIES, INDICATIONS

Individual relays and protection assemblies intended for panel or rack mounting shall be designed so that the internal functional modules are capable of being extracted from their case or rack without altering any external wired connections (including CT's circuits).

Except as stated otherwise, no provision for automatic test facilities is required. Each protection functional assembly shall be provided with easy accessible field testing terminal blocks/sockets. Where Main and Backup or duplicated protection systems are provided, testing of one protection shall be possible without hindering the function of the other.

The protection schemes shall be provided with local and remote DC supply supervision and with following minimum local indications, manually or electrically resettable, allowing for a reliable and precise post-fault/test response analysis:

- faulty phase (where applicable) or general starting
- operating time or time zone
- tripping
- receiving and sending of all associated HF signals (manipulated/ blocking/ permissive/ direct trip)
- associated PLC channel(s) failure
- test/in/off status (in conjunction with a lockable switch with remote position indication).

The operating indications shall not be lost in case of auxiliary supply interruption. Means for testing of the indicators shall be provided at relay case or panel level.

The indications shall be clearly visible without opening of relay cases or relay cubicle doors. Resetting shall be possible without opening relay cases.

Auxiliary supply:

The supply of all static relays shall be ensured by DC/DC converters, preferably for each individual functional unit. Basically, Main and Backup or duplicated protection systems of the same network element shall be supplied from different DC battery circuits. The relay cubicle DC supply shall be monitored and a central alarm issued whenever the voltage exceeds the limits for reliable operation. Schemes shall be based on the fail-safe principle, e.g. DC supply loss or open circuit shall not cause incorrect opening or closing of relay contacts.

If not stated otherwise following basic design data for new bays of corresponding 400kV Substation apply:

- DC trip/control voltage: 110 V DC (+ 10% ... - 30%)
- VT phase secondary voltage: 110 V
- CT phase secondary current: 1 A
- rated frequency: 50 Hz (- 6% ... + 2%)

Within the specified DC voltage and frequency variations the offered relays shall retain their rated characteristic accuracy and full operation capability.

33.35.6 TRIPPING CIRCUITS

The trip contacts shall be hardwired and act via tripping relays on the trip coils of the corresponding circuit breaker. Two tripping relays with remote reset via the station controller shall be implemented, with one trip relay combining the Main (Main1) protection relays and the second combining the Backup (Main2) protection relays. Each trip relay shall act on a separate trip coil of the circuit breaker.

The trip output individual protection functional assemblies shall be of electromechanical type.

The trip circuits shall be continuously supervised in the closed and open position of the circuit breakers. The trip supervision circuit shall include to the extent feasible all loops between trip contacts.

33.35.7 ELECTROMAGNETIC INTERFERENCE, INSULATION

All the necessary measures at substation/control building/cubicle level for ensuring proper function and component safety of the offered relay types with respect to overvoltage's induced in the secondary wiring (from primary and secondary equipment switching) as shielding and earthing of control cables, are part of the scope.

The provided relaying equipment shall basically meet following specifications:

HV test:	2 kV 50 Hz, 1 min or 2.8 kV DC 1 min
HV impulse:	IEC 60255-4/5, Class III, test voltage
5 kV	
HF test:	IEC 60255, Class III
Electrostatic discharge:	IEC 60255, Class IV Radiated electromagnetic field: IEC 60255, Class III
Fast transient tests:	IEC 60255, Class IV
Temperature:	IEC 60068-2 IEC 60068-2
Relative humidity:	IEC 60068-2days
Enclosure:	IEC 60529, IP 50
Vibration:	IEC 60255-21-1, Class 1
Shock & bump:	IEC 60255-21-2, Class 1
Seismic:	IEC 60255-21-3, Class 2

Signal interfaces between protection equipment and switchgear or communication equipment shall be of the opto-coupler type.

To minimize transient over-voltages in measuring, control, alarm and instruments transformer cables, the "Recommendation for measures to minimize transient over-voltages in secondary conductors inside of High Voltage Substations", VDEW (Association of German Electricity Corporations) of 1992 shall be applicable.

33.35.8 QUALITY ASSURANCE

Type tests:
Approved type tests, certificates and documentation shall be available for each functional assembly of the provided protection systems similar in all essential respects to the equipment included in the Contract. Submittal of complete test records can be required by the Employer. If not relevant for the actual service conditions the Employer reserves the right to require re-testing or additional tests to the routine test program.

Factory acceptance tests:
Equipment for modular static protection systems (e.g. distance, busbar protection etc.) pre-assembles in the relevant boards/cubicles etc. shall be tested in the Contractor's workshops as far as wiring and proper function is concerned. Simulated inputs (binary signals, current and voltage inputs from test power supplies) shall be used for the tests.

The Employer/the Engineer reserve the right to attend the factory tests for the main protection equipment.

Software updating:
The Employer/the Engineer reserves the right to attend the factory tests for software of the main protection equipment.

Commissioning tests:
The commissioning test program shall be submitted to the Employer and the Engineer for approval. Minimum test requirements are as follows.

Current transformers
General check of insulators, earth connections and terminal identification. Magnetization curve, polarity, ratio, secondary resistance tests, insulation resistance tests.

Protection basic tests
Insulation resistance of all secondary circuits (current and voltage transformers, control, indication and alarm circuits, etc.).

Primary injection of current transformer circuits, including overall injection of differential protection circuits, to prove all connections and to check ratios, fault settings, stability and phase identification.

Secondary injection of AC and DC relays to check their operating characteristics.

Voltage transformers
General check of insulators, earth connection and terminal identification. H.V. tests, ratio, polarity, measurement of insulation resistance and winding resistance, magnetizing currents.

Secondary injection of voltage transformer circuits

Secondary injection of VT circuits. Measurements of voltage at each point of VT secondary circuit by applying at this circuit 100 V.

Check of schemes
Complete functional tests of tripping, alarm, control and indication circuits. Operation of tripping elements at reduced DC voltage.

Phasing tests (of main plant) prior to making alive.

Measurement of the end-to-end phase comparison and tele-protection channels transmission times.

Simulation by secondary injection and signal transmission of the various protection transferred trips, phase segregated differential protection trips and all auto reclosing programs with their associated breakers.

Load tests for protections and directional units.

33.35.9 MAIN EQUIPMENT DESIGN FOR PROTECTION AND CONTROL EQUIPMENT

33.35.9.1 SERIAL INTERFACING OF ALL NEW RELAYS

All new relays shall be equipment with interface cards to connect them to the Ethernet TCP/IP station bus with IEC 61850-8 protocol. With it these protection relays will be hooked up in future via this station bus to the station controller of the automation system. All signals, alarms, trips and faults will be reported via fiber optic connection to the automation system. It shall be also possible to change pre-set parameter sets for each individual relay from the station automation workplace. The serial working interface for the asynchronous transmission shall have a Hamming distance of 4.

Other required serial interfacing:
System interface, potential-free, suitable for asynchronous connection via local fiber optic connection to the central systems; all devices, connectors and fiber optic connections.

Operator interface for parameterization, setting, and retrieving of stored event records via hand-terminal or PC; the appropriate software and PC are part of this supply.

The working and system interfaces and the associated interfaces devices shall withstand all insulation tests as specified.

33.35.9.2 LINE DIFFERENTIAL PROTECTION INCLUDING AUTO RECLOSING

Line differential protection relay uses OPGW for connection to remote end relay. Dedicated equipment is provided by the Employer for the coupling to the remote ends. All necessary additional devices, plug connectors, conventional and short copper are part of this supply.

The selection of the equipment shall be done so as to allow for 20% attenuation reserve in the end-to-end transmission. All necessary additional devices (transmitter-receivers), plug connectors, conventional and short copper or fiber optic connections up to the terminals of the fiber optic cable shall be the part of this supply.

All necessary additional devices, plug connectors, conventional and short copper or fibre optic connections up to the terminals of the fibre optic cable are part of this supply.

These line differential protections shall be a digital unit protection, working on current differential measuring principle, suitable for the EHV transmission systems, featuring:

- phase selective measuring units and trip outputs
- adjustable sensitivity for phase and earth-faults
- typical operating time (twice the set value) max. 30 ms
- transfer trip in case of one-sided fault infeed
- max. 20 ms total transmission time, opto-coupler input
- IN/OUT switch for transfer trip feature.

If needed, matching interposing transformers shall be a part of the supply.

Built in serial communication for direct connection with control system and second serial communication designated for indirect communication with protection monitoring centre. Both communication shall have a possibility to apply of IEC 61850 protocol.

The protection shall be a digital relays, working on phase current differential principle, for each end of protected line. These relay shall cover phase and earth faults, be connected to a different CT core than the backup protection, suitable for the protection of HV transmission lines with minimum 3 ends, featuring basically:

- phase selective measuring units and trip outputs
- phase segregated trip not required
- adjustable sensitivity for phase and earth-faults
- typical operating time (twice the set value) max. 30 ms
- transfer trip in case of one-sided fault infeed
- IN/OUT switch for transfer feature
- IN/OUT switch for protection.

2-phase O/C and E/F check features are to be provided to prevent the tripping of the circuit breaker if local end fault current is absent. IN/OUT switch for current check feature and inter-tripping scheme shall be provided.

Other features must include:

- backup protection (distance or overcurrent time function)
- self-supervision of the main hardware components and of the communication to the remote end. The "device faulty" and "channel faulty" alarms shall be made available to the SCMS and shall be locally LED-indicated; "the channel faulty" alarm shall be time-delayed (1 to 50s).

- fault locator
- Local LED indications (seal-in) or readable on the LCD-display shall include:

In operation	(green)
Device faulty	(red)
Channel faulty	(red)
Direct transfer trip	(red)
Trip	(red)
or readable LCD	

- resetting by local push-button or via centralized Substation Control and Monitoring System (SCMS),
- typical alarms available to the SCMS shall include:
  - o device faulty
  - o channel faulty
  - o trip
  - o disturbance and event recording, cyclic overwriting, minimum event time 2 s, with pre-fault history, transferable to the SCMS on request
  - o or retrievable menu-guided from the PC; the event recording shall be time-tagged by included real-time clock synchronized to the SCMS;
- settings, parameters and event records shall be stored in a non-volatile memory (at least three successive events capability).
- one-end test facilities, display of the phase and zero-sequence Service currents.
- external switch with the positions IN/OUT (trip circuits interrupted).
- heavy duty trip contacts suitable to the double-pole direct trip with station battery voltage of the main circuit breaker
- main-2 (Backup) protection IN/OUT switch to be provided to isolate the tripping circuit.

Auto reclosing Scheme:

The described protection scheme (function) shall initiate an auto reclosing cycle featuring at least following selectable cycles:

- One-phase AR by one-phase faults
- Three-phase AR by multiphase all kind of faults and after unsuccessful one-phase AR
- Auto reclosing out of service.

Dead time for three-phase AR cycle shall be independently and continuously adjustable. The device shall be provided with following selectable (from control room) checking facilities:

- dead line/live bus
- dead bus/live line
- synchrocheck
- open position of isolator switch by tripping of circuit breaker from autotransformer protections.

The scope of supply includes all necessary time/auxiliary relays etc. external to the AR device necessary to complete the above operational features.

The AR function shall be provided with the possibility of external blocking in case of:

- manual closing of the line
- delayed trips (backup zones)
- busbar and breaker-failure protection operation
- circuit breaker interlocks.

The scheme shall be provided with the following local indications:
- autoreclosing blocked
- autoreclosing initiated
- autoreclosing out of service
- autoreclosing in progress.

All inputs from binary equipment (circuit breakers) shall be provided with opto-couplers.

33.35.9.3 PHASE COMPARISON PROTECTION INCLUDING AUTO RECLOSING

The protection shall be a digital relays, working on phase current differential principle, for each end of protected line. These relay shall cover phase and earth faults, be connected to a different CT core than the backup protection, suitable for the protection of HV transmission lines with minimum 3 ends, featuring basically:
- phase selective measuring units and trip outputs
- phase segregated trip not required
- adjustable sensitivity for phase and earth-faults
- typical operating time (twice the set value) max. 30 ms
- transfer trip in case of one-sided fault infeed
- IN/OUT switch for transfer feature
- IN/OUT switch for protection.

2-phase O/C and E/F check features are to be provided to prevent the tripping of the circuit breaker if local end fault current is absent. IN/OUT switch for current check feature and inter-tripping scheme shall be provided.

The coupling of the remote ends is provided under this contract. Dedicated PLC equipment is provided under this contract for the coupling to the remote ends. All necessary additional devices, plug connectors, conventional and short copper are part of this supply.

Other features must include:
- backup protection (distance or overcurrent time function)
- self-supervision of the main hardware components and of the communication to the remote end. The "device faulty" and "channel faulty" alarms shall be made available to the SCMS and shall be locally LED-indicated; "the channel faulty" alarm shall be time-delayed (1 to 50 s).
- fault locator
- local LED indications (seal-in) or readable on the LCD-display shall include:
  - In operation (green)
  - Device faulty (red)
  - Channel faulty (red)

  - Direct transfer trip (red)
  - Trip (red) or readable LCD
- resetting by local push-button or via centralized Substation Control and Monitoring System (SCMS)
- typical alarms available to the SCMS shall include:
  - device faulty
  - channel faulty
  - trip
- disturbance and event recording, cyclic overwriting, minimum event time 2s, with pre-fault history, transferable to the SCMS on request or retrievable menu-guided from the PC; the event recording shall be time-tagged by included real-time clock synchronized to the SCMS; settings, parameters and event records shall be stored in a non-volatile memory (at least three successive events capability).
- one-end test facilities, display of the phase and zero-sequence service currents.
- external switch with the positions IN/OUT (trip circuits interrupted).
- heavy duty trip contacts suitable to the double-pole direct trip with station battery voltage of the main circuit breaker
- main-2 (Backup) protection IN/OUT switch to be provided to isolate the tripping circuit.

The coupling to the remote ends is provided under this contract. Either PLC technique with using of transmitter-receivers compatible to phase comparison relay or OPGW (fiber optic technique) is required.

As an option, a dedicated 24-core OPGW as alternative to the PLC connection can be provided under this contract for the coupling to the remote ends.

The selection of the equipment shall be done so as to allow for 20% attenuation reserve in the end-to-end transmission. All necessary additional devices (transmitter-receivers), plug connectors, conventional and short copper or fiber optic connections up to the terminals of the fiber optic cable shall be the part of this supply.

Auto reclosing Scheme:
The described protection scheme (function) shall initiate an auto reclosing cycle featuring at least following selectable cycles:

- one-phase AR by one-phase faults
- three-phase AR by multiphase all kind of faults and after unsuccessful one-phase AR
- autoreclosing out of service .

Dead time for three-phase AR cycle shall be independently and continuously adjustable. The device shall be provided with following selectable (from control room) checking facilities:

- dead line/live bus
- dead bus/live line
- synchrocheck.
- open position of isolator switch by tripping of circuit breaker from autotransformer protections.

The scope of supply includes all necessary time/auxiliary relays etc. external to the AR device necessary to complete the above operational features.

The AR function shall be provided with the possibility of external blocking in case of:

- manual closing of the line
- delayed trips (backup zones)
- busbar and breaker-failure protection operation
- circuit breaker interlocks.

The scheme shall be provided with the following local indications:

- auto reclosing blocked
- auto reclosing initiated
- auto reclosing out of service
- auto reclosing in progress.

All inputs from binary equipment (circuit breakers) shall be provided with opto-couplers.

33.35.9.4 DISTANCE PROTECTION (FUNCTION) INCLUDING AUTO RECLOSING

The protection shall be a digital distance relay for phase and earth faults connected (by possibility) to a different CT core than the main protection (for the one side supplied OHL – backup protection) suitable for the protection of HV transmission lines, featuring basically:

- typical operation time of 1st zone less than 30ms
- simultaneous measurement of all fault loops
- preferably, at least for the earth fault measuring elements
- unlimited directional discrimination by cross-polarization and voltage memory
- appropriate hardware/software measures for correct performance in the presence of CT saturation and CVT transients
- accurate impedance measurement down to 20% of the rated current
- separate measuring units for under-reaching Zone 1
- min. 2 forward measuring backup zones (timer-controlled)
- 3-phase and 1-phase trip possibility
- power swing blocking
- switch-on-to-fault feature
- acceleration of Zone 2 via tele-protection feature
- fault locator
- DC supply supervision (local and remote).

Auto reclosing Scheme

The described protection scheme (function) shall initiate a auto reclosing cycle featuring at least following selectable cycles:

- one-phase AR by one-phase faults
- three-phase AR by multiphase all kind of faults and after unsuccessful one-phase AR
- auto reclosing out of service.

Dead times for three-phase AR cycles shall be independently and continuously adjustable. The device shall be provided with following selectable (from control room) checking facilities:

- dead line/live bus
- dead bus/live line
- synchrocheck.
- open position of isolator switch by tripping of circuit breaker from autotransformer protections.

The scope of supply includes all necessary time/auxiliary relays etc. external to the AR device necessary to complete the above operational features.

The AR function shall be provided with the possibility of external blocking in case of:

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- delayed trips (backup zones)
- busbar and breaker-failure protection operation
- circuit breaker interlocks.

The scheme shall be provided with the following local indications:

- auto reclosing blocked
- auto reclosing initiated
- auto reclosing out of service
- auto reclosing in progress.

All inputs from binary equipment (circuit breakers) shall be provided with opto-couplers.

33.35.9.5 TIME-OVERCURRENT FUNCTIONS

Overcurrent functions and earth fault functions shall be the definite time lag (DTL) pattern with separately adjustable time and current settings or inverse definite minimum time (IDMT) pattern. The range of DTL current setting shall be at least 5% to 240% in steps not exceeding 5% for overcurrent functions and 5% to 80% in steps not exceeding 5% for earth fault functions. Time settings for both overcurrent and earth fault functions shall be adjustable over a range of at least 0.05 to 1.0 times in steps not exceeding 0.05 times.

Minimum 2 independent definite stages shall be included.

The IDMT protection characteristics shall comply with the latest IEC stipulations and their curves shall be such as to trip after three seconds at ten times the current setting when a time multiplier setting of 100% is applied.

Where directional overcurrent functions are required, three-pole current element shall be provided as specified, inoperative until the directional element actuates. The external current and voltage connections to the directional overcurrent phase fault elements shall be arranged so that the phase current in any element is associated with a voltage signal which is derived from the line voltage which lags the current phase by 90° (i.e. 90° relay quadrature connection).

The internal connections of the directional overcurrent element shall be such that the maximum torque in a direction to actuate is produced when the current flowing in the current circuit leads the voltage applied to the voltage circuits by 45° maximum torque angle.

33.35.9.6 DIRECTIONAL EARTH FAULT FUNCTIONS

The directional earth fault functions shall be provided with current fault elements, inoperative until the directional element actuates.

The current signal for the directional earth fault relay shall be derived for the residual circuit. The voltage signal shall be the residual voltage produced by an open delta circuit on the main VT and the voltage input rating shall be compatible with the open delta winding output and primary system earthing.

The protection functions for earth faults shall include the following features:

- directional earth fault protection (definite time earth overcurrent protection with non-directional backup and stand-by protection function
- non-directional inverse time lag overcurrent time protection for earth faults with selectable characteristics.

The directional earth fault protection can be extended by an integrated directional comparison logic so that by means of a carrier channel fast and selective tripping for high resistance earth faults shall be possible.

33.35.9.7 OVERVOLTAGE PROTECTION FUNCTIONS

The overvoltage protection relay shall contain the following functions:

- one phase segregated function (minimum 2 stages)
- one zero sequence voltage function (minimum 2 stages).

The residual voltage shall be measured by an open delta VT winding or shall be calculated internally as 3Uo.

The tripping shall be performed at the local circuit breaker and at the other end (ends) of the line/transformer by sending an intertripping signal.

33.35.9.8 UNDERVOLTAGE PROTECTION FUNCTIONS

The undervoltage protection shall protect consumers (including machines) from the consequences of dangerous voltage drips and shall prevent impermissible operating conditions and possible loss of stability.

The undervoltage protection scheme shall contain a one-phase undervoltage detection with minimum 2 stages.

The tripping shall be performed at the local circuit breaker and at the other end (ends) of the line/transformer by sending an intertripping signal.

33.35.9.9 CIRCUIT BREAKER FAILURE PROTECTION

The circuit breaker failure protection shall be installed at all outdoors circuit breakers in 400kV Substation. This protection detects failures of tripping commands execution, for example due to a defective circuit breaker.

The current detection logic shall be phase-segregated and shall therefore also be used in single-pole tripping schemes.

If the fault current has not been interrupted after a settable time delay is expired, a re-trip command or the busbar trip command shall be generated.

33.35.9.10 SYNCHROCHECK FUNCTION

The synchronism and voltage check function shall ensure that the stability of the network will not be endangered when a 400kV line or generator-transformer is switched onto a busbar. For this purpose a synchronism check function is provided.

After verification of the network synchronism the function shall enable the CLOSE command. Alternatively, reclosing shall be enabled for different criteria, e.g. checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Adjustable values shall be the operating modes, permissible voltage difference, frequency difference and angle difference. The supervision time shall adjustable –time steps of 0.01s.

33.35.9.11 OVERLOAD PROTECTION WITH THERMAL REPLICA

The overload protection with thermal replica shall be used to prevent thermal overloading of corresponding equipment, particularly of blocks generator-transformer and autotransformers. The following features shall be included:

- overload calculation using a thermal replica according to IEC 60255-8 without ambient temperature influence
- overload calculation using a thermal replica according to IEC 60255-8 with ambient temperature influence
- calculation of the hot-spot temperature and determination of the aging rate according to IEC 60076-7
- thermal alarm and trip stages.

33.35.10 PROTECTION SETTINGS REPORT

The Contractor shall carry out the Protection Setting Report, in which the protection settings shall be calculated for all protections for this project, stating also the necessary changes in the connected network. The Report shall be also calculate or check the settings of other existing non-unit protections (see the definitions of IEC 50050 (448): 1995) in 400 kV nodes correspondingly, which have to be changed in liaison with implementation of new calculating settings. This Report has to contain the description of all principles of these calculations as well as the entire calculations themselves. The results shall be also shown in one map of selectivity of 400kV networks.

The available data required for preparation of the protection settings report will be provided by the Employer, as far as available. These data have to be verified by the Contractor and the missing data has to be calculated or estimated. The Contractor has to provide in due time a list with the required data.

33.36 TELECOMMUNICATION SYSTEM AND EQUIPMENT

33.36.1 GENERAL

Telecommunication equipment shall be provided by the Contractor.

33.36.2 TELECOMMUNICATION POWER SUPPLY EQUIPMENT

General:
The power supply system shall consist of a storage battery and a charging rectifier system. The system shall serve the power supply requirements of the substation’s telecommunication monitoring unit, main switchgear and a d.c. distribution panel.

The rectifier system shall be a hot-swap N+1 redundant operation system, N being the minimum number of required rectifier modules. The rectifier modules shall have automatic load sharing and be hot-swappable. Rectifier modules shall be added or replaced while the system is operating. Any open/vacant positions in the cabinet shall be covered by blind panels.

The rectifier system shall include a manual by-pass switch. The switch shall be able to provide “make before break” functionality during necessary service works where the load shall be connected to the batteries while simultaneously rendering the rectifier voltage at the d.c. side.

The rectifier system shall have boost charge facilities.

The system shall incorporate a control & monitoring unit. The unit shall monitor such parameters as bus voltage level, rectifier status, a.c. supply and temperature. The unit shall be programmed through the front panel controls or remote monitoring software to provide alarms on dry relay contacts.

The system shall also incorporate a d.c. distribution & protection panel with facilities for sufficient d.c. load automatic circuit breakers, including spares. Various combinations of breaker rating shall be accommodated as required. The panel shall be equipped with a low voltage disconnect (LVD) for protection against deep discharge of the batteries which can result in plate deformation and damage beyond repair.

Input protection to each installed rectifier module shall be provided via circuit breakers. Maintenance free batteries e.g. gel cells, with appropriate battery shelves shall be delivered for installation in the telecommunications room. The batteries should preferably be installed in the same cabinet as the rectifier system.

A battery isolating circuit breaker shall be included to allow easy battery maintenance without compromising the system integrity.

The 48V d.c. system shall meet the power requirements of the connected telecommunication equipment at each site with 50% spare capacity.

The positive pole of the 48V d.c. power supply system shall be earthed. All terminal strips shall be easily accessible for maintenance or rewiring.

The terminals for high voltage wiring shall be protected by a non-metallic cover and carry a conspicuously marked warning. Screw-type terminals of an approved type shall be permitted.

Fire resistant insulation for all wiring shall be utilized.

Overvoltage protection must be very strong.

The batteries, battery charging rectifier, main and distribution boards shall meet the requirements as required in the Data Sheets.

Control unit:

The power supply equipment shall incorporate a control and monitoring unit. The control unit shall control all rectifier modules, set the float voltage and be able to equalize the voltage on all rectifier modules. It shall also monitor the battery voltage and current by means of front panel test points and/or digital meters.

On the front of the control module selectable charge mode shall be available:

- normal maintenance charge
- boost charge.

Accidental change of limit values shall be prevented by the use of a password.

The following indications shall be presented on the front panel:

- normal maintenance charging
- boost charging

- automatic current limitation.

The following alarms shall be available on potential free contacts (normally closed):
- low battery voltage
- high battery voltage
- battery disconnected
- battery fuse alarm
- module failure
- high load (tolerance 100%)
- mains power failure
- battery failure
- boost charge.

The Control Unit shall be interfaced to the SCMS for indication of the above status indications and alarms.

Charging
The rectifier shall be able to operate in two charging modes:
- normal maintenance charge (this shall be the normal charging condition for the batteries)
- boost charging (implies higher than normal charge voltage).

Boost charging is manually activated at the initial charging of the batteries, and after some time of operation to equalize discrepancies in the voltage of the various single cells in the battery system. When boost charging is in process, this shall be indicated on a control panel display.

Change from normal maintenance charging to boost charging and vice versa shall be performed from the control panel of the control module. Status indication “Boost” shall be visually and be available on the external alarm outputs of the rectifier system.

Load connector
The rectifier system shall be equipped with a load connector which disconnects the load if the battery voltage drops or raises below or above settable limits measured on the rectifier output terminals. The load connector shall be installed in the battery circuit.

Load sharing
The rectifier system shall have automatic load sharing between the modules.

Discrepancy < 5% of nominal current.

Cabinets
The equipment should be of standard 19-inch mechanics and mountable in 19-inch racks or cabinets.

The following technical requirements for cabinets are:

- The cabinets shall include all basic elements: side panels, roof plate, eventual gland plate, glazed door with lock, rear door and ventilators.
- The cabinet should have removable rear door (rear panel) thus providing easy rear access to mounted equipment.
- Cable entries shall be as a main rule from the bottom of the cabinet.
- The cabinet shall preferably be equipped with leveling feet to compensate for uneven floor.
- When the batteries are in cabinet they should be in the moveable drawers with screwed connection and interconnection between drawers should be with elastic wires.

Performance guarantees
The equipment shall comply with the following requirements:

Availability >99.995% for 48 V DC supply

Electromagnetic compatibility and insulation shall comply with requirements for emission and immunity (EN 50081-2, EN 50082-2).

Electrical safety shall comply with the safety requirements according to IEC 60950.

Seismic conditions: All telecommunication power supply equipment shall be designed to resist earthquake loadings resulting from accelerations specified in Chapter 1 of Section 5.

Ambient conditions for normal operation:

- Temperature range –Please refer to Chapter 1 of Section 5
- Relative humidity Please refer to Chapter 1 of Section 5

Performance, rules and standards

The HV equipment to be supplied shall operate satisfactory within the rated values and within the environmental conditions as specified. Routine maintenance to any of its components shall not be required in intervals less than 5 years. Internal components shall be maintenance-free for at least 10 years.

Performance, testing and rating of the equipment shall conform with these specifications, including all attachments supplemented with the latest editions of the relevant IEC publications respectively to the rules and standards listed in General Specification (Chapter 3 of Section 5).

Immediately following the Letter of Acceptance, the Contractor shall supply 6 indexed lists (in English), of all standards, codes and their referred associated standards, to which the plant and works are to be performed. One (1) set shall be sent to the Engineer's site office, and four (4) sets to the Employer, along with the English version of the relevant standard.

The 400kV switchgears shall operate satisfactorily within the rated values and within the environmental conditions as specified. Routine maintenance to any of its extended components, including the protective relays and instrument transformers, shall not be required in intervals less than seven years. Internal components shall be maintenance-free for at least 10 years including the refilling of gas.

Any Bidder proposing other than the above preferred standards must specifically testify the standards to which his switchgears conform, indicating all deviations from the above codes which will affect performance and rating.

Compliance of the switchgears with the provisions of this specification does not relieve the manufacturer of the responsibility for furnishing switchgears and accessories of proper design, electrically and mechanically suited to meet the warranted operation at the specified service conditions during the entire defects liability period.

If there are, in the opinion of the supplier, any conflicts between the above codes, the data sheets and the specification, these contradictions shall be brought to the attention of the Employer.

33.37 REPRESENTATIVE EARTHING SYSTEM, POWER AND LIGHTING INSTALLATIONS

33.37.1 EARTHING AND LIGHTNING PROTECTION

General:
In addition to Chapter 6 of Section 5, the following requirements shall be considered.

For outdoor installations, the Contractor shall install a meshed earthing system. The earthing system shall be calculated according to IEEE 80. For the construction of the earthing system approved standards, such as VDE 0141, will be applied. A uniform stranded conductor cross-section is to be used for the entire installation. For potential grading and to offer protection against excessive contact potentials, ring earths made of stranded copper cable shall be installed around the building and these shall be connected to the mesh earth conductors.

At maximum distances of 10m, the ends of the stranded conductors of the mesh earth are to be taken into the inside of the buildings and connected to the internal earthing system.

The earthing and lightning protection system shall include but not be confined to:

- the necessary stranded copper ropes for the indoor earthing installations and mesh system
- the necessary bare copper strips for the earthing ring inside the building
- connection of PVC single core cables being laid out of the concrete to the earthing ring inside the buildings
- the necessary compression connectors or connections by Cadweld system (or similar) for the earthing conductor crossing point connections and junctions
- all connections to the housings of the electrical apparatus, steel frames, pipes, steel strips etc.

- all necessary disconnecting points for measuring purposes which must be readily accessible
- all the necessary lightning protection equipment for the protection of persons and structures such as lightning collectors, roof bushings, lightning rods, potential equalizing systems, spark gaps, lightning arresters etc.
- the required connecting and fixing material such as plugs, screws, angle pieces, expansion strips, conductor support, isolating terminals, earthing and rain gutter clamps, jumper outfits, earthing clamps etc.

Material:

Whenever dissimilar materials are to be joined, the necessary transition plates are to be inserted as required to make sure that electrolytic action is avoided.

Earthing material:

Stranded copper conductor is to be used as earth conductor for laying on cable trays and for the earthing of electric equipment, steel structures and frames etc. Bare copper strips should be used for the internal earthing ring inside the buildings.

Lightning protection material:

Round copper rod of 8 mm diameter is generally to be used as the material for the lightning protection system. The conductor supports of the lightning protection system must be copper or bronze. Nuts and bolts at isolating or other points which are to remain detachable must be made of copper nickel silicon bronze.

Earthing system:

Installations above and below 1000 V shall be made safe by protective earthing. This is required to prevent the occurrence of excessive touch potentials on conducting parts of the installation which are not part of the electrical circuit.

The earthing installations must be designed and constructed in accordance with approved standards.

Generally, underneath the substation building a grid earth of stranded copper cable must be installed. The size of the stranded copper conductor shall be minimum $70mm^2$, but the Contractor has to check this diameter by an earth fault calculation. The size of the mesh shall be in accordance with the maximum occurring earth leakage current to meet the requirements for earthing according to IEEE 80 and IEC 60621. The size of the stranded copper conductors used must be uniform throughout the area under Contract as far as possible.

Inside the buildings encircling, bare copper strips must be installed on the walls. From the inner earthing ring the connections to the switchgear, and other electrical apparatus, cable trays, vertical cable runs, steelwork etc. are to be made using bare copper conductor. All the electrical equipment, frames and mechanical apparatus must be fitted with earthing screws and studs.

The copper conductors can be laid and fixed on the cable trays and vertical runs for AC power cables. Where this is not possible, earthing conductor supports shall be provided and fixed in concrete or masonry by means of plugs. The bare copper strips must be fixed with earthing support on walls.

Cable trays and vertical runs shall be connected to the earthing conductor at intervals of 10m max. in such a way as to give good connection. This earthing conductor must likewise be connected to the earthing ring.

Inside the concrete of buildings a separate round iron (reinforcement bar) mesh in walls and ceilings for earthing purposes must be provided. The size of this mesh should not exceed 8m x 4m. The connections of this earthing reinforcement bar should be welded. The reinforcement bar shall be connected via a flexible PVC single-core cable every 8m to the inside earthing ring.

At a maximum distance of 8m the inside earthing ring of the buildings must be connected with the outdoor earthing system. These connections must be provided with flexible PVC single-core cables which are to be laid through the concrete walls above the ground water level.

In buildings without a basement the internal earthing ring is to be connected by the Contractor to the outer earthing ring at maximum intervals of 10m.

The crossing point connections of the earthing cables underneath the buildings and outside the buildings must be made by compression connectors. Connections, e.g. by Cadweld system, will also be acceptable. All other earthing conductor connections and junctions must be made in the same way to ensure secure, lasting connections having good contact.

The interconnections between the earthing installations of the buildings must be provided with an accessible isolating point in order to be able to measure the earthing resistance. All isolating points must be numbered consecutively in the drawings and clearly marked in the field.

All facilities shall be securely connected, with minimum practicable resistance, to the common ground system. The maximum resistance to ground from the connection point in any facility shall not exceed 0.5Ω, when measured by standard ground resistance measurement techniques.

The lightning installations must also be connected to the central earthing installation.

The effects of lightning strikes on the control and monitoring systems vary from faulty pulses in control and measurement to the destruction of electronic sub assemblies and cables and must therefore be prevented by the earthing of screens. To this end the screens of the control cables leading from the signal transmitters, actuators etc. must be taken to the central earthing points and from there to the indoor earthing installation.

They must be insulated and laid via the screen bars in subsidiary distribution boxes, intermediate terminal boxes, marshalling racks, control cabinets and DC main distribution boards.

Lightning protection system:

The planning, dimensioning and construction of the lightning protection system shall be according VDE 0185, or approved equivalent standards are valid.

All outdoor equipment shall be protected against lightning strikes by means of lightning collectors and conductors.

The existing collectors shall be connected to the outdoor earthing grid.

The buildings shall be protected against lightning strikes by means of lightning collectors and conductors. The collectors are to be arranged in such a way that, as far as possible, they collect all lightning strokes without these directly striking the parts to be protected. This condition is considered to have been fulfilled if no point on the roof surface is more than 8 m away from a collector. Collector lines suffice as collectors, e.g. along the ridge, at gables and eaves.

Ridge conductors must be taken right to the end of the ridge. Moreover, roof conductors should run as natural continuations of all main conductors.

Conductors at the gable extremities or eaves must be laid in the closest possible proximity thereto. In the case of steel-framed structures the ridge conductors must be connected to the roof supporting structure at least every 8m. Lower level annexes are also to be provided with collectors. Roof lines and other conductors are to be laid and fixed in such a way that they can withstand the stresses expected from storms, lightning strokes, roof work etc.
One main conductor between the lightning collectors mounted on top of the building and the potential grading ring laid in the ground are to be provided every 8m of the afore mentioned lightning collector. The max. spacing between conductor fixings shall not exceed 1.25m for horizontal runs and 1.25m for vertical runs.

All main and secondary conductors which are connected to an earthing conductor must be provided with an accessible isolating point in order to be able to measure the earth resistance. All isolating points must be numbered consecutively in the drawings and shall be labeled at the buildings and at the substation steel structures.

Nuts and bolts at isolating or other points, which shall remain detachable, must be made of copper nickel silicon bronze.

All main and secondary conductors are to be connected, using compression connectors, to the earthing ring running around the buildings at a distance of 1 m and a depth of 0.8 m. At the connection points the copper conductor and the round copper rod must be stripped of the lead sheath. The subsoil connection points are to be protected against corrosion by wrappings or bitumen.

33.37.2 LIGHTING SYSTEM

General:
All requirements in Electrical (Chapter 6 of Section 5) shall be followed. In case not specified there the following shall be considered.

All lighting fittings and all equipment comprising the lighting sub distribution units must meet the operating requirements in full at a local ambient temperature and for a relative humidity.

The lighting fittings shall be designed for an operating voltage from 230 to 275V. For protection against contact with live components, all lighting fixtures must be suitable for the following protection measures:

- protective conductor connection, or
- protective insulation

and must visibly carry the accepted symbol to indicate this.

In substation areas subject to danger of explosion (i.e. battery rooms) the necessary explosion-proof lighting fittings, cable connection boxes and pushbuttons are to be used according to IEC 60079. Sub distribution units shall not be installed in such rooms or areas.

Sub distribution boards:
Metal-clad sub distribution boards (protective type IP 41 / IP 54) suitable for flush or surface mounting on the walls shall be provided. Each sub distribution board must at least be equipped with:

- manual feed-in change-over switches with I - 0 - II positions
- one voltmeter with voltmeter switch for measurements between the individual phases and the neutral as well as between two phases
- five (5) bus bars for 3-phase system, neutral and earth
- the necessary single pole MCBs for lighting circuits and control
- the necessary single pole MCBs for domestic power outlets (sockets)
- the necessary single pole MCBs for power sockets
- the necessary current relays and contactors for pushbutton energizing, de energizing of lighting circuits.

The sub-distribution boards are to be designed so that after handing over 5% fully equipped and 15% not equipped reserve feeders are still available.

Indoor lighting
Generally, lighting fixtures wired for three-phase supply and fitted with LED lights are to be provided for the control building.

The lighting fixtures are to be selected so that they can be used for single or strip lighting.

The room lights shall generally be controlled by pushbuttons via current impulse relays. The pushbuttons must be located at the access doors to the appropriate rooms.

The internal lighting must be designed to give the lighting intensities of 360 Lux. An aging factor of 20% must be taken into account, and therefore the lighting intensities of the fittings when new (new value) must be achieved as a minimum during the acceptance tests.

Location, Room	Type of lighting fixture	Lighting utility new / aging
Control room	3	600/550
20kV switchgear room	2, 4	360/300
Battery room	2	240/200
Toilets and store	1 or 2	120/100
Corridor, passage ways	3	120/100

Key to light type numbers of above table:

1. Free-beaming, protection IP 32
2. Watertight fitting, protection IP 54
3. Lighting fitting, protection IP 32, with cover
4. Lighting fitting with halogen lamp, protection IP 54.

The fluorescent lighting fitting should be equipped with fluorescent lamps. The halogen lighting fitting should be equipped with halogen lamps.

The color of the light produced by the lamps must be selected according to requirements. If different lamps (e.g. halogen and fluorescent lamps) are used in the same room, then lamps giving the same color of light are to be used in accordance with the requirements.

Internal lights must be connected in 3 phase circuits so that only every third lamp will fail in the event of failure of a single phase. Cables with a cross-section of at least 2.5mm^2 are to be used as lighting cables for fluorescent lamps.

Emergency lighting (indoor)

The emergency lighting shall be operated from the DC station battery system.

In the event of a blackout the emergency system shall be automatically switched on. A manual changeover facility shall also be provided.

The emergency lighting shall be designed simply as emergency escape route lighting. At least one emergency light must be visible from every point in the room. The lighting density must be at least 50 Lux.

Substation lighting

The substation lighting shall consist of:

a) Lighting Fixture:
Lighting fixture shall be of outdoor, flood type, symmetrical beam spread of not less than 2x30 degrees with built-in ballast. The housing shall be die-cast aluminium and the reflector shall be high grade aluminium. A cast aluminium door frame shall be designed for easy relamping. The front glass shall be heat shock resistance with the gasket for jet-proof and dust-proof sealing.

b) Lamp:
The lamps shall be of non-color corrected, high pressure mercury vapor, 400 watts, 230 volts and shall have minimum luminous flux of 20,000 lumens with 16,000 hour service life.

c) Ballast:
The ballast shall be for use with 400 watt lamp, 230 volts, 50 hertz and shall have a 90 percent power factor, 45 decibel sound level. The ballast shall be electrical designed to ensure very low operating temperature and low wattage losses.

d) Cable:
The wiring cable shall be of single core, direct burial and shall be installed underground or laid in the cable trench except those rising along the steel structure which shall be run in conduit.

e) Control Panel:
The control panel shall be galvanized, outdoor type. The over-current protective devices shall be of moulded case circuit breaker. The ON-OFF operation of substation lighting shall be both manual and automatic control. The arrangement of lighting branch circuits shall be reliable and of easy maintenance.

f) Lighting level:

Access roads	20 lux
Outdoor equipment	20 lux
Fence	20 lux
Transformer area	30 lux
Main entrance	50 lux

Emergency Lighting (outdoor)

The emergency lighting shall be installed in the substation equipment lighting and shall be of incandescent type. The emergency lighting fixtures shall be wired so that they shall be lit automatically upon the loss of normal power supply and they shall be cut off automatically upon the restoration of normal power supply. The lighting density must be at least 10 Lux.

33.37.3 POWER AND PROTECTIVE SOCKETS

General

The power and protective sockets are intended for the plug-in connection of mobile electrical equipment for repairs and maintenance of any kind. The mobile electrical equipment must be fitted with the necessary 3 phase and earthing contact plugs.

Power sockets:

The power supply to the power sockets shall be provided from the sub-distribution board. In each substation building at least 1 power socket shall be installed.

Plugs and sockets must be in accordance with CEE form.

Generally, different power sockets are to be used, with stainless steel metal casings resistant to impact, direct sun etc. and suitable for service wall mounting. The sockets are to have a degree of protection of at least IP 65. All the sockets shall be of outdoor type, even if installed indoors, and shall operate satisfactorily under direct sunlight.

Each socket shall be equipped as follows as a minimum requirement:

- with the necessary wire inlets at the top of the power socket casing for the incoming and the outgoing feeders including the necessary glands or blanking plugs
- with the necessary fuses in the top of the metal casings
- with the necessary main manual switch before the fuses of the socket circuits in the top of the metal casing
- with a three-phase socket 400 V, 32 A, 5 pole (three-phase, neutral and earth) in CEE form (CEE = International Commission on Rules for the Approval of Electrical Equipment) in the bottom of the metal casing
- with two AC single-phase sockets 230 V, each 16 A, screwed, 3 pole, (phase, neutral and earth) in CEE form, in the bottom of the metal casing
- with all the necessary fuse bases, connection and its intermediate terminals and any other attachment fittings.

All sockets shall be provided with plugs.

The power supply of the sockets shall be generally provided with the PVC power cables.

For the internal wiring in the metal casing, stranded copper conductors with PVC insulation shall be used.

Domestic power outlets (sockets):

In rooms such as switchgear, battery, control, office etc. the domestic power outlets (sockets) are to be provided in adequate quantity in accordance with the requirements, surface-mounted. All sockets shall be provided with plugs. The power supply shall be provided from the lighting distribution boards. The power outlets must be 16A, 3 pole type, i.e. phase, neutral and earth.

All sockets must be in accordance with CEE form.

In The corridors, one power outlet must be arranged every 10m.

Generally plastic-insulated power outlets for 230V AC are to be provided.

The power outlets (sockets) shall be supplied via the single-pole MCBs of the lighting distribution units via three-core cables. Not more than five power outlets (sockets) may be supplied from one circuit. The conductor cross-section must be at least 4mm^2 for the cables supplying the sockets.

33.38 FIRE ALARM AND FIRE FIGHTING SYSTEM

33.38.1 GENERAL

This specification covers the design, manufacture, pre-assembly and acceptance testing in the supply, delivery, unloading, erection, adjusting, painting, identification, commissioning and acceptance testing of the Fire Alarm and Fire Fighting System complete in every respect and for satisfactory operation.

33.38.2 SCOPE OF SUPPLY AND SERVICES

This sub-section sets out the scope of installations covered by this specification as well as the requested supplies and services, including all necessary auxiliary units and accessories for a reliable continuous operation even if this is not expressly stated in this specification.

Generally the following equipment is covered by this specification:

Fire Alarm Center (main Board):

- fire alarm center (main board) with all necessary self supervising fire alarm circuits, interconnection to the SCMS computer, free standing, including redundant DC supply and audio-visual alarm, with all accessories in order to establish an effective and reliable fire alarm system

Fire alarm system for the substations:

- fire alarm system for the substation buildings including all fire alarm detectors and the fire alarm cables for connection to the detectors and to the fire alarm center (main board)
- lot of installation material and accessories for fire alarm detectors and fire alarm cables including clamps, connectors, splitting boxes, joint boxes etc.

Fire alarm system for the cable tunnels and cable ducts:

- fire alarm system for the cable tunnels and cable ducts including all fire alarm detectors and the fire alarm cables for connection to the detectors and to the fire alarm center (main board)

- lot of installation material and accessories for fire alarm detectors and fire alarm cables including clamps, connectors, splitting boxes, joint boxes etc.
- Portable firefighting equipment:
- potable CO_2 bottles 5.5kg
- carrier mounted CO_2 bottles 50kg
- firefighting truck fully equipped for fire fighting with water, CO_2 and Halon gas.

33.38.3 FIRE EXTINGUISHERS

33.38.3.1 EXTENT OF WORK

Portable and mobile fire extinguishers shall be provided for the switchgear room.

The appliances shall comply with BS 5423 or equivalent standard.

All apparatus shall be suitable for operation by one person alone and is to be easily recharged. The discharge shall be non-corrosive and free of chemicals prone to give off toxic gases when heated.

The Contract shall include supply and installation of all wall brackets and fittings. Four recharge units shall be provided for each type and size of equipment.

33.38.3.2 PORTABLE WALL MOUNTED EXTINGUISHERS

Portable, wall mounted, hand held extinguishers shall be 5 to 6kg pressurized control discharge CO_2 units.

Construction and operation:
The body of the extinguisher shall be seamless, welded or brazed as appropriate.

The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin.

Extinguishers shall be capable of controlled partial discharge.

Marking:
All extinguishers shall be painted and marked in accordance with BS 5423 or equivalent standard. In addition, they shall be marked in the English language with clear instructions for use.

Housings for portable fire extinguishers:
Where extinguishers are provided in external positions or other areas where they may be subjected to the whether they shall be hung inside protective cabinets.

The protective cabinets shall be red in color and marked with the words "FIREEXTINGUISHERS" in English, in white. The cabinet shall provide protection for rain and wind blown dust and have a pull off front cover allowing ease of access to the extinguisher.

Mounting:

Where extinguishers are provided internally they shall be wall mounted and attached in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5 meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the instructions for operation face outwards.

33.38.3.3 MOBILE TROLLEY EXTINGUISHERS

The extinguishers shall be 50kg CO_2 units. The equipment shall be mounted on a metal frame with wheels and handle to make it mobile and maneuverable.

The CO_2 Container shall be of steel construction and shall have been pressure tested to at least twice its operating pressure. The container shall hold 50kg.

The hose conducting the extinguishing agent to the discharge nozzle shall be 10 meters long and made of braided synthetic flexible hose. The hose shall be permanently connected to the container. The hose shall be stored in a manner allowing easy removal for use. The unit shall have at least two wheels, which shall have rubber or synthetic tires and a minimum overall diameter of 300mm. The overall width of the unit shall not exceed 800mm.

A single easily accessible valve shall be used to release the extinguishing agent and shall be designed for controlled partial delivery. The unit shall be capable of total discharge in at most 60 seconds.

The extinguishers shall be painted and marked in English with clear instructions for use, which shall include "FOR USE ON ALL FIRES".

Mobile fire extinguishers shall be protected from the prevailing climatic conditions, and shall be clearly visible and accessible.

33.38.4 SIGNS

Electrical hazard warning signs in English shall be positioned each entry door.

33.38.5 FIRE ALARM SYSTEM

33.38.5.1 GENERAL

The purpose of the fire alarm system is to guarantee a reliable and fault-free early-warning system in the event of fire, so that orders for extinguishing the fire can be issued from a central point.

The fire alarm system shall be designed in .accordance with DIN VDE 0833 the relevant VdS (Verband der Schadensversicherer) guidelines, and shall conform to the latest state-of-¬the-art in the field of fire alarm system engineering. The fire alarm system provides for early detection of fires by means of automatically activated detectors.

Push-button actuation must be provided for manually operated fire alarms in staircases, next by exits and on all escape routes. For outdoor installation, the necessary push-button fire alarms are to be provided in pillow type or wall-mounted housings.

Sirens for indoor and outdoor installation must be provided for warning the operating personnel.

In all rooms the necessary automatic fire detectors are to be incorporated in the luminous ceiling.

The whole of the plant area to be monitored is to be divided into individual alarm sections, the latter being so arranged as to enable rapid and positive identification of fires.

Detectors installed in false floors, suspended ceilings, cable ducts, air-conditioning or ventilation systems are also to be combined to form separate alarm sections.

Detectors belonging to a particular alarm section are to be incorporated in alarm lines, the automatic and manual fire alarms being connected via separate alarm lines to the common fire alarm central station in the central control room.

The arrangement and number of detectors is determined by the type of fire detector used, by the room configuration (size, height, form of floor and roofing, etc.) as well as by the ambient conditions in the rooms to be monitored.

Detectors installed in inaccessible points such as cable ducts, false floors, cable basements, etc. are to be connected in parallel to external optical alarm indicators installed close by and in readily visible positions.

No restrictions on the proper functioning of fire alarm by reason of movement of air, optical radiation, smoke, dust, vibration, high humidity, etc. are acceptable. Moreover, fire alarms shall be located in the outgoing air flows of air-conditioning and ventilation systems.

The alarm signal receiving units must be so designed that by use of a standardized alarm unit socket, any of the types of detector may be used with equal facility on any of the fire alarm circuits.

The fire alarm central station must be housed in sheet-steel enclosed cabinets and located in the central control room or nearby in an appropriate location. Both optical and audible signals must be given when a fire alarm or fault alarm occurs.

Power supply for the fire alarm system shall be taken from the safe AC bus bar, emergency supply shall be maintained by a rectifier/battery set (1 (one) x 100%), designed for 4 (four) hours discharge time.

33.38.5.2 FIRE ALARM CENTRAL STATION

The fire alarm central station is to be implemented in all-electronic technology using plug-in units and assemblies and the modular construction principle, and shall be accommodated in metal clad enclosed panels with type IP 31 enclosure for wall-mounted/free standing installation.

The arrangement and functioning of the fire alarm central station shall be such as to permit as a minimum the following:

- The fire alarm and fault annunciation system shall be designed with optical and audible alarms. Whereas the audible alarm must be resettable, the optical indication shall persist until the annunciation is finally extinguished or the fault cleared. if a fault warning is followed by a fire alarm annunciation, the fault indication must be stored and suppressed until the fire alarm condition has been cancelled. Provision shall be made for clear audible identification of the alarm/fault signal. Furthermore, fire alarm signals and fault signals shall be strictly segregated.
- An automatic fire alarm signal shall be transmitted externally to the central control room.
- The individual fire alarm lines and function lines of the fire-fighting equipment and facilities, as well as important functional groups of the fire alarm central station shall be continuously monitored for faults and breakdowns e.g. for:
  - wire breakage of each alarm line
  - short-circuit of each alarm line
  - earth fault of the fire alarm system
  - power supply system faulty
  - main fuses and MCB's failure
  - alarm modules disconnected from plug-in frame.

All fault signals shall be optically and audibly indicated.

For checking out the functioning of the complete fire alarm system including the fire alarm lines and fire alarm devices, testing facilities shall be provided. When testing a circuit, initiation of fire alarm warnings in external facilities shall be prevented. After testing, the tested circuit shall automatically reset to normal Operation. Simulation (e.g. test pins) of all relevant fault signals as listed above as well as of all fire alarms shall be possible in order to check-out the externally connected fire fighting facilities.

Thee fire alarm central station shall be provided with potential-free change-over contacts wired to a central terminal board as follows:

- contacts to control the fire protection doors
- contacts to control the air-conditioning and ventilation equipment
- contacts for spare.

Activation of fire protection doors shall be signaled as a group annunciation to the fire alarm central station and included in the alarm annunciation system.

33.38.5.3 LAYOUT DISPLAY BOARD

For indicating fire alarm and fault annunciations from the fire alarm system, a layout display board has to be provided in the panel in the central control room. This board shall include a graphic display to show a simplified ground plan of the individual buildings and shall feature signal lamps for the separate optical indication of the alarm line, and shall include the annunciator with alarm test, reset and acknowledge buttons.

Preferably a separate monitor with appropriate graphics etc. shall be supplied.

33.38.5.4 DETECTION SYSTEMS

The fire detector system elements and the associated mountings are to be provided with sturdy, corrosion-proof plastic housings.

The fire alarm detectors are to be provided with optical means for signalling their activation (light-emitting diode), and are to be suitable for the connection of an additional optical, external alarm indication.

The fire alarm detectors shall reset ready for operation following each alarm, without outside intervention, and shall plug-in and be provided with suitable means to prevent unauthorized removal or disconnection and for connection to the fire alarm central station.

The following detector types as a minimum shall be used for fulfilling the requirements as a whole.

33.38.5.5 IONISATION DETECTORS (IF REQUIRED)

For the early identification of visible and invisible fire aerosols, consisting of ionisation chamber, alarm electronics, optical alarm indication, response delay presettable to suit ambient conditions, detector socket, variable response sensitivity and connection possibility for a parallel optical alarm indication.

33.38.5.6 OPTICAL SMOKE DETECTOR

For early identification of visible smoke generation, consisting of photoelectric alarm electronics, optical alarm indication, detector socket and connection possibility for a parallel optical alarm indication.

33.38.5.7 FLAME DETECTOR

For early identification of fire outbreaks and open flames, consisting of optical unit, alarm electronics, optical alarm indication, detector socket, variable response sensitivity and connection possibility for a parallel optical alarm indication.

33.38.5.8 THERMO-DIFFERENTIAL AND THERMO-MAXIMUM DETECTOR

For early identification of fires as they break out with rapid temperature rise and little smoke generation, consisting of temperature sensor, alarm electronics, detector socket and connecting possibility for a parallel optical alarm indication.

33.38.5.9 MANUALLY OPERATED PUSH BUTTONS

Push-button fire alarms are used for the manual initiation of an alarm and are to be connected to the fire alarm central station. These are to be installed in the necessary number at readily accessible points located e.g. on escape routes, corridors and stairways, exit doors, transformer etc. and are to consist:

- push-button, only operable after smashing the replaceable glass window fitted in the housing
- interlocking mechanism, which holds the push-button in the operated position and cannot be released until the glass window has been replaced or reset by key
- plastics or aluminum housing, painted red, type of enclosure IP 54
- instructions for use are to be provided on the operating side.

33.38.5.10 SIRENS

The protection degree of the sirens for indoor and outdoor installation must be at least IP 54.

The outdoor sirens are to be arranged on the control building. The arrangement of the indoor sirens must meet the requirements at site for satisfactory warning of the operating personnel.

The control of the sirens shall be performed automatically by the fire alarm system, but manual operation from the central control room must also be possible.

33.39 VENTILATION SYSTEM

33.39.1 GENERAL

This specification covers the design, manufacture, pre-assembly and acceptance testing in the Contractor’s workshops as delivery, unloading, erection, adjusting, painting, identification, commissioning and acceptance testing of ventilation system complete in every respect and for satisfactory operation.

33.39.2 LAYOUT

The proposed ventilation system shall be in accordance with the ASHRAE standards or equivalent standards.

The HVAC system shall provide comfort to the following areas:

- area / room designation type of ventilation system applied
- new GIS and control buildings ventilation
- inlet: double bank louvers
- exhaust:
    - 4 x 25% roof mount axial flow fans with self-acting flaps
    - Ventilation.

33.39.3 SCOPE OF SUPPLY AND SERVICES

The scope of supply and services shall include the design, manufacture, construction, factory testing, packing for transport, delivery, installation, commissioning and site testing of ventilation systems components and associated equipment including but not limited to:

- all air conditioning and ventilating systems
- all equipment and/or accessories not specifically mentioned in this specification, but which are necessary for a safe, reliable and proper operation, service and maintenance of the systems
- All necessary documents shall be submitted for review and approval by the Employer/ the Engineer but not limited to calculations, layout, drawings with construction details, certificates, installation plans, switch and control diagrams, airflow diagrams, equipment selecting sheets, test records, cable, wiring and terminal lists, technical data sheets of all major parts of the plant and characteristics curves, working, operating and servicing manuals, lubrication schedules, spare part lists, etc.

33.39.3.1 VENTILATION SYSTEM

The type of ventilation system provided for various areas is based on the inside condition to be maintained, the heat loads, operational and maintenance ease.

The ventilation system shall make sure that the permissible maximum and minimum temperature and humidity values are not exceeded. At the same time, the dust content must be limited to a level acceptable for the equipment installed.

The Contractor shall demonstrate by adequate calculations the capacity of ventilation systems provided for the above mentioned buildings and cable ducts.

For the cable ducts appropriate chimneys shall be provided to ensure the evacuation of exhaust air.

33.39.3.2 AUXILIARY EQUIPMENT

The auxiliary equipment enumerated below shall be included in the scope of supply:

- all necessary base frames, base plates, anchor bolts, supports, covers, etc.
- all necessary insulation
- all necessary painting, corrosion protection and preservation measures
- complete detailed labeling of all installation
- documentation
- spare parts
- all consumables such as lubricants, chemicals, etc. for the complete commissioning, trial operation and a period of 5 years after final taking over.
- one set of special tools and equipment for maintenance and erection, inspection and repair in steel boxes, including identification and operation instructions as well as equipment for storing dismantled parts during inspection
- all standard equipment and accessories normally included in the supply schedule but not separately listed
- Complete electrical system including drive motors suitable for area specified, Motor Control Centre, control panel, local push button stations, transformers rectifier set, power & control cables, cabling complete with supports, cable trays, glands, lugs, earthing and lightning protection system for the successful operation of the plant. The electrical system shall conform to the requirements specified in Section B0.

33.39.4 TECHNICAL REQUIREMENTS

33.39.4.1 VENTILATION SYSTEM

Dry Pressurized Ventilation:
The ventilation system fan capacity is derived considering the following:

- solar heat load (sensible and latent)
- equipment, cable loads
- allowable temperature rise.

These design parameters to be considered for arriving at the ventilation system capacity:

System parameter Design Criteria

a) Outdoor Design Condition maximum dry bulb temperature: Please refer to Chapter 1 of Section 5

b) Indoor Design Condition Minimum room temperature: Please refer to Chapter 1 of Section 5

c) Equipment heat load: As per equipment installed in each area or 60W/m^2 of floor area whichever is higher.

d) Noise Criteria: Ventilation equipment < 50dB(A) at origin

General Exhaust Ventilation
The general exhaust ventilation system fan capacity shall be designed considering the following minimum recommended air change rates:

System parameter	**Design Criteria**
Cable ducts	6 air changes/h.

33.39.5 CONTROL PHILOSOPHY

33.39.5.1 VENTILATION SYSTEM

The ventilation systems shall be provided with PLC (Programmable Logic Controller) based control logic. The local start/stop push button station shall be provided for the centrifugal fans. The annunciation facia shall include the following annunciation:

- fan running
- fan stop
- fan motor overload
- FIRE damper closed.

Local starter for all wall mounted Supply / Exhaust fans shall be provided.

Filter conditions interlock
A high differential pressure switch provided across the filters will automatically clean filter material. The filter shall rise an alarm in the control panel when the filter requires cleaning/replenishing.

Fire safety interlock
The centrifugal fan motor and the axial flow fan motor shall be interlocked with fire detection system such that the motors will trip closing the smoke damper at the SA ducting, with the sensing of fire / smoke (by FPS system) in the respective ventilated area.

Exhaust Roof Fans Interlock
The units control panel shall be interlocked with the fire alarm system such that the exhaust roof fan is tripped on sense of fire in turbine building.

Fault annunciation
Duty, run and stop indication along with filter dirty, filter replacement status and unit trip alarms of centrifugal fan units will be provided in control panel. Similarly the Duty, standby, run and stop indication of exhaust fan will be provided in control panel.

33.40 CODES AND STANDARDS

AMCA - 210	Test code for Air Moving device
AMCA - 300	Test code for sound rating of Air Moving device
ARI 850	Standard for Commercial and Industrial Air Filter Equipment

ASHRAE 52.2	Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by particle size
AMCA 99	Fan –Standards handbook
UL 705	Underwriters laboratories –Standard for safety for Roof Ventilators
TEMA	Standards for Tubular Exchangers Manufactures Association
SMACNA Std	Sheet metal ductwork
UL 555	Underwriters laboratories –Standard for safety for fire dampers

Equivalent SNIP codes

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 34 – CHIMNEY

CONTENTS

34 CHIMNEY

The Chimney, consisting of a single reinforced concrete shell and two steel inner flue, shall be provided to serve the Plant.

The chimney system shall be provided for the discharge of combustion gas to the atmosphere at a sufficient elevation minimum 275m to provide adequate dispersion as required by the air permit. The chimney shall be provided with a outer concrete shell, Two steel inner flue with borosilicate or with a lining material superior to borosilicate for the application intended, foundation with piles, platform and ladders and an elevator, sampling ports, access doors(s), aviation obstruction lighting and lightning protection. The chimney inner flue shall be sized to limit the flue gas velocity while operating at maximum unit load, to prevent re-entrainment of moisture from the walls of the inner flue.

To meet the requirement of one boiler working and the other for chimney and desulfuration flue repair and maintenance, a reinforced concrete outer cylinder. The steel inner core of chimney of ϕ 7.2m in (min) diameter and (min) 275m in height. However Bidder to meet the emission requirements specified elsewhere in the Specifications.

As the chimney uses wet desulfurization process and does not operate under Gas – Gas Heater (GGH), the discharged flue gas slightly to be corrosive. The internal cylinder is suggested to use Pennguard block lining system to resistant corrosion of flue gas.

This project has desulfuration bypass for the flue gas. When the desulfuration system breaks down, the flue gas is discharged directly through the chimney but not the absorption tower.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 35 – JETTY

CONTENTS

35 JETTY

The proposed Payra 1320MW (2 x 660MW) Ultra-supercritical Coal-fired Power Plant is located on the east side of Kalapra Town in Patuakhali and the west side in the upper reaches of Rabnabad River, borders Tiakhli River on south and is adjacent to Kazol River.

In compare to other parts of the Rabnabad, Tentulia and Andharmanik River, the bank immediate around the project site is less vulnerable to erosion problem. Though the area has gone under a small to moderate erosion-deposition scenario over the last 37 years, it is generally understood that bank protection works of the proposed power plant would restraint those erosion tendency of the river bank. A further study comprising detail two- and three-dimensional model could investigate the matter more profoundly. However, based on the present preliminary study conducted here, it is recommended that the river bank at the project site should be protected.

Under the impacts of sea current and river runoff, there is not much change to the water depth of the river channel, and the position and width of the deep groove of the river channel remain basically the same. Partial sea areas between the estuary and lightering anchorage are silted, with maximum siltation depth reaching 1m. On the whole, there is no severe siltation in the area. Due to the impacts of trestle and wharf, the flow resistance within the bulkhead line will increase, and partial and minor siltation might take place within the bulkhead line.

This project will construct three coal unloading wharfs for berthing 8000-DWT coal barges, one 2000-DWT heavy cargo wharf and one approach bridge, serving the need for transporting and transferring coal and heavy cargos to the Plant.

The handling process system consists of wharf loading-unloading process and horizontal transport process. The handling capacity of each process shall match with each other to allow efficient operation and ensure the operating efficiency of the wharf process system.

The construction of approach bridge shall contain both conveying belt and drive way to meet the needs of coal conveying and driving at the same time.

35.1 GENERAL REQUIREMENTS

This section covers the design, construction and supply of all hydraulic structures constructions including wharfs and trestle for the specified power plant. It also describes quality standards, required functions and certain philosophies of the system but is in no case a detailed specification. Therefore the requirements are not limited to the descriptions hereafter; items not mentioned shall be in the same best quality range as for the entire works of the Plant.

The various buildings and parts of the Plant must form an architectural, structural and functional unit. Special attention must be paid, in addition to basic design and construction, to the aspects which are specific to climate and local requirements.

The structures shall be designed with due considerations regarding the need for inspection, maintenance, cleaning and repair and be able to operate for long-time periods with a minimum of inspection, adjustment and repair.

All material shall be new and of the best quality suitable for working under the conditions, variations in temperature and load encountered in service without undue distortion or deterioration or the occurrence of undue stresses in any part, such as to affect the efficiency and reliability of the Plant.

The Contractor is not allowed to use the works, materials or furniture or parts thereof for temporary purposes without the written consent of the Employer.

The conceptual and detailed plant configuration of the various components shall be proposed by the Contractor, subject to the approval of the Employer to suit the requirements of the supplied equipment, under consideration of the existing situation, as well as the tie-in points. In doing so, adequate safety clearances, favorable layout of the plant components for monitoring and maintenance and any other requirements of up-to-date power plant construction shall be taken into account.

35.2 CODES AND STANDARDS

All materials and the design must conform to the latest edition of the existing effective codes and norms associated with harbor engineering and related industries. Alternatively, internationally recognized codes and standards, which ensure a quality equal to or higher than the standards mentioned above (it is the obligation of the Contractor to demonstrate this requirement) may be used, but only if these are submitted in the English language edition for review and approval by the Employer’s engineer.

It is the Contractor’s responsibility to fully comply with the local regulations and is therefore requested to carefully review the documents with regard to the regulations. The engineering and execution of all the works shall be based on the latest editions and revisions of the applicable codes and standards as listed in other relevant sections of the document.

In case of discrepancies or conflict between the national and international codes & standards, the Contractor shall apply the most stringent requirement but shall maintain consistency and homogeneity in its supply or works.

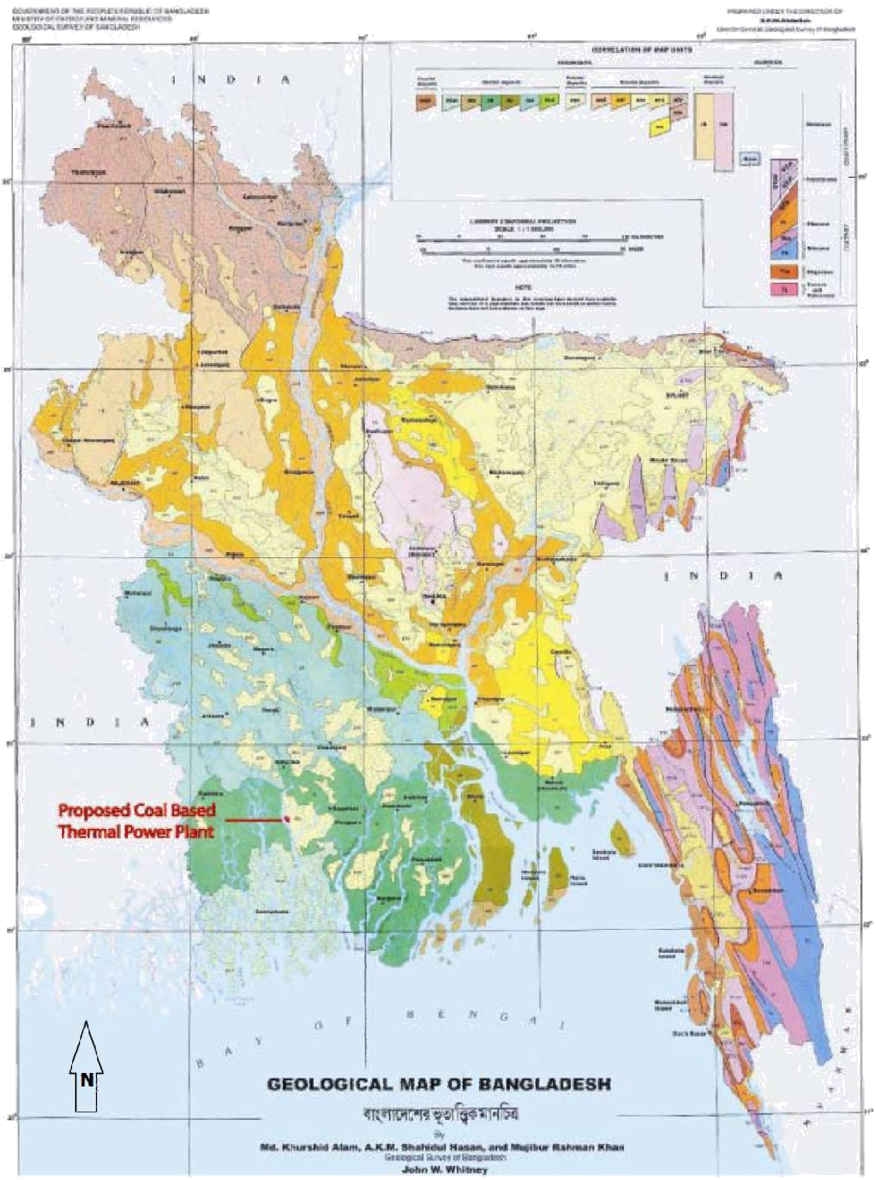
In case of doubt, the Contractor shall ask the confirmation of the Engineer.

Current editions of the codes and standards, including all mandatory addenda in effect at the time of the contract award, shall apply unless otherwise indicated.

35.3 GEOLOGY AND SOIL CONDITIONS

Certain strata in the subject water area consist of loose, medium-dense and dense fine sands mixed with marshy soil and marsh soil. The soil strata at the depth of 12m-13m consist of loose find sands, and that below the depth of 13m consist of medium-dense and dense find sands. The soil strata above the depth of 13m consist of low-plastic soil, and that below the depth of 13m consist of non-plastic soil.

The general geology is shown in Figure 35.3-1. The general geomorphological unit is shown in Figure 35.3-2. The detail study of engineering sediment of the proposed site is under way and the information will be supplemented when relevant materials are ready.



(*Source: Geological Survey of Bangladesh*)

Figure 35.3-1: Geological map of Bangladesh

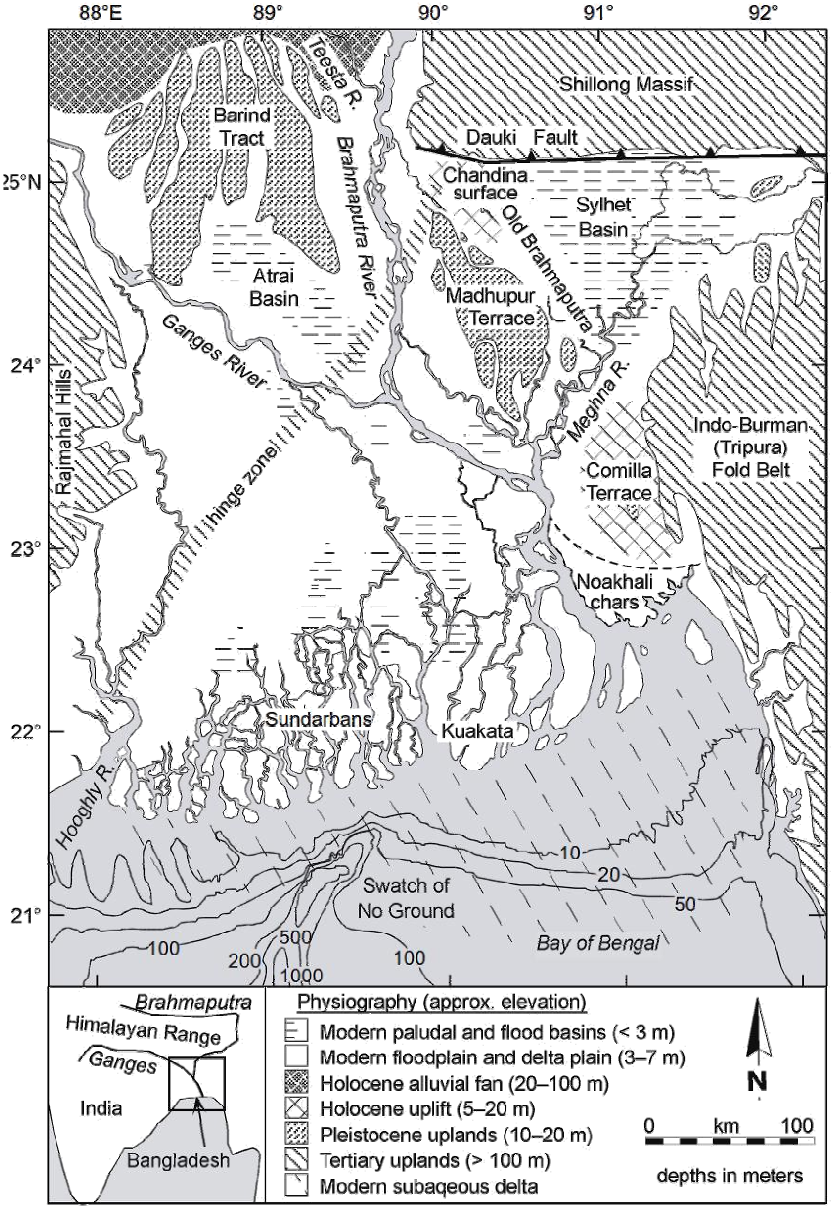


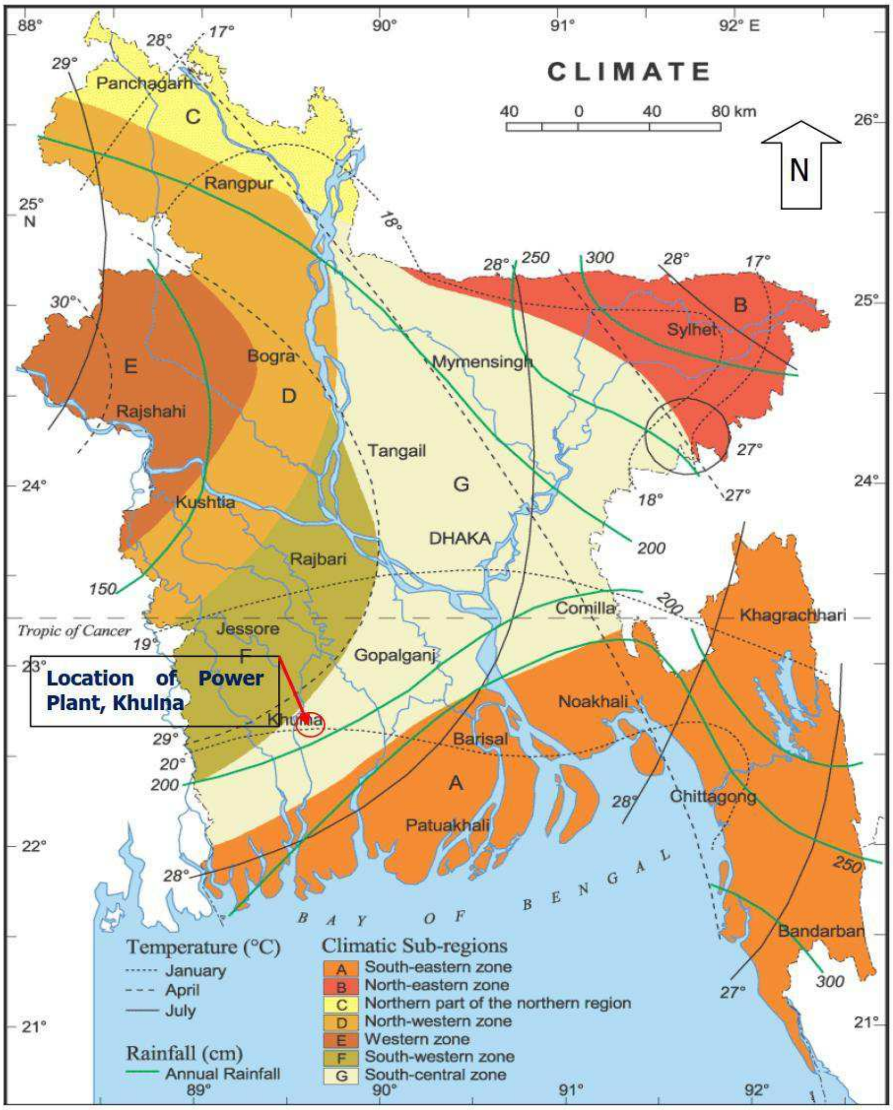
Figure 35.3-2: Geomorphological unit of Ganges-Brahmaputra Delta

The Ganges-Brahmaputra Delta, Kühl, Allison, Goodbred & Kundrass SEP, VIM, 2005

The Site area occurs in the seismic zone where hinge line would be the major potential source of earthquake. For additional Seismic Conditions please refer to Chapter 1 of Section 5.

35.4 CLIMATIC REQUIREMENTS

The Site is located in the south-eastern climatic zone of Bangladesh (see Figure 35.4-1). The Site lies close to the border of the south zone. On average, high tide water level reaches up to 3.0 – 3.2m PWD during monsoon while low water level goes down up to -1.23m PWD during dry season at Khepupara. The same high and low water level scenario can be expected for the project area since the latitudinal difference between Khepupara and the Site is only 2.5km and the difference in water level between these two points is considered to be negligible. On average, the fluctuation between high and low water level at the Site is 2.14m during dry (Feb – May), 2.1m during monsoon (Jun – Sep) and 1.87m during post-monsoon (Oct – Nov) season.



Source: ASB,2006

Figure 35.4-1: Climatic Sub-region of Bangladesh [EIA - 2 x (500-600) MW Coal Based Thermal Power Plant_Volume_I]

For Additional Climatic Conditions please refer to Chapter 1 of Section 5.

35.5 HYDRAULIC CONDITIONS

35.5.1 WATER LEVELS

The average high water level is 3.21m PWD while 20, 50 and 100 year return period high water level is 4.05, 4.51 and 4.89m PWD, respectively. The 75 year return period value almost matches with the maximum tidal surge height of cyclone Sidr that hit over the southern coastal area of Bangladesh on May 25, 2009. During that cyclone surge, maximum water level reached up to 4.64m PWD at Khepupara.

Average low water level is -1.04m PWD. For 20, 50 and 100 year return period, it is about -1.28, -1.46, and -1.58m PWD, respectively. Therefore, the river bed should be at least at -5.98, -6.16, and -6.28m PWD for 20, 50, and 100 year return period's low water level, respectively to ensure the safe navigation of the coal carrying vessels.

35.5.2 WAVES

Please refer to Chapter 1 of Section 5 for more details.

35.5.3 CURRENTS

Please refer to Chapter 1 of Section 5 for more details.

35.5.4 RIVER BATHMETRY, TOPOGRAPHY

In compare to other parts of the Rabnabad, Tentulia and Andharmanik River, the bank immediate around the project site is less vulnerable to erosion problem. Though the area has gone under a small to moderate erosion-deposition scenario over the last 37 years, it is generally understood that bank protection works of the proposed power plant would restraint those erosion tendency of the river bank.

The proposed site is located on the west side of Rabnabad River in Khepupara Town of Patuakhali, bordering Tiakhli River on south. The area for constructing the power plant is mainly used to grow paddy rice, and there are also scattered dwellings. There is no airport, natural park, wild life conservation or historic sport. The Site stretches 2.0km from east to west and 1.8km from north to south, with altitude reaching -0.2m to 3.8m.

35.6 DESIGN VESSELS

The vessel to be used for coal transportation shall satisfy all international and national standards. The activity of the vessel shall be monitored to ensure enforcement of mitigation measures. Coast guard might be given responsibility of inspecting whether the vessels are adopting mitigation measures, complying national and international rules of safety and environmental conservation. Besides, an Environment Manager shall be given responsibility of monitoring transportation activities and of auditing environmental efficiency of the transportation system.

As design vessel will be taken any vessel into consideration with actual dimensions within +10% of the following nominal values.

The jetty shall be planned to for one 2000-DWT cargo carrier and three 8000-DWT coal barge and reserve two 8000-DWT coal barge.

The design vessel types are shown in Table 1.6-1.

Table 1.6-1 Design vessel types

Vessel	Design vessel dimensions (m)				Remark
	Molded length	Molded breadth	Molded depth	Load draught	
8000-DWT coal barge	92	24.4	5.5	4.6	Coal unloading berth Design vessel
2000-DWT general cargo carrier	86	13.5	7.0	4.9	Heavy cargo berth Design vessel
3000-DWT general cargo carrier	108	16	7.8	5.9	Heavy cargo berth Berthing vessel

35.7 REFERENCE LEVELS

Reference level for onshore and offshore is Mean Sea Water Level MSL. The relation between MSL and the local PWD is as below:

PWD Level = MSL Level + 0.46m

35.8 SCOPE OF SUPPLIES AND SERVICES

This section sets out the scope of works for the jetty and retaining wall and installations covered by this specification as well as the requested supplies and services, but without excluding other necessary components and services not mentioned.

35.8.1 GENERAL

The Contractor shall supply and erect the jetty, the retaining wall and river bank protection which are necessary to support, to protect and to provide the required environmental conditions for the entire plant.

The following types of works have to be considered, but without excluding other necessary works and services not mentioned:

- all necessary surveys
- all necessary soil investigation required in addition to the investigation works carried out prior to the Contract.
- all other investigations and studies necessary for the design and execution of civil works (hydrodynamic model, mooring & berthing analysis, maneuvering studies, flooding possibility of the site, safety measures, etc.).
- site organization works for the entire project execution phase including but not limited to:
    - access roads and outdoor storage facilities
    - temporary water
    - temporary electricity supply
- structural and civil engineering design of the jetty structures, retaining wall and river bank protection, foundations including the complete statically and dynamical analysis, design, execution and workshop drawing
- removal of all debris, underground obstacles (if any) and surplus materials to approved dumping locations
- dredging works, Earthworks, permanent and temporary drainage works, soil exchange (if needed), refilling works on the additional areas allocated for temporary works
- all ancillary works and installations necessary for the execution of works, such as but not limited to piling, dewatering, dredging, etc.
- piling works
- concrete and steel works
- Supply of all necessary equipment for the unloading system, transport system, mooring and dolphins etc.
- all necessary crane and hoist girders, pipe and cable bridges and supports according to the requirements of the electrical and mechanical installations.

35.8.2 WHARF PLATFORM

The handling process system of this project consists of wharf loading-unloading process and horizontal transport process. The handling capacity of each process shall match with each other to allow efficient operation and ensure the operating efficiency of the wharf process system.

This project mainly handles coal. Each coal unloading berth will be provided with two 16t gantry cranes, with track gauge reaching 10.5 meters. The coal arrived will be unloaded with the gantry crane, and the cabin will be cleared under the aid of the loader. The heave cargo berth will be provided with a stationary crane (leased) to handle heavy cargos.

The horizontal transport will employ a stationary belt conveyer system with belt width reaching 1.4m and speed being V = 2.5m/s (conveying capacity = 1500t/h). In the current phase, one conveyer system will be installed and the room for another one will be reserved.

To guarantee for an effective operation the marine facility will be provided with the following components:

SN	Item	Model/Specifications	Unit	QTY	
				Scheme 1	Scheme 2
1	Gantry crane	Q=16t，R=28m, L_K=10.5m	Set	6	-
2	Screw-type ship unloader	Q=800t/h，R=28m，L_K=10.5m	Set	-	3
2	Stationary crane	Q=250t/h	Set	1	1
6	Belt conveyor	B=1.4m, V=2.5m/s, Q=1500t/h	M	2×345	
		B=1.4m, V=2.0m/s, Q=1500t/h	M	2×945	
7	Sampling and testing system	B=1.4m	Set	2	2
8	Electronic belt weigher	B=1.4m	Set	2	2
9	Calibrating apparatus	B=1.4m	Set	2	2
10	De-ironing separator	B=1.4m	Set	2	2
11	Loader (clearing)		Set	6	4
12	Other equipment	Auxiliary facilities/tools	Set	1	1

35.8.3 TRESTLE (APPROACH BANK)

The connecting passage consists of trestle and approach bank, with total length reaching 750m. The trestle has a length of 544.31m and a width of 16m, while the approach bank has a length of 205.69m and a width of 16m.

1) Trestle

The trestle has a length of 544.31m and a width of 16m, with elevation reaching +5.5m. It's of high-piled beam-slab structure. The trestle will have a coal conveying corridor and a crane travelling area, meeting the needs for both coal conveying and crane travelling. The trestle will consist of eight structural sections, with trestle stand spacing reaching 12m. There will be totally 45 spans and 51 rows, with each trestle stand having 3 cast-in-place piles with diameter reaching 1m. The pile toe supporting course will be a compacted fine silty layer. The pile top will have cast-in-place transverse beams, with cored slabs laid on top of transverse beams of the coal conveying corridor. The heavy cargo crane travelling area will use concrete box girders, with a cast-in-place C40 concrete surface course and a wearing course.

2) Approach bank
The approach bank has a length of 205.69m and a width of 16m, with the elevation of approach bank surface reaching +5.0 to +5.5m. The approach bank is of sloped riprap structure, with the core filled with 10-300kg block stones. Both sides of the crown will have cast-in-place blocking course.

35.8.4 REVETMENT AND SHORE PROTECTION

The river bed in the area of the Jetty consists of silty fine sands, which are not stable against erosion by increased flow. It is therefore necessary to protect the river bed. This can be carried out by applying a revetment or the design depth for the jetty and retaining wall must include the scour. The revetment class shall be selected according to the rated ship. The revetment must have a stable position against the propeller jet pressure as well as swell and sunk (filter stability). The retaining wall and water intake, that is located north of the jetty, should also be protected with the same revetment.

The width of the bed protection has to be greater than 1.5-times the width of the vessel.

35.8.5 FENCING

All structure outside the boundary wall need to be secured with a fencing system.

35.9 DESIGN CRITERIA FOR HYDRAULIC STRUCTURES

Initially the jetty is foreseen with berthing and mooring facilities designed for Barge carriers from 2,000 DWT to 8,000 DWT.

Design requirements for the jetty and retaining wall are provided in the following clauses:

35.9.1 MAIN DESIGN REQUIREMENTS FOR WHARF PLATFORM

Overall external dimensions Layout:
25m x 437m.

Note:
After the dimensions of the vessels are determined the layout must be checked.

The wharf platform will have a minimal slope to allow water runoff. Top of deck to be provided with a brushed (or other non-slip) finish.

Conveying system:
- The dimensions, here indicated, are to be considered as a guide only and the space as a minimum requirement; the detail design shall dictate the final dimensions.
- The given heights shall be kept as minimum clearance heights; allowance shall be foreseen for conveying system and to be determined by the Contractor.

Crane system - rail mounted ship unloaders:

- The dimensions, here indicated, are to be considered as a guide only and the space as a minimum requirement; the detail design shall dictate the final dimensions.

Provisions for future extension:

- Reserve for two 8000-DWT coal barge

Outside construction:

- None.

Outside paved areas:

- As part of the jetty deck.

Parking:

- None.

35.9.2 MAIN DESIGN REQUIREMENTS FOR TRESTLE (APPROACH BANK)

- Overall external dimensions
- Layout
- Length about 750m
- Elevation of trestle is +5.5m MSL, and elevation of approach bank is +4.9m to +5.5m.

35.9.3 DESIGN DEPTH AND ELEVATION

The design depth in the area of the wharf is to be configured in such a way that a safe berthing and mooring of the largest vessel is guaranteed. For these purposes the maximum draught of the fully laden vessel and design features as an appropriate under keel clearance, a certain dredging zone and a dredging tolerance shall be taken into consideration. The design depth of the terminal is related to the lowest water level in order to allow the vessels to call at the jetty independently of the tide effects (see Figure 35.9-1).

The elevation of the structures shall be such that parts, other than piles will not be subjected to wave loading for the 1 in 10 year waves on a high tide.

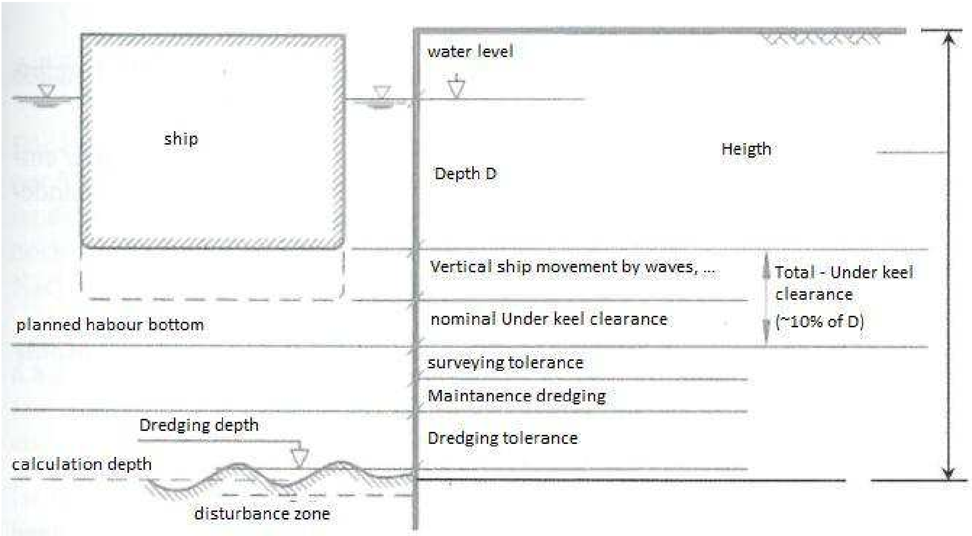


Figure 35.9-1: Design Depth [EAU 2014]

The same deck levels shall be given to the unloading platform, berthing dolphins and mooring dolphins.

Final levels are fixed as follows for the different areas:

- Wharf platform (Top of Concrete): +5.5m

These levels are based on the required site conditions as a guide only. It is the responsibility of contractor to confirm these levels during detailed engineering, to appraise all consequences of any change and to implement all required modifications.

- Design bed elevation of the coal unloading berth: -7.4m
- Design bed elevation of the heavy cargo berth: -8.5m

The width of berthing area in front of the wharf shall be twice of design ship beam:

Coal unloading berth: B1=2×24.4=48.8m, assumed at 49m;
Heavy cargo berth: B2=2×16=32m, assumed at 32m.

Notes:
1) Special Ship sizes: must be checked after determined the dimensions (vessels).
2) The dredging shall be done approx. once a year. The sedimentation rate during the year is roughly determined with 15cm.

35.9.4 SAFETY STANDARDS

35.9.4.1 GENERAL

The jetty superstructure will have acceptable probabilities that they will not reach a limit state, i.e. will not become unfit for their purpose by collapse, overturning, instability (ULS) or deformation, cracking, etc. (SLS) and that the structures will not deteriorate under the action of the environment over the design life of 50 years.

35.9.4.2 ULTIMATE LIMIT STATE (ULS)

The structure shall be designed in order to transmit the design loads safely to the foundation system.

The design strength of materials and the design loads shall be those given in the Standards. The design strengths of materials are given from their characteristic values.

The design shall satisfy the requirement that no ULS is reached by rupture of any section, by overturning or by instability under the worst combination of ultimate loads.

The construction cases are not detailed but shall be carefully considered according to the phases, methods and temporary means adopted by the contractor.

35.9.4.3 SERVICEABILITY LIMIT STATE (SLS)

The superstructure shall be designed to meet the specific service requirements.

Structural system, and components thereof, shall be designed to have the adequate stiffness to limit deflections, lateral drift, vibration, or any other deformations that adversely affect the intended use and performance of buildings and other structures.

The design shall satisfy the following requirements:

- no deformations or deflections which may affect the appearance or effective use of the structure (including malfunction of equipment and instruments) or cause damage to the connected structures or non-structural elements or to the protective coating;
- no vibrations which limit its functional effectiveness;
- no cracking of concrete which is likely to affect appearance, durability or water tightness;
- no damage affecting the durability and embrittlement protection, in accordance with safety philosophy.

35.9.4.4 LOAD CASES COMBINATION & ELEMENTARY LOADING CASES

The load combinations will depend on the loading context, representative of one of the four basic scenario cases for realistic loading occurrences (Normal, testing, accidental, construction).

The load cases to be combined are context sensitive, so that for each load combination representative of a particular scenario, the load cases to be combined will be defined in function of the scenario itself. For a same scenario, the load combinations will be further modulated by the way the inherent load cases are combined.

At the ULS, the general combination rules are given in the Standards and shall be modulated according to the identified scenarios.

The Engineer is responsible of classifying the load cases as per their context sensitivity. The following particular facts shall be considered:

- Action type such as earthquake shall be extended to other accidental actions like explosion, water hammer, equipment malfunction
- Testing load cases shall not be combined with accidental load cases, unless this latter is directly related with the test condition (equipment malfunction, vessel or pipe leakage)
- Construction scenario load cases shall be identified along the detail design process
- Effects of local effects around anchorages, change of direction
- All load cases in the combination are affected by the maximum load factor; a minimum load factor (0 for variable loads) shall be applied to these loads if the resulted combination is more stringent.
- The following provision shall also be considered:
  - The permanent actions (dead loads or quasi permanent live loads) that increase the effect of variable actions (i.e. produce unfavourable effects) shall be represented by their upper design values, those that decrease the effect of variable action (i.e. produce favourable effects) by their lower design value
  - The load partial safety factors for the self-limiting loads (imposed loads or displacements) is 1.35 assuming that the analysis is performed on a linear structure (elastic). In case of nonlinear analysis the load partial safety factors should be 1.5 instead of 1.35
  - The favourable and unfavourable parts of the actions shall be considered in individual actions
  - All load cases introduced in the combinations shall consist in the most stringent realistic effect or superposition of effects. As realistic, the Engineer shall distribute the individual load cases in load combinations considering the actual loading, meaning that loads that cannot act simultaneously will never be taken together (example: test load and operation load, wind and earthquake)

35.9.5 DESIGN LIFE

The design life is defined as the period for which the structure or element is to be used for its intended purpose with reasonable maintenance, but without major repair and/or replacement being necessary.

The main structures, including the wharf, trestle and approach bank, shall have a service life of 50 years.

The return period of the extreme water level, wind and wave conditions shall be 50 years.

35.9.6 DESIGN LOADS

The wharf, dolphins, fenders and catwalks shall be designed to receive a range of bulk carriers. Further details of the vessels and their dimensions are given in this document. The structures need to be able to resist all loading forces caused by receiving the ships and performing all unloading processes.

The construction must be designed that all mooring forces (both berthing and mooring) are totally supported by the jetty.

To facilitate the mooring of ships, a tethered platform will be provided at the elevation of +3.7m, and 500KN bollards will be provided on the platform. The front edges will be installed with DA-A400H rubber fenders.

Construction loads during all phases are taken into account, w.r.t. the resistance of the structure at that moment.

Design load combinations shall be generally in accordance with the relevant Chinese Standard or equivalent, taking into account the following loads:

- **Dead load**
  Dead load is defined as the weight of all permanent construction including superstructure, foundations and fixed service equipment and shall be calculated according to BS 6399: Part 1 & 3 or equivalent (e.g. DIN EN 1991-1-1) or Load Code for Harbor Engineering (JTS 144-1-2010) or equivalent.

  Equipment and conveyor system should be considered empty when calculating dead load. The gravity weight of soil overburden shall be considered as dead load.
  Foundations:
  Structure supported by and linked to the jetty head structure.

- **Erection dead load**
  The erection dead load is the weight of the equipment at time of erection plus the weight of the footing, pedestal and overburden soil.

- **Live load**
  Live load is defined as the weight superimposed by the use and occupancy of the building or other structure, but not permanently attached to it. For design, live load is defined as the load produced by personnel, moveable equipment, cranes, handling products and other items placed on the structure, but not permanently attached to it.

  Design shall be done for the actual plant live loads or the live loads specified in BS 6399: Part 1 & 3 or equivalent (e.g. DIN EN 1991-1-1) or Load Code for Harbor Engineering (JTS 144-1-2010) or equivalent.

  The Employer's verification is required in all cases for reductions of load carrying capacities and for exceeding the permissible stresses.

  Areas designated for different loadings on the structure shall be clearly and permanently marked.

- **Crane/hoist load**
  Crane/hoist loads shall be considered as live loads. The vertical and horizontal loads from cranes/hoists shall be as per the manufacturer's data.

  In the absence of specific information, the following minimum horizontal loads shall be considered at the location of each wheel.

  (i) transverse surge = 15% of static wheel load.
  (ii) longitudinal surge = 5% of static wheel load.

  The vertical wheel loads from dead load, live load, inertia forces and wind forces are to be applied when designing the crane way (Din 15018 part 1/DIN EN 13301-3).

  The Figure 35.9-2 shows the minimum distance between the quay edge and the crane rails as well as the minimum distance from the quay and the mooring point as well as the required bollard height.

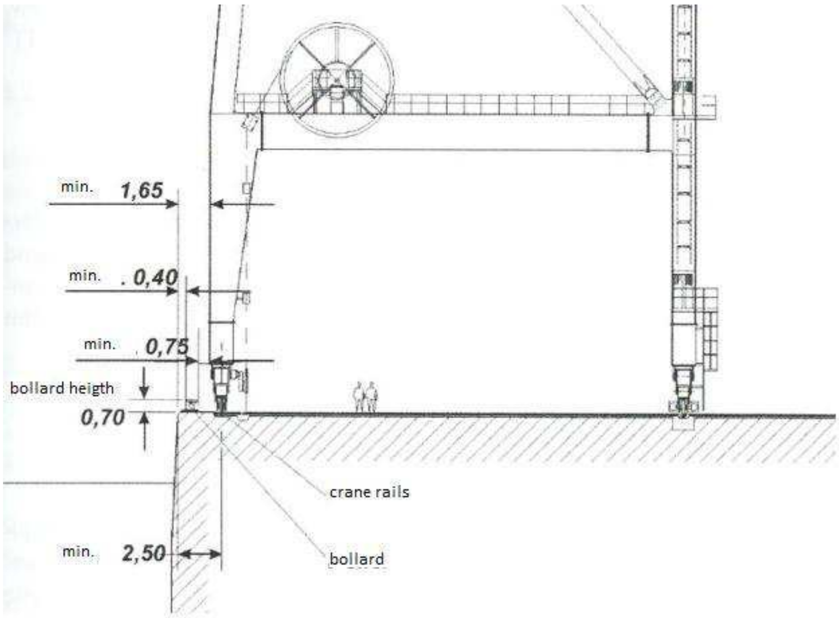


Figure 35.9-2: Min. Distance [EAU 2014]

- **Product load**
  The product load shall be defined as the gravity load imposed by liquid, solid, or viscous materials in vessels, tanks, equipment or piping during operation.

- **Maintenance loads**
  The load for component delivery during maintenance of power plant shall be defined as the gravity load.

- **Mooring and dolphin loads**
  The design of structures shall include all mooring and dolphin loads when applicable.

- **Test load**
  The test load is defined as the gravity load imposed by any method necessary to test vessels, tanks, cranes, equipment or piping.

- **Thermal load**
  Thermal loads shall be defined as forces caused by changes in temperature. A major source of thermal loads in jetty structure is the expansion or contraction of the entire structure or individual structural components.

- **Belt conveyor system load**
  Structures accessible to conveying belt shall be designed to withstand the gravity, lateral and impact effects of conveying belt loading. Belt conveyor system loading shall be determined according to BS 6399: Part 1 & 3 or equivalent (e.g. DIN EN 1991-1-1) or Load Code for Harbor Engineering (JTS 144-1-2010) or equivalent.

- **Mobile load**
  Mobile load mainly comes from the transport vehicle and construction machinery during the construction period and from loader during the operation period, assumed at the 10kN/m^2 (uniform load)

- **Soil load**
  Soil loads shall consist of lateral earth pressures. Active and passive coefficients for lateral pressures shall be obtained from the project soils report. The weight of soil shall be considered as dead load.

- **Hydrostatic load and buoyancy**
  Hydrostatic load is the load due to water pressure. The design of structures shall include hydrostatic loads when applicable. The buoyancy load is equal to the weight of the volume of displaced water.

- **Wave loads**
  Wave load is the load due to water waves. The design of structures shall include Wave loads when applicable.

- **Current load**
  Current load is the load due to water current. The design of structures shall include Current loads when applicable.

- **Wind load**
  The wind load calculation for the structures shall be as per BS 6399: Part 2. The basic wind speed shall be as specified in the local standards.

- **Earthquake load**
  The Payra-STPP is located in a specific earthquake region. However, seismic loads shall be considered according to Chapter 1 of Section 5.

- **Dynamic loads**
  The jetty structure and foundation shall be designed to withstand the effects of fatigue loads to which it may be subjected. The jetty structure supporting the rail

mounted grab bucket type ship unloaders and trucks that have significant dynamic loads shall be designed to resist the peak loads.

Vibration amplitudes of the supporting structure or foundation shall be kept within acceptable limits for dynamic forces that occur during normal operation.

In the dynamic analysis, the following codes are to be considered: DIN 4024, ISO 1940-1 and VDI 2056. The vibration amplitudes, if not specified by the manufacturer, shall follow VDI 2056.

Rail mounted grab bucket type ship unloaders:
Crane load shall be considered as live load. When applying this load, the following impact load shall be considered as per BS 6399: Part 1 or equivalent.

- Vertical force
- Lateral force:
  - 20% of the weight of trolley and lifted load (but exclusive of other parts of the crane).
- Longitudinal force:
  - 10% of maximum wheel loads.

35.9.7 MOORING AND BERTHING OPERATIONS

The fenders will be designed in accordance with BS 6349, Part 4, 1994. The following condition shall be designed for under normal conditions:

Maximum vessel list	7°
Maximum angle of approach	10°
Maximum eccentricity of berthing vessel	¼ point
Fender tolerance from manufacturers data	±10%
Coefficient of friction between vessel, hull and fender	0.3
Factor of safety on abnormal berthing	2.0
Velocity of the ship	0.35 m/s (good conditions)

In calculating the approach velocity the conditions at site shall be taken as good berthing, exposed.

The berthing line, with the fenders completely deflected will be set sufficiently offshore from the face of the unloading platform to ensure that, on berthing, or when moored, the vessels cannot impact on the unloading platform or any equipment set upon it. In calculating this offset the design will give due cognizance to the vessel flare and vessel list.

The design of the mooring dolphins, berthing dolphins and unloading platform shall be carried out to accept loads from:

- the moored vessel
- wind, waves and currents
- impact from tugs and mooring vessels.

Main jetty and dolphins need to be interconnected with structural steel walkways. These walkways shall be capable to withstand all major relative displacements between the dolphins and between the jetty and adjacent dolphins.

Mooring

The loads from the moored vessel shall include those obtained from calculating the windage, current forces and wave forces on the vessel.

In addition to the loads applied through the vessel, the structures will be subject to direct loads from wind, currents and waves. To allow for abnormal impacts from tugs and mooring craft each of the mooring structures i.e. unloading platform, mooring and berthing dolphins will be designed to withstand a horizontal force of 50 tons to any point reachable by such a vessel and in any direction.

The maximum distance between the mooring points is 30m. For the mooring point is a double bollard foreseen.

Berthing

The berthing energy is calculated according to the following formula:

$$E_o = \frac{\rho}{2} M V_n^2$$

Where:

- E—Effective impact force when the vessel is docked (kJ);
- ρ —Effective kinetic energy coefficient;
- M—Vessel mass (t);
- Vn—Normal velocity when the vessel is docked (m/s).

35.9.8 DISPLACEMENTS AND VIBRATIONS

Displacements and vibrations of structural elements shall be limited.

Stresses in all materials shall be limited to the proposed values in the appropriate codes, as well in SLS as ULS conditions.

Unloading platform

Horizontal max. +-15cm

Dolphin

Horizontal max. +-15cm

35.9.9 DEFLECTIONS

For the requirements please refer to Chapter 4 of Section 5.

35.9.10 SETTLEMENTS

For the requirements please refer to Chapter 4 of Section 5.

35.9.11 STABILITY

All ground stability analysis should be based on data given in the soil investigation report.

Ground stability of structures has to be calculated according to EN 1997-1 based on BS 8004 or equivalent.

For additional Conditions please refer to Chapter 4 of Section 5.

35.9.12 CORROSION PROTECTION

For the unloading facilities, a corrosion protection with coating acc. JTJ 275- 2000 “Corrosion Prevention Technical Specifications for Concrete Structures of Marine Harbour Engineering” shall be implemented, where applicable.

The Contractor shall submit to the Employer, for approval, a comprehensive proposal of painting systems.

Each system shall be perfectly suitable for the specific conditions of application, i.e.:

- site location atmosphere
- type of surface (material and possible existing coatings)
- temperature range
- exposure conditions (indoor, outdoor, subjected to chemical, seawater, abrasion, etc.)
- possibility of blast cleaning or not
- surface to be insulated or not
- shop or site fabricated equipment
- transport, storage and erection conditions.

35.10 SPECIAL TECHNICAL REQUIREMENTS

35.10.1 BASIC REQUIREMENTS FOR JETTY AND RIVER BANK PROTECTION

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Employer.

Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards.

The dimensions shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Employer.

The work shall be carried out by competent personnel skilled in their various trades.

Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles which will be used (cars, forklifts, trucks/trailers etc.) to reach up to the point of unloading of the equipment.

Before starting of design works, the Contractor shall submit to the Employer for approval a project design manual containing the design data, the design criteria and the standards for all civil works. All loadings considered in the design shall be justified with supporting details.

All works are to be carried out under the tidal wave and weather conditions prevailing at the Site. The works and structures should meet codes well and standards as other relevant.

35.10.2 SITE ORGANIZATION AND PREPARATORY WORKS

Refer Chapter 4 of Section 5.

35.10.3 SURVEY WORKS

The site investigations is provided in the Bidding Document, nevertheless the Contractor shall carry out the necessary topographical survey works in order to obtain the following information:

- location of the plant site relative to the existing bench marks of the area
- establishment of site boundaries with site levels
- installation of site bench marks
- Preparation of a site survey report, with the description of survey works, methods applied and survey map(s) on scale 1:500, showing the results with the location of bench marks. The levels have to be given in an adequate scaled grid line system.

Moreover the Contractor shall carry out a bathymetric survey and all marine investigations required for the offshore structures.

The full responsibility of the investigations to be carried out lies with the Contractor.

35.10.4 DREDGING WORKS

35.10.4.1 GENERAL REQUIREMENTS

This section specifies all excavation or dredging works (i.e. excavation or dredging of existing river bed, excavation or dredging of existing rubble and debris, etc.) for the construction and development of the Plant. For the location and levels of the dredging work see scope related to the jetty construction and retaining wall. The dredged area shall cover the barge berthing, turning area, and voyage connection part (two-way barges route, each 8000t (DW) of 50m from jetty). The outward extension of 50m shall be considered.

The following Applicable Codes and Standards shall be used when carrying out the Works:

- BS 5930: Code of Practice for Site Investigations.
- BS EN 14688:2002: Geotechnical Investigation and Testing – Identification and classification of soil Part 1 Identification and description.
- BS 6349: Maritime Structures.
- JTS 165-2013: Design Code of General Layout for Sea Ports.
- JTS 133-2013: Code for Geotechnical Investigation on Port and Waterway Engineering
- JTS 167-1-2010: Design and Construction Code for Open Type Wharf on Piles

The Method Statement shall cover all aspects of dredging works including, as a minimum, the following:

- Details of the Contractor's proposed investigation
- Type and capacity of excavation plant/dredgers and barges necessary for completion of the Works
- Disposal of unsuitable material off Site to approved or specified locations.
- Contractor's and Safety Health Plan
- Contractor's Environmental Management
- Method of position control, surveys and soundings to be used.
- Methods of excavation and dredging adjacent to existing or new structures.
- Methods of achieving stable excavated or dredged slopes
- Methods of disposal of dredged material unsuitable for the Works
- Methods to estimate dredging quantities

- Details of monitoring works.

Any necessary stabilization measures, due to inadequate dredging method and/or dredging execution are to be performed by the Contractor at their own costs as ordered by the Employer.

35.10.4.2 DESIGN

The Contractor shall submit his design calculations supporting his chosen, planned and actual dredge side slopes. Such submission does not relieve the Contractor from the requirements of any other Clause having jurisdiction over such matters and contained within the Contract.

35.10.4.3 QUALITY CONTROL

Quality control for materials and workmanship shall be performed throughout the entire works, strictly following the requirements of this specification. Where nothing else is specified, samples shall be taken in accordance with the applicable British Standards.

35.10.4.4 DISPOSAL OF DREDGED MATERIAL

The Contractor shall be responsible for disposal of excavated or dredged material unsuitable for incorporation in the permanent Works and/or excess to requirements and shall obtain all permits and licenses to permit same. Such material may be disposed of offshore (subject to permits and licenses being obtained) but not within the Site or adjacent areas except where agreed with the Employer/Engineer. The Contractor shall dispose the dredged materials at the location as indicated in the environmental license. Where surveys show that excavated and dredged material has been placed or has accumulated within areas of the Site where the land was previously lower, the Contractor will be required to remove such material.

35.10.4.5 DREDGING TOLERANCES

Dredging shall be carried out to the levels and profiles required by the Contractor's Design or such notified modified by the Employer/Engineer to the Contractor in writing. No part of the finished dredging work shall, on completion, be higher than the specified dredged level or profiles.

Vertical finished tolerance –dredging shall be accomplished within 0.00m above and 0.50m below the design levels.

The horizontal tolerance shall be defined as 2.50m outwards from the theoretical dredge boundary lines.

If required by the Employer/Engineer, the Contractor shall propose to the Employer/Engineer's, and then satisfaction make good any over-excavated areas with such material and in such a manner accepted by the Employer/Engineer.

35.10.4.6 SIDE SLOPES

Side slopes shall be formed to profiles designed by the Contractor. The Contractor shall demonstrate to the satisfaction of the Employer/Engineer that the slopes to be provided in the various material types shall be stable under the construction loading, sequence methodology and final phase anticipated by the Contractor. Where dredged slopes are specified, the line of such slopes in cross section may be executed as a number of steps with a maximum height of 1.5m under the provisions that the steps do not cut the theoretical slope line and that no slope failure below the theoretical slope line will occur. Otherwise, the Contractor shall adapt the dredging method to the local conditions by decreasing to the step height, reduction of the dredging capacity, etc. The Contractor shall immediately inform the Employer of any deviations from the theoretical profile. Notwithstanding this all works and stability of the dredged slopes are at the liability of the Contractor.

Side slopes shall be at a stable gradient as determined by geotechnical analysis.

35.10.5 PILING WORKS

35.10.5.1 GENERAL REQUIREMENTS

These specifications cover the requirements for the materials, the installation and the realization of bored cast-in-place concrete piles with grouting at the base and driven piles (Concrete or Steel piles).

The piling works and design shall be in accordance with EN 1997 (based on BS 8004) or JTS 167-4-2012 or equivalent.

Two types of piles foundation can be proposed and quoted by the Contractor: driven piles or cast-in-place bored piles.

The net vertical pile capacity computed from the soil investigation report is used to determine the maximum test load in case of pile testing.

For the general requirements please refer to Chapter 4 of Section 5.

35.10.5.2 CONCRETE PILES

Refer to Chapter 4 of Section 5.

35.10.5.3 STEEL PILES

Piles are to be of tubular steel construction and of a suitable steel grade; all steel shall be capable of site welding as necessary.

- The specifications for offshore structural steel shall be established according to "EN10225" or "JTS 167-4-2012".
- Material certificates are required as specified in the applicable standard
- In the standard "EN10225" or "JTS 167-4-2012" the mechanical prop are described as well as its chemical composition. Note that the yield stress decreases with increasing thickness of the material. The calculations should take this into account.
- Some common steel parameters are shown in Table 35.10-1.

Elastic modulus	**Es = 210000 N/mm²**
Poisson's ratio	υs = 0.30
Density	ρs = 7850 kg/m³
coefficient of thermal expansion	αs = 12 x 1e-6 m/(m °C)

Table 35.10-1: Some properties of the standard steel

- Welding details determine fatigue design and execution drawings should include all necessary details to ensure that the expected lifetime can be attained. Special attention must be paid to post-weld treatments such as grinding, peening and others.

Grade of structural steel shall at least be S355 (characteristic yield stress > 345 MPa)

Coating

Sheet piles for permanent structures shall be sandblasted, cleaned and coated.
For the coating, the surface shall be prepared to classification Sa2½.

The corrosion protection shall be designed according JTJ 275- 2000.
The following classification shall be considered:

- Atmospheric exposure –C4
- Immersion in sea water –Im2 (incl. splash zone)

35.10.5.4 RAKER PILES

The Contractor shall carry out a piling template for the execution of raker piles which guarantees the inclination and tolerances.

For the jetty and dolphins must be considered raker piles for the horizontal loads.

35.10.5.5 PILE TESTS

The Contractor shall carry out a minimum of three working pile tests for each type of pile used.

The following type of pile must be considered:
- concrete piles onshore
- concrete piles in water
- steel piles onshore
- steel piles in water
- raker piles onshore
- raker piles in water.

The piles to be tested shall be to the approval of the Employer.

For the raker piles a pile testing in inclination must be considered.

35.10.5.6 DESIGN

Pile design shall be based on the available soil data. The Contractor shall submit a detailed design for the foundation to the Employer for approval.

Upon finalization of the Plant layout by the Contractor, a more detailed geotechnical investigation shall be carried out by the Contactor.

Information on the soil investigation of the Site is provided to the Bidder in the bidding document for information.

The pile foundations shall be calculated and executed in conformity to the latest international codes and/or other approved standards and codes of practice.

Furthermore, the ICE Specification for Piling and Embedded Retaining Walls (latest edition) shall be observed.

The calculations shall be made using finite element method.

The platform dimensions shall take into account of sufficient distance between pile tips to allow development of full resistance at the pile tip. In any case, the minimum center to center distance of the underground part of the piles shall be at least 3 times the maximum pile diameter.

Pile design shall take into account the presence of nearby structures that could lead to a reduction of bearing capacity, change of deformation behavior, additional horizontal forces and negative skin friction.

Mooring loads as well as earthquake loads are to be considered as short term loading conditions (possibility of undrained soil behavior).

Piles shall never enter the navigation channel, nor the mooring zone (including a 2m clearance between piles at sea bottom level and coal ships). Effect of scour around the piles shall be considered (in influence area of bow thrusters during emergency maneuvers) and taken into account in the design. If necessary, a scour protection will have to be designed.

The Contractor shall allow for a thickness of marine growth on the piles according to the appropriate standard.

If appropriate, all weak soil layers will be removed out of the pile after pile installation.

The organic check of the steel section, shall take corrosion effects into account.

35.10.6 CONCRETE WORKS

35.10.6.1 GENERAL

The purpose of this section is to provide the mandatory technical requirements for the goods or services provided by the Contractor. It briefly describes the scope of supply and details all requirements necessary for the execution of the Works.

During the execution of the Works, the Contractor shall as a minimum perform the engineering activities and execute the Detail Design Engineering for Concrete Structures.

The aim of this specification is to define and characterize the representative values of actions (Load Cases) that are relevant for the detail design of the reinforced and concrete structures of the project.

The concrete works shall be based on applicable approved codes and standards.

35.10.6.2 MATERIAL

35.10.6.2.1 CONCRETE

All materials used for concrete and reinforced concrete structures shall be of the best quality and free of defects likely to undermine the strength and shorten the service life of the works.

For more specific requirements please refer to Chapter 4 of Section 5. Specified compressive strengths are obtained for exposure to sea water and soil/environment aggressivity according the soil investigation report.

In general, the concrete for superstructures shall be a minimum Grade 30. The type of cement to be used shall satisfy the requirements of the relevant international and local Standards or equivalent.

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Contractor.

All aggregate and sand used in the production of concrete shall be thoroughly tested for silica alkaline reaction, flakiness, aggregate crushing value etc.

The design and execution of the Works shall consider a minimum crack development, the corrosion risks and the durability of the concrete and be based on the latest applicable approved codes and standards as listed in Chapter 4 of Section 5.

35.10.6.2.2 REINFORCING STEEL

Reinforcing steel used in reinforced concrete shall comply with BS 4449, BS 8666, BS 4483, JTS 151-2011 or equivalent.

All reinforcement shall be hammered free of scale, scraped and wire brushed free of all loose rust and after such treatment shall be within the margins allowed by the Standards. The reinforcing steel shall be free of oil, grease or preservative coatings.

The Contractor shall supply the Employer with the manufacturer's certificate stating the process of manufacture and a test sheet giving the results of each of the materials purchased and, when required, the chemical analysis and all tests as specified in the relevant standards.

In particular it shall be possible to derive the following data from the stress-deformation curves:

- ultimate tensile strength
- guaranteed yield stress
- permissible stress
- elongation.

Reinforcing bars shall be transported and stored so that they remain clean, straight, undamaged and free of corrosion, rust or scale.

Reinforcement shall be cut and/or bent in accordance with BS 8666 or equivalent standards.

Reinforcement shall be accurately fixed and secured against displacement in the position shown in the drawings by means of spacers, chairs or other supports in order to maintain the reinforcement in its correct position, within a tolerance of 3mm. For the distance between the bars (horizontal and vertical distances), the requirements of EN 1991 (based on BS 8110) or JTS 151-2011 or equivalent standards shall be observed.

Jointing of reinforcement bars by welding on site shall be avoided if possible, but where necessary the requirements of EN 1991 (based on BS 8110) or JTS 151-2011 or equivalent standards have to be observed.

Where reinforcement is to remain exposed to the weather for a prolonged period, a thick cement grout shall be applied to the bars.

Grinding of reinforcement

Reinforcement shall be grounded according to the requirements laid down in other parts of these specifications.

35.10.6.3 PHILOSOPHY

This note is intended to give some minimum requirements for the determination of the load cases and load cases combinations by identifying the compatible loads arrangements for both the Ultimate Limit State Design (ULS) and Serviceability Limit State Design (SLS).

35.10.7 STRUCTURAL STEEL WORKS

35.10.7.1 GENERAL

The aim of this specification is to define and characterize the representative values of actions (Load Cases) that are relevant for the detail design of the steel structures of the project.

The wording steel structure covers the steel construction for the Jetty top side facilities, buildings structures, conveyer system and related constructions (foundation of silos, cable-trays supporting structures, etc.).

This specification defines as well the material classification for each type of structure.

35.10.7.2 MATERIALS

In general, the material shall be new and free from defects and in accordance with the ASTM and or equivalent, except specified or approved otherwise.

All ferrous materials, their dimensions, forms, weights, tolerances, chemical and mechanical properties, shall be the best of their kind, complying with relevant international Standards.

For additional requirements please refer to Chapter 4 of Section 5.

35.10.8 MISCELLANEOUS EQUIPMENT

35.10.8.1 MOORING AND BERTHING

The Constructor has to furnish mooring and berthing structures with equipment needed for operational demands (e.g. ascending ladders, mooring bitts, etc.).

Fender constructions have to be dimensioned considering water levels, construction heights and design vessel dimensions.

35.10.8.2 FENDER TYPES

The main requirements for the design of the fender are as follows: The mooring and berthing loads on the main breasting dolphins shall be determined from the manufacturer’s c fenders, making due allowance for manufacturers of 10% tolerance. The influence of temperature (from 0 - 65°C) shall also be considered. The fenders shall be selected to absorb the maximum extreme berthing energy of the incoming vessels. The fender shall be designed to accommodate a range of NPG ships of capacities between as mentioned in the design base. The energy shall be calculated to BS 634 design of Fender systems: 2002” or JTS 144-1-2010 “Load Code for Harbor Engineering” using as mentioned in the DB.

The dolphins shall not be recessed at fender locations. The design shall demonstrate that, for abnormal impacts, vessels of the full design range can berth without the fender panel contacting the structure of the breasting dolphin or the vessel contacting the loading arms, the jetty structure or other jetty equipment.

All fenders shall be pre-compressed prior to installation. In addition, the fendering shall be tested in accordance with the recommendations of PIANC. The test press shall be computer controlled and the test results shall be obtained from a calibrated load cell system.

The rubber fenders shall be produced by a company with an adequate QA/QC system and certified ISO 9001.

Chains and fixings shall be designed to resist horizontal and vertical shear using a friction factor of 0.2. The factor of safety against any chain breaking shall be greater than 5.0. A 'weak-link', in the form of a shackle, shall be provided in the mooring chains to avoid damage to any fixings cast into the quay structure.

Cast-in items - galvanized or stainless steel items cast into concrete shall not be permitted to come into contact with steel reinforcement bars or other steel cast-in items. Holding-down bolts shall be cast in to the correct level ± 3mm and vertical and shall be adequately supported by templates and accurately positioned before the concrete is placed. Ducts shall be adequately restrained to resist movement.

The anchors shall be accurately placed by means of a template, to be supplied by the fender manufacturer.

35.10.8.3 EDGE BOLLARDS

Edge bollards that are positioned flush with the face of the quay wall have caused difficulties in handling heavy rope hawsers when the ship is lying close to the quay. Therefore, the face of the bollards must lie at least 0.15m behind the front face of the quay wall. The width of the head of a bollard may be taken as 0.50m. The bogies of modern harbor cranes may be assumed to be about 0.60 to 1.20m wide.

35.10.8.4 LADDERS

Cat ladders shall be provided for human access from small passenger launches to the top of the platform.

The ladders shall be made of stainless steel pipes that extend down to the deck of the berthed vessel.

35.10.8.5 SUPPLY AND DISPOSAL

The Contractor has to equip the jetty, mooring and berthing structures with supply and disposal facilities considering the demands of the unloading and power plant operations (e.g. coal transshipment, silos, converter systems etc.). Illumination of the jetty and quay has to satisfy operational standards and according to the BNBC.

Rain water on the jetty is to be collected. Coal polluted water is not allowed to get into river. The Constructor has to consider this for the construction of the jetty.

For other equipment please refer to Chapter 4 of Section 5.

35.10.8.6 SAFETY

Safety equipment has to satisfy current standards.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 36 – WATER SUPPLY

CONTENTS

36 WATER SUPPLY

36.1 WATER DEMAND OF THE POWER PLANT

The main raw water source is from the nearby river. It is the responsibility of the Contractor to investigate and analyze the river source in order to design the water supply to the power plant. A sufficient system redundancy shall be designed for the entire water supply system, for example all the important equipment shall be designed to 2 x 100% redundancy capacity unless otherwise specified. Refer drawing nos. 10-PM-PAY-14, 10-PM-PAY-15, 10-PM-PAY-21 and 10-PM-PAY-17, 10-PM-PAY-10 in Section 5, Attachment B4.

According to international practice, a 110% capacity of Cooling Water (CW) pump shall be adopted.

36.2 CIRCULATING WATER SUPPLY AND DRAINAGE SYSTEM

For the unit capacity of 2 x 660MW, a recirculating cooling water system with cooling tower shall be considered.

Recirculating cooling system flow shall be as follows:
CW pump → CW pressure water supply pipe → condenser & auxiliary → CW water recycle pipe → cooling tower → CW recycle ditch → trash rack → bar screen → CW water intake tank → CW pump

Contractor is required to optimize CW flow, capacity and type of cooling tower, size of condenser and size of CW pipeline. Contractor shall also give detailed comparison and selection of the type of cooling tower, for example between natural draft cooling tower or force draft cooling tower from economic and operational perspective.

A 110% capacity of CW pump shall be required, so 2x CW pumps are in operation and 1x CW pump is in standby for each 660MW unit.

Considering the situation of general layout, each 660MW unit shall own a CW pump house which will be in connection with the intake bay. At the cooling water intake bay near the river, raw water lift pump shall be designed to 2x in operation and 1x in standby. Flow passage shall be wet well structure style according to the suction requirements of the flow of the CW pump. Given factors such as maintenance, project investment and so on, the CW pump house shall be indoor arrangement and adjacent to the cooling tower. The intake bay shall be outdoors arrangement.

Each CW pump house shall have 3 x CW pump (2w1s) and 2 discharge pump (1w1s).

Each CW pump shall have a dedicated intake room and flow passage.

Within intake bay constructs 3 flow passages and each of them shall have a steel gate and a trash racks.

The CW pump house shall have an E.O.T crane and the intake bay shall have an E.O.T crane too.

The CW pump house shall also contain power distribution room and maintenance area.

The circulating pump house shall be adjacent to the cooling tower. Outlet of each CW pump shall be welded steel pipe. These 3 branch pipes combine as a main pipe and lead to the 660MW unit condenser. Both cooling water main inlet and outlet pipe for condenser are welded steel.

Considering the construction conditions, local specific situation and the short distance between cooling tower and condenser, the circulating cooling water pipe shall be welded steel pipe. A cathodic protection for the CW pipe is required.

Each CW pump flow passage passes through reinforced concrete trench connecting cooling tower basin and CW pump house. The cooling water is supposed to run on gravity in this trench.

36.3 COOLING TOWER

The cooling water flow for auxiliary is much less than the condenser (5% of the condenser cooling water). Base on this situation, the cooling water coming back from auxiliary shall go to the cooling tower water basin directly instead of going into cooling tower.

Contractor is required to design redundancy for the cooling tower. In order to satisfy the requirement for maintenance and fire fighting, access stairway(s) shall be constructed adjacent to the cooling tower structure.

36.4 PRETREATMENT OF MAKE UP WATER FOR COOLING TOWER

Make up water for cooling tower is taken from the Andharmanik River which on the south side of the power plant. Considering the suspended sediment concentration could be higher during the flood period, pretreatments such as coagulation and clarification are required. The suspended sediment concentration of the outlet after pretreatment should not exceed 20 mg/l.

The make up water pretreatment area shall be adjacent to the cooling tower, comprise of 2x 100% flocculation setting tank, dosing room and power distribution room, sludge tank, etc. Outlet water from flocculation setting tank shall go to cooling tower basin running on gravity.

36.5 PLANT FRESHWATER SUPPLY SYSTEM

Freshwater in the power plant are mainly used for living, entire plant firefighting, boiler feedwater, service water, landscaping and road sprinkling and vehicle washing, wash water for all systems, dust prevention, private use in water purification station, etc. These facilities have different water use requirements that can be categorized into two types: Category I is fresh water of high quality requiring coagulation and clarification or coagulation and clarification filtration; the discharged sewage and wastewater may be recycled and reused after advanced treatment. Category II does not have high requirement on water quality and may be the reusing water after advanced treatment discharged by Category I water using facilities; the discharged water may also be recycled and reused for water circulation after advanced treatment.

Based on the characteristic of water use and operation process in the plant, water purification station is provided to perform coagulation and clarification or coagulation and clarification filtration treatment on raw water inflow for Category I water use including domestic water supply system, firefighting water supply system, chemical water treatment process water supply system and other processes. Reusing water system is also designed and sources are sewage and wastewater after advanced treatment and reaching standard of water use; insufficient part is provided from raw water inflow in water purification station or clarified water.

36.5.1 FRESHWATER SUPPLY REQUIREMENT

The freshwater required shall be supplied from the river near the plant site. Raw water lift pump shall be arranged at makeup water pump house. River water shall be sent to water purification station raw water reservoir in power plant via steel pipe after pressure boosting by raw water lift pump. The raw water lift pump shall be designed to 2x in operation and 1x in standby.

As the raw water area is in sea water tidal reach and to avoid intake of salt water, raw water reservoir shall be designed in water purification station and the volume could be adjustable subject to Contractor investigation and optimization.

36.5.2 WATER PURIFICATION STATION

Raw water shall be treated with clarification, filtration and disinfection according to water quality requirements in different utilization points, to be used for chemical water, service water, potable water, firefighting water, and etc. All the important equipment shall be designed to 2x 100% redundancy capacity unless otherwise specified.

Structures of purification facility include 1 complex pump house containing fire pump room, dosing room and switchboard room; 2 raw water reservoirs; 2 mechanical accelerated clarifiers; 2 sand filter; 2 service fire water tanks; 2 chemical water tanks; 1 potable water; 1 recycle water tank; 1 sludge tank; 2 reuse water pool; and relevant water pumps, etc.

36.6 SERVICE AND POTABLE WATER SUPPLY SYSTEM

Service and potable water supply system mainly provides industrial water, raw water for chemical water treatment, water for wharf area, domestic water, firefighting water, desulfurization water and wash water for coal handling system.

Pressure feedwater piping includes domestic water supply pipe, fire main, chemical unboiled water pipe, industrial water pipe, high-pressure reusing water supply pipe, low-pressure reusing water supply pipe, landscaping flush water supply pipe and other miscellaneous piping.

Potable water is sent to independent domestic water supply pipe after chlorination and pressure boosting by potable water pump to provide domestic water for users in power plant. Frequency control is adopted to perform startup and stop of potable water pump and adjust water flow; potable water pipe forms ring net in the power plant to guarantee reliable potable water supply.

36.7 DRAINAGE SYSTEM

Domestic sewage and rainwater shall be collected in different systems for the power plant and designed according to the entire plant water management and water balance. Based on wastewater quality and treatment characteristics, independent drainage system shall be provided accordingly, i.e. domestic sewage system, industrial wastewater system, coal contained wastewater drainage system, rainwater drainage system and entire plant oil contaminated water drainage system, etc.

Coal contained wastewater:
Coal contained wastewater shall be collected from plant site followed by pre-sedimentation and reused after recovery treatment. The two coal sedimentation pools shall be in reinforced concrete structure.

Emergency oil drainage and oil contaminated water of entire plant:
Emergency oil sump shall be provided for oil discharge from transformer and turbine oil tank in case of accident. Oil contaminated water of entire plant shall be sent to the oil contaminated water collecting pit and pumped to oily water treatment equipment; when the treatment is reaching acceptable discharge standard, the water shall be recycled to industrial wastewater treatment station for secondary treatment and utilization. Water output after the treatment shall be for reusing water in water system.

Rainwater in plant site:
Storm water drainage ditch shall be provided on the sides of all roads and cement floor in the plant. In certain low-lying area pipe and inspection manhole shall be considered. Rainwater on land surface and road shall be drained to rainwater pipe through drainage ditch. Rainwater could be drained to local river course through gravity flow subject to local regulations.

Domestic sewage:
Domestic sewage shall be brought together to regulating reservoir in the domestic sewage treatment station by gravity flow via domestic wastewater sewer and boosted by sewage pump for secondary biological chemical treatment; the treated water output is discharged into reusing water pool after reaching acceptable discharge standard and shall be used for plant site landscaping and road sprinkling after pressure boosting.

Domestic sewage treatment equipment mainly treat and process sanitary wastewater in the plant, washing wastewater and domestic wastewater from canteen and shower room. Water quality of the output shall meet local emission standard and / or acceptable international standard.

36.8 REUSING WATER SYSTEM

The water source for reusing water system shall be the output water from industrial wastewater treatment station after reaching acceptable standard. Under normal circumstances, the water shall be used as wash water of coal handling system, desulfurization water and dust conditioning water in coal handling system; insufficient reuse water shall be supplemented from water purification station.

Reusing water pool (underground type) shall be arranged inside or near water purification station, as two reinforced concrete structure pools.

36.9 CLOSED-CIRCUIT COOLING WATER SYSTEM

Except that the closed cooling water heat exchanger, water ring vacuum pump cooler use the secondary cooling water system for circulating water cooling, all the rest equipments use closed-circuit cooling water, which could not only reduce the pollution and erosion to the equipments and make the equipments have higher heat transfer efficiency, but also prevent channel blockage, improve the operation safety and reliability of the main and auxiliary equipments and greatly reduce the workload of equipment maintenance. The system has two closed-circuit cooling water pumps of 100% capacity (one for service and one for backup) and the water-water heat exchanger of 2x100% capacity.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 37 – SAFETY SYSTEMS

CONTENTS

37. SAFETY SYSTEMS

The Contractor shall design the Plant to include safety features to protect the Plant and the operating staff. Work areas shall be properly lit and arranged to provide sufficient access and clearance for operations and maintenance including equipment disassembly/removal. The equipment including piping, valves and electrical gear shall be properly tagged. Safety signs with directions to exits shall be provided. All surfaces accessible by platforms, stairs, caged ladders and floors shall have surface temperatures limited to 60°C under all ambient and operating conditions. Hazardous areas shall be classified. Safety showers shall be provided near the battery room and all chemical unloading areas. Entrances from ladders shall be fitted with self-closing safety gates. Open gearing, exposed belts or chain drives and similar arrangements shall not be used. Only enclosed or permanently guarded couplings and drives shall be used.

Safety-Health and Environment (SHE) and Security

The Contractor has to develop a SHE policy in accordance to the contract requirements, according to the local rules, laws and regulations and according to international practices.

The SHE policy shall contain at least:

- SHE in Construction and Commissioning
- Environment Management

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 38 – ERECTION, TESTING & COMMISSIONING AND DEFECT LIABILITY PERIOD (DLP)

CONTENTS

38 ERECTION, TESTING AND COMMISSIONING

38.1 ERECTION WORKS

38.1.1 GENERAL

38.1.1.1 WORK, SCHEDULES AND COORDINATION

It shall be the responsibility of the Contractor to engage the proper trades for carrying on all phases of the works harmoniously. The Contractor may sublet any portion of the Works, as may be required. However, the Subcontractor shall be subject to the written approval of the Employer, prior to performance of any work by Subcontractor.

It shall be the responsibility of the Contractor to co-ordinate his installation activities with the materials delivery schedule of his subcontractor and the construction program so that a smooth and harmonious schedule may be maintained. It shall also be the responsibility of the Contractor to co-ordinate his installation activities with his subcontractors. The Contractor shall be responsible for any work done by his Subcontractor.

38.1.1.2 ACCEPTABLE AND UNACCEPTABLE WORK

All poor, defective or condemned work including work condemned because of interference with other work shall be remedied at the expense of the Contractor and he shall not be reimbursed for any expense in connection with such repairs. The Contractor shall be responsible for the care, safety and maintenance of all the materials until acceptance of the installed materials by the Employer. The Employer will not pay for the removal or replacement of damaged or faulty material after it has been installed or if damaged prior to installation. The Employer shall make the final decision as to whether Work is acceptable or not.

38.1.2 EQUIPMENT

38.1.2.1 FOUNDATION

The Contractor shall not place equipment bases on foundation pads and floors before the top surface of the foundation pad or floor area, where base is to be mounted, has been properly chipped off, roughened and cleaned for grouting.

The Contractor shall chip away at least 10 mm of foundation surface to provide a good bonding surface for grouting. Roughing of foundation surface shall be acceptable to equipment manufacturer’s representative, prior to grouting of equipment.

38.1.2.2 ROTATING EQUIPMENT

The Contractor shall be responsible for the correct setting, mounting and alignment of all equipment erected by him and shall maintain and submit to Employer written records of alignment reading. For 200 kW and larger rotating equipment the Employer will inspect the completion of each of the shimming, grouting, alignment and dowelling work. The Contractor shall not proceed with the subsequent work and operation of the equipment until each inspection is completed.

Alignment of rotating equipment and its motor drive shall include furnishing of anchoring devices of equipment and drives to base plates where required. This shall also include any special balancing of rotating elements of equipment due to faulty balancing in manufacturer's shops, checking and adjusting of bearings, setting of proper clearances, establishing the specified rotor to stator air gap for motors, realigning of all equipment which is shipped as a complete unit from the shop and rechecking of all alignment before start up. If equipment is realigned dowel holes shall be reamed again and the dowels reinstalled. Equipment shall not be operated without the dowels firmly set in place. Tolerance on initial shaft alignment and realignment of the above work shall be within the manufacture's specified limits. The Contractor shall drill equipment baseplates for drives where required.

38.1.2.3 PRESERVATIVES

The Contractor shall be responsible during the installation process for the complete removal of all preservatives applied to power plant equipment components which are incompatible with the system path and auxiliary systems to which they are applied.

The Contractor shall provide any and all equipment, mineral spirits, or solvents required to completely remove all preservatives from the equipment parts.

The Contractor shall install components immediately after removal of preservatives. If this cannot be done, the Contractor shall apply a light duty preservative to the components which is compatible with the equipment. Light duty preservatives to be used shall be in strict accordance with the manufacturer's recommendations.

38.1.2.4 CLEANING

In each case the methods of cleaning and/or flushing shall be as approved by the equipment manufacturer and as reviewed by the Employer.

Oil and gland steam piping other than stainless steel oil piping furnished by the Contractor shall be pickled in the shop. All piping shall be thoroughly cleaned by the Contractor before it is installed and all lines shall also be thoroughly cleaned out after erection so as to remove any possibility of dirt or any the foreign material being left in the system when the plant equipment is placed in operation. The method of cleaning piping shall be subject to review and acceptance by the equipment manufacturer and the Employer. Any temporary piping and facilities used in conjunction with cleaning out the piping shall be furnished by the Contractor.

38.1.2.5 HEATING AND BLANKETING

The Contractor shall supply, erect and maintain necessary heating equipment to keep electrical equipment free from moisture, in accordance with manufacturer's recommendations, for as long as necessary.

The Contractor shall maintain a nitrogen blanket system or other means in all heat exchangers as necessary and provide all maintenance operation and testing to ensure compliance with manufacturer's recommendations for storage and handling.

38.1.3 ERECTION WORK

38.1.3.1 EQUIPMENT AND ACCESSORIES

The Work shall be in accordance with the Employer's Requirement and all work shall be done in orderly and workmanlike manner. It shall present a neat appearance when completed and shall conform to the best modern engineering practice for the class or work, notwithstanding any omission in the Drawings and Employer's Requirement.

Each piece of equipment shall be located, as shown on the drawings and shall be erected complete in all respects unless exceptions are specifically noted herein.

The Works shall include the assembly and alignment of components where equipment is shipped unassembled or knocked down, or where the components are shipped separately.

The Works shall include the erection of all piping, wiring, instruments, controls, drivers and other components and accessories furnished with the equipment, unless otherwise indicated in the Employer's Requirement or on the drawings.

The erection of equipment shall be in accordance with the recommendations of the equipment manufactures.

During the course of erection, the Employer shall have full access at all times for inspecting work progress and witnessing checks for accuracy as may be required.

Equipment shall be installed, strictly in accordance with dimensions or drawing, with minimum tolerances, particularly with respect to level of concrete floors, clearances, welding thicknesses etc.

The Contractor shall provide all erection check lists for the works, copies of which are to be provided to the Employer after signing at each stage of inspection.

38.1.3.2 TEST FOR CIVIL WORKS

Tests for Civil Work, including but not limited to the following:

- Concrete Works
- Earth Works
- Piling.

The Test shall be executed by the Contractor according to the requirement in the related Employer's Requirement for each Civil Works.

38.1.4 ADJUSTMENT AND CORRECTION WORK

At the completion of erection of each system, the Contractor shall perform all the necessary tests, including hydrostatic tests, commissioning tests and performance tests.

The Works shall be subject to inspection and acceptance by the Employer.

The Contractor shall make such adjustments and do such other work as may be required by the Employer to place each piece of equipment erected by Contractor in proper operating condition ready for service. This adjustment and correction work shall be done by the Contractor without additional cost to the Employer.

Any correctional work required to be done by the Contactor in order to install the equipment properly and which is due to the manufacturers' faulty shop work or design shall be reported by the Contractor to the Employer and shall be done by Contractor only after review by the Employer of the correctional procedures. This is no way shall effect the warranty on the equipment.

38.1.5 SUPERVISION AND MANUFACTURER'S REPRESENTATIVES

38.1.5.1 MANUFACTURER'S REPRESENTATIVES

The Contractor shall furnish guidance from manufacturer's technical representative for erection and commissioning of the equipment under this Contract. A manufacturer's representative shall be included for each major equipment.

If the services of any additional manufacturer's representatives are required by the Contractor, the total cost of such services shall be at the expense of the Contractor. All equipment shall be unloaded, stored, protected, erected, set, and aligned in complete accordance with the manufacturer's instruction books or directives. All rework or additional work required due to non-compliance with manufacturer's instructions shall be at the expense of the Contractor and no claims shall be made by the Contractor for lack of understanding of the complete Scope of Work.

The Contractor shall identify his Site personnel including Erection Supervisors, Start-up Supervisors and Performance Test Supervisors. Such personnel shall be subject to approval by the Employer.

38.1.5.2 RECORDS AND REPORTS

The Contractor shall maintain a Site inspection record of Quality Assurance /Quality Control.

The Contractor's representative at Site shall maintain a daily log-book consisting of:

- Employer's instructions
- Employer's complaints
- Schedule of important events of the day
- Record of disagreements.

38.1.5.3 EMPLOYER'S INSPECTOR

The Employer will have his inspection personnel at Site, to inspect the work done by the Contractor.

38.1.6 TEMPORARY FACILITIES AND AREA

38.1.6.1 CONSTRUCTION FACILITY

The Contractor shall provide the construction facilities, consisting of his site office and Employer's and Engineer's site office, workshop warehouse, laydown areas, fenced storage areas, toilet, canteen, welfare facilities, personal protective equipment, site ambulance, car parks, fence and gates, as required.

As a minimum, the Contractor shall man his office with responsible personnel to match the Employer's working hours.

38.1.6.2 SECURITY AND DRAINAGE

The Contractor shall be responsible for the security of his own storage areas, construction area and the Contractor's temporary facilities.

The Contractor shall ensure proper drainage of the storage area to prevent standing water for extended periods.

38.1.6.3 RIVER AND LAND ACCESS AND CONSTRUCTION VEHICLE PARKING

The Contractor shall ensure timely dredging of river access channel and provision of all necessary unloading facilities for equipment arriving by river.

Any roads or access areas which the Contractor deems necessary for access to his work shall be constructed and maintained by the Contractor at his own expense. The Contractor shall supply and maintain all required parking facilities.

38.1.6.4 TEMPORARY WORK

38.1.6.4.1 REMOVAL OF SOIL

All removal or disposal soil and debris or obstruction shall be removed to outside area. Disposal area shall be responsible by the Contractor. The Contractor shall, when directed to do so by the Employer, restore at his expense any site area to its original condition that is altered or damaged.

38.1.6.4.2 CONSTRUCTION WATER AND ELECTRICITY SUPPLY AND TELECOMMUNICATION FACILITIES

The Contractor shall provide and maintain the Construction water system to the necessary position in the Site for the Works. The equipment and piping of the temporary water supply system shall not obstruct the Works and the access ways. The Contractor shall also provide fresh water and drinking water.

The water supply source shall be decided in consideration of his capacity, the necessary quantity for the Works and no bad environmental effects around the source.

The Contractor shall provide and maintain construction electricity system to the necessary position in the Site for the Works including all temporary works.

All the electricity and water to be used for Works whether it is inside or outside of the Site shall be paid by the Contractor.

The Contractor shall provide and maintain the temporary telecommunication facilities in the site office for the Contractor and for the Employer and the Engineer. The Contractor shall provide sanitary and sewage disposal system by his own cost.

38.1.6.4.3 TEMPORARY STAGING, SCAFFOLDING, ETC.

The Contractor shall provide and maintain the temporary staging and scaffolding at all of the necessary locations for the Works in consideration of the material transportation, construction machine access, human access and safety. The temporary staging and scaffolding shall not cause damage to any permanent structures. The Contractor shall calculate and confirm their safety, and select the suitable materials and construction method prior to setting them, The Contractor shall provide the additional supports, or replace their unsuitable materials or locations in case that they are deemed to cause damage to the permanent structures, to have lack of safety by using or instructed by the Employer.

The Contractor shall remove all the materials for the staging and scaffolding when they are not necessary to be used for the Works. The connection materials to the permanent structure shall not be remained after removal of the staging and scaffolding. The holes or damages shall be repaired after removal of the connection materials if any. The Contractor shall not remain all of the temporary materials in the Site, unless otherwise directed by the Employer.

The Contractor shall furnish all hoisting, rigging cables, slings and other construction equipment (regardless of size and type) and supplies required for unloading, assembly and erection of equipment to be erected by the Contractor. Attachments to building steel for hoisting and rigging shall be reviewed by the Employer.

The Contractor shall erect all temporary barricades to isolate the block under construction and commission that may be required as approved by the Employer. All such barricades shall be arranged so as to ensure the safety of the workmen and passers-by. The Contractor shall remove such protection at the completion of the Works.

38.1.6.4.4 TEMPORARY CONSTRUCTION ROAD

The Contractor shall provide and maintain the temporary construction road necessary for the Works. The temporary drainage system shall be provided and maintained during the Works. The permanent road shall not be used as temporary construction road. All materials debris or obstruction of the temporary construction road and drainage system shall be cleared from the site to the satisfaction of the Employer when they are not necessary to be used for the Works.

Temporary construction road may be re-routed to avoid interference according to the progress of the construction works. The Contractor shall provide plan for temporary construction road through the construction period for to the Employer at the initial stage of the construction works.

38.1.6.4.5 TEMPORARY LATRINES AND ABLUTIONS

The temporary toilets and ablutions shall be provided for the use of the Contractor and his subcontractors.

The Contractor shall also include in his Contract the disposal of the sewage resulting from all temporary toilet and ablution facilities.

38.2 START-UP AND TESTING

38.2.1 START-UP ACTIVITIES

Start-up activities shall be performed by a start-up team lead by and consisting of Contractor’s Personnel from various disciplines (Start-up Team). Employer’s Personnel may be made available to operate Plant under Contractor’s direction. If the Employer assigns the relevant Employer’s Personnel to participate in these start-up activities, those Employer’s Personnel shall be integrated into the Start-up Team. The following outlines the responsibilities of the Start-up Team:

1. A first revision of the start-up plan shall be submitted by the Contractor to the Employer for review at least ninety (90) days prior to the initiation of the start-up

work. The Employer will review the startup plan and provide comments to the Contractor. A mutually acceptable start-up plan shall be implemented.

2. Prepare and maintain a start-up schedule for the Project covering major milestone dates and reflecting the Plant and its corresponding systems/sub-systems to be started.
3. Prepare three-week look ahead and 'break-out' schedules for activities as necessary to properly plan and coordinate all required activities.
4. Prepare overall start-up, tagging procedures, and other documentation such as permit-to-work as required during the phase.
5. Coordinate and direct Subcontractor's activities during start-up.
6. Review all Contractor's construction test and check off documentation and where required have additional tests performed.
7. Direct Contractor's Personnel in final instrumentation or equipment check offs, calibrations, and adjustments during preoperational tests.
8. Perform and coordinate all start-up, testing, and commissioning activities in accordance with the Contract.
9. Operate and coordinate operation and maintenance of the Plant in accordance with the Contract.
10. Coordinate start-up activities with the Engineer and the relevant Employer's Personnel assigned to the Start-up Team.
11. Develop punch lists of work to be completed and assure the Works are done and completed by the appropriate party.
12. Develop all documentation regarding start-up activities for presentation to the Employer.
13. Provide load profiles for electricity, demineralised water fuel oil, and coal as required by the Employer.
14. Develop procedures described in sub-section 38.3 (Test on Completion) and implement the requirements of Tests on Completion and provide the documentation according to those procedures.
15. Develop steam blow and chemical cleaning procedures.

The start-up engineer of the Contractor shall prepare start-up packages pertaining to the Plant and its corresponding system/sub-systems. Those start-up packages shall serve to document to the Employer and Contractor the scope of the work under sub-section 38.2.1 [Start-up Activities]. The start-up packages shall include the following documents in relation to the Plant and its corresponding systems/sub-systems:

1. Definition of their scope.
2. Marked up P&ID's indicating their boundary included in the package.
3. Lists of equipment, components, valves, appurtenances included.
4. Signoff sheets for construction, startup, operators, and the Employer's Personnel for items including but not limited to rotational check on monitors, system walk downs, alignment checks, hydro tests.
5. Maintenance logs and other data associated with equipment maintenance performed during storage, installation, and commissioning activities.
6. Data sheets for all component calibrations, tests and inspections.

7. List of exceptions (to be addressed after startup).

38.2.2 PHASES OF START-UP

Mechanical Completion Activities:
This phase comprises the activities that the Contractor’s construction team shall carry out to assure that the Plant and its corresponding systems/sub-systems are erected and ready for release to the Start-up Team. Mechanical completion activities shall mean the Plant and its corresponding systems/sub-systems have been erected in accordance with the Contract to permit pre-commissioning, commissioning and start-up operations.

At the start of the mechanical completion activities, there shall be a shift in primary emphasis and responsibility from the Contractor’s construction team to that of Start-up Team. Incomplete works and deficiencies, if any, shall be identified with the declaration of start of the mechanical completion activities. Any completed Plant and its corresponding systems/sub-systems may be agreed between the Contractor and the Employer to be mechanically complete independently of the status of the remainder of the work subject to the requirements of the Contract.

Check-offs for the Plant shall be conducted by the Contractor’s construction team and verified by members of the Start-up Team. Check-offs shall include review of reports and test results produced by the Contractor’s Personnel and Subcontractors. Those reports and test results include but not limited to pressure tests, electrical resistance measurements, continuity checks, instrument and device calibrations, rotational direction checks, and extended driver run tests to assure that each item independently complies with the Contract.

Detailed inspections shall be made to determine that features affected by flow direction (such as meters) are properly oriented; facilities for bypassing, blocking, and blinding are properly located; temporary blinds and other provisions required only for Test on Completion shall have been removed; temporary startup strainers and any other mechanical condition which may delay or complicate start-up have been properly accommodated.

A final turnover equipment walk down check shall be conducted by the Contractor’s construction team with Start-up Team and Employer’s Personnel involvement. It shall be a line-by-line, feature-by-feature check of the installation of the Plant against the flow sheets and thoroughness shall be essential to minimize difficulties and delays to Tests on Completion. Such checks shall be conducted prior to mechanical completion so any discrepancies uncovered may be corrected by the construction team.

Notice of completion of the mechanical completion activities by the Contractor informing the Start-up Team that pre-commissioning operations can commence shall be formally sent to the Engineer and copied to the Employer. This formal notice shall include the results of all executed tests required for mechanical completion activities.

Daily meetings chaired by the Engineer for mechanical completion activities will be held between the Contractor and Employer's Personnel to ensure proper coordination of all activities.

Pre-commissioning:
Daily meetings chaired by the Engineer for pre-commissioning activities will be held between the Contractor and Employer's Personnel to ensure proper coordination of all activities.

Pre-commissioning shall comprise the activities that the Start-up Team carries out to prepare the Plant and its corresponding systems/sub-systems for an integrated Plant start-up. These activities, which include pre-operational testing, chemical cleaning and steam blow, shall generally commence shortly after a Plant and its corresponding systems/sub-systems are declared mechanically complete and shall be completed prior to initial power energization, of the Plant and its corresponding systems/sub-systems, and steam development operations. Pre-commissioning shall include motor and air valve calibrations, loop and function checks, final system clean up and check, driven equipment run-ins, flushing, purging, and energizing equipment on permanent power.

The Start-up Team for pre-commissioning activities shall include the Contractor's Personnel from construction, testing, operations and Employer's Personnel, depending on the specific responsibilities identified for each group during the pre-commissioning activities. Completion of pre-commissioning activities shall be the responsibility of the Start-up Team. Employer's Personnel may be made available for pre-commissioning activities under Contractor's direction.

Where required, flushing of the process equipment and piping with water, demineralized water or oil, and air blowing systems to remove dirt, welding slag, and other construction debris shall be completed by Start-Up Team depending on system flushing methodology.

Motors and prime movers shall be initially uncoupled during run-ins. The driven equipment run-ins shall be performed by the Start-up Team as part of pre-commissioning. During these run-ins, manufacturers' recommendations shall be closely followed and all possible adjustments of alarms, controls, and auxiliary equipment shall be completed.

Upon successful completion of start-up for each Plant and its corresponding systems/sub-systems, tests verifying their operability in accordance with the Contract shall be documented by the Start-up Team. This successful completion and corresponding documentation are to allow the Employer to verify the performance and acceptance of Plant and its corresponding systems/sub-systems prior to final overall operability and reliability runs.

Chemical Cleaning:
The Contractor shall perform pre-boiler and boiler chemical cleaning operations. The Works to be performed shall include cleaning pre-boiler systems and feedwater heater shells; installing temporary piping and equipment; providing supervision and personnel to install and

remove piping; making repairs; removing, cleaning and replacing strainers; and removing temporary piping and equipment after completion of pre-boiler and boiler cleaning operation.

The pre-boiler chemical cleaning shall be a continuous, around-the-clock operation until completion. Temporary piping and equipment installed to support this activity shall be completely removed after completing the chemical cleaning. Proper disposal of all chemicals used in the chemical cleaning operation shall be the responsibility of the Contractor.

A complete chemical cleaning procedure, including requirements for pre-boiler and boiler cleaning, shall be prepared by the Contractor and submitted to the Employer and the Engineer in accordance with the Contract.

The proposed boiler chemical cleaning procedure shall have been reviewed and approved by the boiler manufacturer and submitted to the Employer and the Engineer in accordance with the Contract.

Steam Blow:
The Contractor shall perform steam blow operations for high energy steam piping. A complete detailed procedure shall be developed and documented by the Contractor in accordance with the recommendations of the boiler manufacturer, the turbine generator manufacturer and codes.

This procedure shall be submitted to the Employer and the Engineer in accordance with the Contract for review.

Temporary piping system used for steam blow service shall be routed so that the discharge point is away from surrounding facilities and supported with due regard for the maximum forces which may be developed during such operations.

The Contractor shall ensure that noise levels generated during steam blow shall not exceed regulatory limits at the Site perimeter. Contractor shall manage the local community at the vicinity of the Site which may be affected by or in connection to those noise issues. The Contractor shall make his own arrangement for auxiliary steam to be used for steam blowing at his own cost.

The high energy steam piping that includes main steam lines, hot and cold reheat steam lines, Auxiliary steam system piping, and all main turbine seal steam lines, shall be blown with steam until all visible signs of mill scale, sand, rust, and other foreign substances are blown free.

Cover plates and internals for the main steam stop valves, reheat stop and intercept valves, and flow measurement nozzles or orifices shall be removed and blanking fixtures, temporary cover plates, silencers, temporary vent and drain piping, and temporary hangers and braces as required to make the systems safe during the blowing operation shall be furnished and installed by the Contractor.

All miscellaneous operations, such as removing check valve disks, shall be performed by the Contractor.

Polished test plates or bars of brass or mild steel (target plates) shall be furnished and installed on the outlet of the blowing pipe.

The target bars design and method of holding the target bars in the steam path shall be of a design suitable for the service.

These test plates shall be inspected after each blow to determine if the line is clean. The blowing operation shall continue until the turbine manufacturer's erection supervisor and/or the Employer accepts the system as clean.

After blowing, all temporary blanking fixtures, cover plates, vent and drain piping, valves, hangers, and braces shall be removed; and the strainers, valve internals, and cover plates shall be reinstalled by the Contractor.

After blowing, the piping system, strainers, and valves shall be restored to a state of readiness for plant operation. All temporary equipment shall be removed and stored or disposed of.

Any structures discoloured by the blowing operation shall be cleaned and restored to their original condition.

Compressed air blowing or high velocity water washing of the high energy piping is not an acceptable alternative to steam blow cleaning of the piping.

The steam blow configurations and cleaning acceptance criteria are described below. The actual configuration shall be designed by the Contractor to achieve the required cleaning ratio.

1. **Main Steam**
   The main steam blow shall be accomplished by supplying steam from the boiler, through the superheaters, through the main steam piping, through the temporary piping, and then to atmosphere.

2. **Cold Reheat**
   The cold reheat steam blow shall be accomplished by supplying steam from the boiler, through the temporary piping, through a bypass line and the cold reheat line (blind flanged to prevent steam from entering the turbine), and then to atmosphere.

3. **Hot Reheat (as applicable)**
   The hot reheat steam blow shall be accomplished by supplying steam from the boiler, through the temporary piping, through the reheater, through the hot reheat piping, and then to atmosphere.

4. **Intermediate-Pressure Turbine Bypass (as applicable)**

The intermediate-pressure turbine bypass steam blow shall be accomplished by supplying steam from the boiler, through the temporary piping, through the intermediate-pressure turbine bypass piping, and then to atmosphere.

5. **Acceptance Criteria**

The following criteria shall be considered the minimum criteria for acceptance of successful steam blowing of a pipeline judging from the target plate condition after each blow:

i. A cleaning ratio of not less than 1.2 shall be met to ensure adequate cleaning of the pipe.
ii. There shall be no raised pits or indentations on the target plate.
iii. No strikes have a diameter bigger than 0.4mm.
iv. The number of strikes with diameters between 0.2 and 0.4mm do not exceed 10 per dm2 (1dm2=0.01m2)The length of blow-through piping between the outlet of the system being purged and the target plate(s) shall be such that an even distribution of particulate matter at the target plate(s) is achieved.
v. The sizes of the target plates and the maximum steam velocity for blow-through, and the limits of acceptable target plate damage shall be in accordance with the steam turbine manufacturer's requirements.
vi. A succession of target plates must demonstrate a progressive improvement in system cleanliness. The system shall be declared acceptably clean when the following conditions have been met:
   a) Two successive target plates show no damage outside the limits provided by the steam turbine manufacturer.
   b) Following a 12 hour cooling of the system, two further target plates show no damage outside the limits provided by the steam turbine manufacturer.
   c) The disturbance factor within the pipework shall be at least 1.2.
   d) Disturbance Factor = $(Mp^2 \times Vp) / (Mc^2 \times Vc)$

Where:

Mp and Mc	steam mass flows in the piping at the target plate(s) under purging and M.C.R. conditions, respectively
Vp and Vc	steam specific volumes in the piping at the target plate(s) under purging and M.C.R. conditions, respectively

If the Contractor has different steam blowing procedures, the procedures shall be submitted by the Contractor for review to the Employer and the Engineer in accordance with the Contract.

Pre-operational Testing and Start-up:
The Contractor shall render all services and perform all work required to place each item of equipment, including all auxiliaries and piping, in operating condition.

The Employer may provide Employer's Personnel for the operation of the Plant to facilitate commissioning of the Plant.

All Plant shall be prepared for commissioning and operation as recommended by the Plant manufacturer and shall be operated in accordance with the Plant manufacturer's recommendations.

Testing and start-up of the Plant and its corresponding system/sub-systems shall be completed in a sequence that will permit their being subject to systematic check, clearance of operability and trial operation before being incorporated for the Plant's initial operation.

Commissioning:
This phase comprises the activities that the Start-up Team shall carry out in conjunction with the primary equipment suppliers when introducing fuels and operating the Power Station to produce electrical power. This phase shall require initial Power Station run-ins, final adjustment of integrated controls, and operation of the steam turbine unit at full load according to established design criteria. The phase shall be completed when the Plant is ready to perform the Commissioning Tests.

Daily meetings chaired by the Engineer for Commissioning Test activities will be held between the Contractor and Employer's Personnel to ensure proper coordination of all activities.

38.3 TESTS ON COMPLETION

This section details the requirements of the Tests on Completion including but not limited to the Performance Guarantees [Attachment A3 (i) of Section 5] and Other Guarantees [Attachment A3 (ii) of Section 5].

The level of achievement of the guarantees for Performance Guarantees and Other Guarantees for the Power Station shall be demonstrated by conducting a set of Performance Tests to include:

1. Net Plant Heat Rate Test;
2. Net Electrical Output Test;
3. Emission Tests; and
4. Monitoring Test.

The first draft of the Performance Test Program (PTP) together with an original copy of the standards and codes referred to shall be submitted to the Employer for review at least 12 months prior to the scheduled commencement of the Performance Test. Detailed test procedures based on the Contract shall be included in the finalized PTP which shall be agreed by all Parties at least 6 months prior to the scheduled commencement of the Performance Test.

Inspections, capacity or redundancy check tests, where required, and “dry” or “cold” functional tests will be performed during the pre-commissioning tests or Commissioning Tests in order to demonstrate that the Plant and its corresponding system/sub-systems can safely and properly undertake the Performance Tests. All tests will be performed safely and as specified on subsystems independent of the Power Station’s operations. As an example, the water treatment systems or the coal handling systems will be tested well ahead of initial operation of the turbine generator. Some of the functional tests can only be performed with the Power Station producing power to the Grid System. Any non-compliance to the Contract in relation to Tests on Completion discovered during the pre-commissioning tests or Commissioning Tests which would affect Performance Tests and Reliability Run Test or would affect stable, continuous safe Plant operation shall be corrected prior to conducting the Performance Tests and Reliability Run Test.

Commissioning Tests shall be completed simultaneously or sequentially with system/component and pre-commissioning test and prior to Performance Tests to confirm the Plant is complete for the intended service and can operate continuously and stably under varying operating conditions. The Contractor will conduct Emission Tests during the Performance Tests. The Contractor will use their reasonable endeavors to complete the Emission Tests within five (5) days or as agreed between the Engineer and the Contractor.

The Plant shall be considered ready for Performance Tests on successful completion of the Commissioning Tests.

The Performance Tests shall be completed prior to the 30-day Reliability Run Test.

Data from the Performance Tests, adjusted to guarantee basis, shall be compiled in a formal report by the Contractor and submitted to the Engineer.

38.3.1 GENERAL REQUIREMENTS

The following requirements shall apply for Tests on Completion.

38.3.1.1 SCOPE

This section describes the general requirements for Tests on Completion of the Plant. The detailed technical requirements for Tests on Completion shall cover the following tests:

1) Pre-commissioning tests
2) Commissioning Tests
3) Performance Tests
4) Reliability Run Test

The timing of the submission of the technical requirements by the Contractor to the Engineer shall be in accordance with the Contract.

In addition, the Contractor shall carry out tests (or possible retests) which are deemed required by related statutory bodies and authorities for their witness and acceptance.

38.3.1.2 TEST RESPONSIBILITIES

The Contractor shall designate a Contractor's Personnel to act as the Test Coordinator (TCR) no less than six (6) months prior to the commencement of the pre-commissioning test. The TCR shall be responsible in coordinating all Tests on Completion and ensure the Tests on Completion are carried out in accordance with the approved PTP. The TCR shall have authority to direct relevant Employer's Personnel assigned as plant operators during testing and shall ensure compliance with the agreed PTP. For all Tests on Completion, the Plant shall be operated within the limits and constraints of the manufacturer's recommendations and operating instructions. The Employer shall designate Employer's Personnel to witness the Tests on Completion. The name of the representatives of the Employer's Personnel and Contractor's Personnel shall be specified in the PTP.

The Employer shall obtain any permission required to conduct the Tests on Completion from load dispatch and/or any Bangladesh agencies.

Fuel to be used during the Tests on Completion shall be within the specification in sub-clause 1.9, Chapter 1 of Section 5.

38.3.1.3 INSTRUMENTATION

The DCS and instruments of the Power Station shall be used to collect relevant test measurements. The Contractor will use high accuracy, temporary test instruments for selected measurements in accordance with the PTP. Identification of instruments to be used in the Performance Tests shall be specified in detail in the PTP.

Instruments shall be calibrated in accordance to the Employer's Requirement. Instruments used for Performance Tests measurements shall be calibrated at the factory when appropriate, the Site, or at a laboratory facility as may be required by the relevant ASME performance test codes. Complete calibration records shall be provided for all permanent and temporary installed instruments used for primary and secondary measurements. Installed instruments used for secondary measurements shall be verified for accuracy by comparison to a known instrument and the result of the same shall be documented and submitted to the Engineer. Critical instruments shall be calibrated before the Performance Test in accordance with the PTP. Instrument calibration factors shall be determined prior to the commencement of the Performance Test and the appropriate calculations adjusted in accordance with after-test calibrations shall be recorded in the test report. Calibrated backup instruments for primary measurements, as defined in the PTP, shall be provided by the Contractor at the Site during the Performance Test.

Throughout the Performance Tests, the Contractor shall record the data of the test parameters using an automatic data acquisition system and the Contractor shall minimize the manual data collection. The Contractor shall also be responsible for all collection and analysis of coal and ash samples.

38.3.1.4 TEST UNCERTAINTY AND TEST TOLERANCES

The Contractor shall provide the instrumentation to meet test uncertainty requirements for Performance Test as described in ASME PTC-46 and ASME PTC-19.1. Methods for determining test uncertainties shall be detailed in the PTP. Test uncertainties shall be determined prior to the Performance Tests. The post-test uncertainty analyses shall be performed to verify the actual tests were within the code limits. The test uncertainty requirements shall not be used to adjust the results of the Performance Tests. Test tolerances as defined in ASME PTC-46 for Performance Tests shall not be allowed.

38.3.1.5 TEST TIMING

The Commissioning Tests shall be conducted simultaneously or sequentially with all pre-commissioning tests and prior to Performance Tests. The Performance Tests shall take place after the successful completion of the Commissioning Tests.

Emissions testing will be performed during the Performance Test period.

During the Performance Tests, the Net Plant Heat Rate Test shall be performed by the Contractor independent of the Net Electrical Output Test. The Employer shall coordinate the selection of the commencement and completion of the Net Plant Heat Rate Test and Net Electrical Output Test with Grid System Operator.

The Performance Tests shall be performed prior to the Reliability Run Test.

38.3.1.6 TEST CONDITIONS

The Contractor shall be responsible on the operation for the Power Station during the Tests on Completion. Upon receiving Grid System Operator instruction, the Employer may request dispatch and/or change of the load during the Reliability Run Test from the Contractor. The test boundary of the Performance Tests is the area of the entire Power Station as defined in the PTP. Performance Tests shall be conducted at a steady state condition at, or near, rated steam conditions according to the PTP.

Boiler soot-blowing shall not be in operation during the Performance Tests. The boiler soot-blowing shall be performed in accordance with the standard manufacturer's recommendations prior to the Performance Test.

Prior to the Performance Test, the boiler shall be operated with Performance Test coal, in accordance with sub-clause 1.9, Chapter 1 of Section 5, for not less than 3 days to ensure its cleanliness.

38.3.1.7 TEST RESULTS

For all Tests on Completion performed on the Plant, the Contractor shall submit to the Employer copies of all test results, not later than thirty (30) days after the date of the test.

38.3.1.8 TEST COORDINATION

Test of various systems/components may take place concurrently or overlap as long as they do not interfere with or conflict with the PTP. The Contractor may coordinate the Tests on Completion by using the common instrumentation and test data.

38.3.2 TEST STANDARDS

The Performance Test shall be carried out using latest revision of the following standards as guidelines:

Performance test codes	ASME PTC 46-1996 Overall Plant Performance
	ASME PTC 4-1998, Revised 2008
Steam tables	IAPWS-IF97
Emissions	US EPA Method 7E (for NO_x) US EPA Method 6C (for SO_2) US EPA Method 10 (for CO) US EPA Method 5B (for Particulate)
Near Field Noise	ISO 3746 (1995)
Far Field Noise	ISO 1996-2 (2007)

38.3.3 COMMISSIONING TESTS

The Commissioning Tests shall be conducted simultaneously or sequentially with pre-commissioning tests and prior to Performance Test to provide assurance the Power Station can be operated in a continuous, safe and stable manner through the normal range of output in all control modes.

The Commissioning Tests shall include 24-hours of continuous operation for control stability testing. The control stability testing shall consist of four (4) hours of operation at 50 percent (50%), 75 percent (75%) and 100 percent (100%) gross electrical output; and at maximum continuous rating with approximately 3 percent (3%) additional turbine throttle flow with turbine valves wide open.

Load level changes shall be performed at the allowable ramp rates within equipment manufacturers' recommendations. At each load level specified above, normal operations shall be demonstrated in expected normal control modes with "bumpless" transfers.

The Power Station is ready for Performance Tests when the Commissioning Test is successfully completed.

Commissioning Tests shall be performed in accordance with the manufacturers' recommendations and the Contract. All such tests shall be proposed by the Contractor and reviewed by the Engineer and shall include the capacity tests, operations functionality tests and the Grid Code tests. The operations functionality tests shall include but not limited to, standby starts, generator and voltage regulation tests, frequency response, vacuum tests, over speed tests, load rejection tests, steam temperature control tests, steam quality and oxygen content verification and soot blower tests.

Capacity and operations functionality tests shall also be carried out for equipment and overall systems that operate independently of the overall electrical generation operation including but not limited to, coal handling systems, the water and waste treatment systems, the ash handling systems, cooling water systems, emergency diesel generator system, and air quality control systems. All such tests shall be proposed by the Contractor and reviewed by the Engineer and include, but not limited to, routine tests such as capacity tests, safety device verification, ventilation system tests, dust suppression functionality, crane and hoist tests, coal laden belt restart tests and weigh scale reliability tests.

The Commissioning Tests shall comply with the requirements in Attachment A4 of Section 5 [Schedule of Contractor's Obligations with Respect to the Employer's Power Purchase Agreement] of the Contract.

38.3.4 PERFORMANCE TESTS

38.3.4.1 POWER STATION AUXILIARY POWER CONSUMPTION (P_{AUX}) DETERMINATION

Power Station auxiliary power consumption is defined as the electrical power required to run the Unit, including transformer and electrical transmission losses.

Auxiliary consumers are considered according to Attachment A3 of Section 5 of the Contract. P_{AUX} shall be determined from the power value measured at high voltage side (primary side) of unit auxiliary transformer, and main step-up transformer losses calculated from factory tests certificates.

Average value is taken into account for each test within their respective duration in accordance with sub-clause 38.3.4.2 and 38.3.4.3. Auxiliaries that are not listed in Attachment A3 of Section 5 are to be stopped or their individual consumption measured or estimated and subtracted from the total auxiliary consumption. The consumption of some auxiliaries (for example boiler forced draft fans) shall be corrected for ambient conditions.

The Dependable Capacity and Weighted Plant Net Heat Rate as guaranteed in Attachment A3 of Section 5 do not take into account any intermittent auxiliaries and therefore will not be included in the Performance Test.

38.3.4.2 NET PLANT HEAT RATE TEST

Immediately prior to the start of the Net Plant Heat Rate Test runs, all coal bunkers shall be fully filled and their levels recorded, in order to ensure sufficiency of coal supply during the Performance Tests. The Power Station shall be operated at or near rated turbine throttle flow, pressure, and temperature as close as possible to the reference heat balance diagram values during the test at tested load of 100% MCR, 75% MCR, and 50% MCR. All normally operating, electrically driven equipment shall be operated at normal conditions appropriate to the load during the test and all equipment shall be operated according to manufacturer's recommendations. The Net Plant Heat Rate Test shall run at constant volume flow (fixed turbine control valve position) at near rated turbine throttle flow. TCR may suspend data taking during a Net Plant Heat Rate Test in order to make a turbine valve adjustment to more closely achieve the target operational point and long enough for conditions to re-stabilize after such adjustment.

The Contractor shall perform the Net Plant Heat Rate Test independent of the Net Electrical Output Test. Net Plant Heat Rate Test shall consist of a test period of four (4) hours for each load of 50% MCR, 75% MCR and 100% MCR without interruption. The measured net plant heat rate shall be determined from the measured net electrical output, the measured boiler efficiency and the measured heat absorbed by the boiler fluids. The measured net plant heat rate from each test run shall be adjusted to the guarantee basis in accordance with the PTP.

The Net Plant Heat Rate (NPHR) will be calculated according to the formula:

$$\mathrm{NPHR}=\frac{m_{HP}\times(h_{HP}-h_{FW})+m_{SHS}\times(h_{FW}-h_{SHS})+m_{CR}\times(h_{HR}-h_{CR})+m_{SRH}\times(h_{HR}-h_{SRH})}{P_{NET}\times E_{fuel}}$$

NPHR Net Plant Heat Rate
P_{NET} Net Electrical Output
m_{HP} HP live steam flow
h_{HP} Enthalpy of live steam at HP turbine stop valve
h_{FW} Enthalpy of feed-water at boiler economizer inlet
m_{SHS} Super-heater de-superheating water flow
h_{SHS} Enthalpy of super-heater de-superheating water
m_{CR} Cold reheat steam flow to steam generator re-heater
h_{CR} Enthalpy of cold reheat steam at HP turbine exhaust
h_{HR} Enthalpy of hot reheat steam at IP turbine stop valve
m_{SRH} Re-heater de-superheating water flow (if any)
h_{SRH} Enthalpy of re-heater de-superheating water
E_{fuel} Steam generator fuel efficiency based upon higher heating value

The following weighting factors are to be applied to determine the Weighted Plant Net Heat Rate;

(a) Weighting factor of 75% x heat rate measured at 100% MCR

(b) Weighting factor of 15% x heat rate measured at 75% MCR
(c) Weighting factor of 10% x heat rate measured at 50% MCR

Weighted Plant Net Heat Rate shall be:
(a) + (b) + (c)

The Bidder is to provide the reference internal cycle parameters from the heat balance diagrams as part of the Technical Proposal of the Bidder's Proposal:

Net Plant Heat Rate Test – Boiler Efficiency Determination
The thermal efficiency of the boiler, based on HHV (GCV), shall be determined from the average parameter values from two (2) test runs of two (2) hours each. The procedures, as described in the ASME PTC 4 for pulverized coal units (energy balance method), are used as guidelines for developing the PTP boiler efficiency test procedures. The measurements needed for this calculation shall be taken at the boiler boundaries.

The formula to calculate the boiler fuel efficiency as per ASME PTC4 is:
$E_{fuel}[\%] = (100 - Q_P L_{HHV} + Q_P B_{HHV})$
E_{fuel}: steam generator fuel efficiency based on High Heating Value (Gross Calorific Value)

$Q_P L_{HHV}$: sum of the heat losses based on HHV (GCV) (ASME PTC4).

HHV (GCV): higher heating value (Gross Calorific Value) of fuel.

$Q_P B_{HHV}$: sum of heat credits based on HHV (GCV) (ASME PTC4).
Heat loss components to be calculated from the boiler efficiency test data include the following:

1. Losses due to unburned carbon in ash residue.
2. Losses due to heat in dry flue gas.
3. Losses due to moisture in the "as-fired" fuel.
4. Losses due to moisture from burning hydrogen.
5. Losses due to moisture in air.
6. Losses due to surface radiation and convection both of which are not measured, in accordance with the American Boiler Manufacturers Association("ABMA") curves on a HHV (GCV) basis and as described in ASME PTC 4.1 1991.
7. Unmeasured losses shall be equal to the unaccounted losses which shall be taken as 0.5 percent (0.5%).

Heat credit components to be calculated from the boiler efficiency test data include the following:

1. Credits due to heat from entering dry air
2. Credits due to heat from pulverized power
3. Credits due to heat from moisture in entering air

4. Credits due to sensible heat in fuel
5. Credits due to temperature rise across FD and PA fans.

Heat in the fuel shall be based on the actual higher heating value of as-fired fuel as determined using a constant volume bomb calorimeter with adjustment to constant pressure conditions. During the Net Plant Heat Rate Test, coal samples shall be taken at regular intervals at each operating feeder. Each sample taken during the Net Plant Heat Rate Test shall be thoroughly mixed in accordance with the standards referenced in the PTP. Four (4) airtight containers (or sets of containers) shall be filled equally from each extracted coal sample. One of the four samples obtained shall be analyzed by a testing laboratory agreed on by the Parties; one sample shall be held by the Contractor to be analyzed at a future date if a question arises; one sample shall be retained by the Employer; and one sample shall be provided to the boiler supplier.

The sum of the boiler heat losses (as a percent of heat inputs; fuel plus heat credits) subtracted from 100 percent (100%) indicates the efficiency of the boiler under actual operating conditions (as defined by PTC 4). The efficiency obtained by this method is based on the as-fired fuel and ambient conditions at the time of the test. Actual test ambient conditions and fuel may not be the same as the design conditions. If actual test ambient conditions and fuel differ from the design conditions, corrections shall be made to the boiler efficiency in accordance with ASME PTC4 and the PTP. Corrections for any other deviations from performance guaranteed conditions as in Table 1.12.1-1 of sub-clause 1.12.1, Chapter 1 of Section 5 will be made as per the applicable ASME performance test code and in accordance with the PTP.

The amount of excess air has a significant impact in the efficiency of the boiler and shall be maintained as close as possible to a value determined in the PTP. If necessary, corrections shall be made in accordance with the PTP. The Contractor's Personnel shall monitor and adjust the excess air as directed by the TCR.

Net Plant Heat Rate Test – Heat Absorbed Method

The heat absorbed by the boiler's water/steam shall be calculated from the working fluid conditions entering and exiting the control volume surrounding the boiler. Conditions of the following flows shall be monitored or calculated from a mass/energy balance: feedwater to the boiler, main steam, cold reheat steam to the boiler, hot reheat steam from the boiler and miscellaneous flows such as desuperheating spray flows.

Test Incident Management

For Net Plant Heat Rate Test, the TCR may suspend its data collection, restart its test runs or extend its test runs as allowed by the PTP. Also as stipulated in the PTP, erroneous or invalid data of the Net Plant Heat Rate Test shall be eliminated and the test period extended during periods in which:

1. A plant component trips off but does not cause a Power Station trip, and for up to one hour after return of the component that tripped to full load service; and/or

2. Conditions of maximum cycle isolation, in accordance with the PTP, are broken (sootblowing or leakages).

38.3.4.3 GROSS ELECTRICAL OUTPUT TEST

Gross Electrical Output Test will be performed with the Power Station fired as much as necessary to reach the guaranteed output at guarantee conditions. The nominal duration of Gross Electrical Output Test shall be 2 hours. The measured output will be corrected to the guarantee basis in accordance with PTP.

If the Gross Electrical Output Test is interrupted or suspended as a result of actions of Employer, actions of load dispatch or due to an event of excusable delay such test may be continued after the interruption is over and the Power Station has reached full load at steady state.

38.3.4.4 EMISSION TESTS

The Contractor guarantees that the Power Station's emissions shall be in compliance with requirements listed in Attachment A3 [(ii) Schedule of Other Guaranteed Criteria] of Section 5.

The Contractor will secure the services of an independent testing laboratory to perform the Emission Tests in accordance with the Contract.

The Contractor shall provide test ports with shutoff valves wherever required. The number and type of test ports shall be consistent with the applicable regulatory agency's requirement. If not stated by the applicable regulatory agency, the US Environmental Protection Agency requirements shall be utilized. All test ports shall be specifically identified on the Contractor's Documents which shall be subjected to the Engineer's review.

Test methods or an acceptable equal with reference to US EPA test methods in Volume 40, Part 60 of the Code of Federal Regulations (40CFR60) Appendix A, are as follows:

NO_x	Method 7E
SO_2	Method 6C
Particulate Matter	Method 5
HCl	Method 26
HF	Method 26
Hg	Modified Method 29 (ASTM D6784-02 - Ontario Hydro modifications) or Mercury CEMS
CO	Method 10
Diluent gas (O_2/CO_2)	Method 3A
Flow rate	Method 2
Moisture	Method 4

38.3.4.5 EFFLUENT DISCHARGE MONITORING TEST

The Contractor guarantees that the Power Station's effluent discharge to the river shall be in compliance with requirements listed in Attachment A3 [(ii) Schedule of Other Guaranteed Criteria] of Section 5.

The Contractor shall carry out the Effluent Discharge Monitoring Tests during Unit start-up and unit normal operation condition. Samples shall be taken during such period and laboratory analysis shall be performed on these samples to ensure compliance to the guaranteed values.

38.3.4.6 MONITORING TEST

The Monitoring Test is intended to prove to the Employer that the Power Station has complied with the Employer's Requirements regarding Attachment A4 of Section 5 [Schedule of Contractor's Obligations with Respect to the Employer's Power Purchase Agreement]. The Monitoring Test shall be performed using fuels within the design limits of sub-clause 1.9, Chapter 1 of Section 5. Start-up and shut-down period of the Power Station will not be considered for the Monitoring Test period.

Between the Performance Test and the Reliability Run Test, one (1) Monitoring Test on the Power Station will be conducted by the Contractor.

Before the Monitoring Test, the Power Station will operate in a stable manner between the minimum generating level and the Dependable Capacity. On the scheduled day of such test with a minimum half (1/2) hour prior notice, the Employer will advise the Contractor the level of generation required of the Power Station which may be any level from the minimum generating level up to the Dependable Capacity. This level will take into account but not limited to the Performance Test results, the ambient condition and the Grid System's condition.

During the Monitoring Test intermittent auxiliaries as stated in Table 3-2 of Attachment A3 [(i) Schedule of Performance Guarantees] not to be in operation during the Performance Test should also not be in operation, and the frequency control of the Power Station shall be disabled to avoid fluctuation of power due to external variation. The prior notice by the Employer will take into account the necessary time for the Power Station to achieve the above said level of generation with the specific ramp rate of +/- 1% of MCR per minute.

Upon receipt of the notice from the Employer, the Contractor shall conduct the Monitoring Test until its successful completion. The said level of generation shall be maintained for a continuous period of not less than one (1) hour. If on testing by the Contractor pursuant to a Monitoring Test, the Power Station generates at a level of generation that exceeds the level of generation specified in the notice for the Monitoring Test by more than one percent (1%) average measured over any one hour period during the Monitoring Test, Monitoring Test shall be deemed to have failed.

If on testing by the Contractor pursuant to a Monitoring Test, the Power Station fails to achieve and maintain over any one (1) hour period during the Monitoring Test a level of generation of at least ninety-nine percent (99%) average measured over any one hour period of the lower of:

(i) the declared minimum stable load of the Power Station under coal firing and without distillate support; and
(ii) the level of generation specified in the notice for such Monitoring Test in accordance with the ramp rates

then Monitoring test shall be deemed to have failed.

If the test failed for any reason, it will be re-started until full completion. Failure of the Monitoring Test will be dealt with in accordance with the Contract.

38.3.4.7 NOISE EMISSION TEST

The Contractor shall perform a noise emission test to verify compliance with the guaranteed noise emissions listed in Attachment A3 [(ii) Schedule of Other Guaranteed Criteria] of the Contract. The noise emission test shall be conducted in accordance with a test procedure to be developed by the Contractor reviewed by the Engineer. The noise emission test procedure shall be based on applicable industry standards including ASME PTC 36, ANSI S1.13, ANSI S12.18, ISO 3746, ISO 1996 and ASTM E1014, and shall include the requirements outlined below.

Sound Level Test Equipment

The noise emission test shall be conducted by the Contractor’s Personnel with previous experience or training in sound level testing. All sound level measurements shall be conducted using a Type 1 sound level meter that meets the requirements of ANSI S1.4. The sound level meter shall be equipped with integrating capabilities to determine the average and statistical sound levels over a specified duration. For outdoor measurements, the microphone shall be equipped with a windscreen provided by or recommended by the sound level meter manufacturer. If necessary, the microphone shall be mounted on a tripod to maintain stability. The sound level meter shall be field calibrated immediately before and after each measurement series. The sound level meter equipment and calibrator shall have been laboratory calibrated within the last 12 months prior to the noise emission test.

Outdoor sound level measurements shall not be conducted during adverse weather conditions or conditions which may damage the instrumentation. Measurements should be avoided during periods when the average wind speed exceeds 3.0 m per second measured 1.5 m above the ground or platform. Measurements shall not be conducted during periods of precipitation or wet surface road conditions if such conditions increase the background noise. Weather conditions shall be noted on the field data sheets.

Environmental Sound Level Measurements

Sound level measurements shall be conducted in accordance to the agreed PTP. If local conditions such as background noise, accessibility, reflecting surfaces, screens, topographical conditions, or other restrictions preclude meaningful measurements at the prescribed locations, alternate locations may be selected upon review of the Engineer. The background and operational measurements shall be taken at the same measurement locations. The microphone shall be positioned approximately 1.5 m above the ground for all measurements.

The operational sound level measurements shall be conducted at each measurement location during normal operation of the Power Station. During night time (2200hrs-0700hrs) noise measurements of intermittent operations may be taken of such facilities such as coal conveyors, transfer towers and coal screening house. However, the guarantee noise measurements shall not include the contributions of noise from such intermittent operations of such facilities. All non-Plant noise sources that are audible during the measurement period shall be noted on the field data sheets. All sound level measurements shall be recorded during a period of minimal background influence that is between vehicle passes, aircraft flyovers, train passes, and other discrete non-facility sources. The measurement may be paused during such discrete noise sources if necessary to achieve the minimum measurement period.

If deemed necessary by the Engineer, background sound level measurements shall be conducted while the Power Station is not operating in order to quantify the noise not associated with the normal operation of the Power Station. Background sound level measurements shall be conducted at each prescribed receptor location during a period when the Power Station is completely shut down. The background sound level measurements shall be conducted during a period that experiences ambient conditions similar to the background conditions experienced during the operational measurements. Background sound level measurements shall be deemed unnecessary if the operational measurements, without any corrections for background noise, show compliance with the contractual requirements.

The Plant’s sound level at each measurement location shall be determined by correcting the measured operational sound level in accordance with the referenced industry standards to account for background noise. Following the background correction, the Plant sound level at all measurement locations that are not receptor locations shall be corrected in accordance with the referenced industry standards for the distance to the receptor location. The Power Station sound level at each receptor location, after appropriate corrections, shall be compared to the guaranteed sound level, inclusive of measurement uncertainty, to determine compliance.

In-Plant Sound Level Survey

Survey locations shall be positioned along the equipment envelope of the equipment packages. The equipment envelope is defined as the periphery contour which completely surrounds the equipment at a distance of 1 m from the equipment face or equipment enclosure. Measurements shall be taken at locations equally spaced a maximum of 3 m along the equipment envelope. The microphone shall be positioned approximately 1.5 m above the ground or personnel platform for all measurements. If the measured A-weighted surface sound pressure level exceeds 85 dB(A), additional measurements shall be conducted at increasing distances from the equipment to identify the location of the 85 dB(A) sound pressure level contours/areas.

The sound level measurement parameter shall include the A-weighted equivalent-continuous sound level, Leq. The duration of the measurement period shall be a minimum of 5 seconds or longer to capture a representative sound level.

All areas that experience sound levels exceeding 85 dB(A) during normal operation (transient modes excluded) shall be identified with warning signs prescribing hearing protection in order to support compliance with DOSH permissible noise exposure levels. These areas shall also be delineated on appropriate arrangement drawings.

Noise Emissions Test Report
A final noise emission test report shall be developed by the Contractor and submitted to the Engineer. The final report shall include a list of all test equipment and the corresponding serial number(s) as well as copies of all laboratory calibration certificates. Additionally, the final report shall include the names of all personnel who conducted and witnessed the testing. A drawing shall be generated which shows the location of each measurement. All data shall be reported in tabular form identifying each measurement location, the measured background sound levels, the measured operational sound levels, and the corrected sound levels, as applicable. Summary tables shall be included which verify the calculation procedure and results at each measurement location.

38.3.5 RELIABILITY RUN TEST

The 30-day Reliability Run Test shall be performed on the Power Station after the completion of the Performance Tests.

The Reliability Run Test is intended to prove to the Employer that the Power Station has complied with the requirements of the Contract. The Reliability Run Test shall be performed using fuels within the design limits of sub-clause 1.9, Chapter 1 of Section 5. Start-up and shut-down time of the Power Station will be counted into the Reliability Run Test period.

The first draft of the Reliability Run Test Program (RRTP) shall be submitted to the Employer for review at least 12 months prior to the scheduled commencement of the Reliability Run Test. Detailed test procedures based on the Contract shall be included in the finalized RRTP which shall be agreed by all Parties at least 6 months prior to the scheduled commencement of the Reliability Run Test.

During the Reliability Run Test, the Power Station shall operate within the limits of minimum and maximum rated output, continuously without interruption of any kind for a period of thirty (30) days in which time the Plant shall operate continuously (without interruption) for seventy-two (72) continuous hours at then demonstrated Dependable Capacity, following the Grid System Operator’s requirements. The output during the remaining hours of the test will be as requested by the NLDC. However, if the load demands from the Grid System decreases below minimum rated load or if variations of frequency, power factor, and other conditions are beyond the design limitations, the Power Station shall be isolated from the Grid System. The period of time the Power Station is isolated shall be counted as a period of reliable operation.

In the event of any failure or interruption of the Power Station preventing the Power Station from complying with the requirements of the Reliability Run Test, then the 30-day Reliability Run Test shall pause. The cause of the failure or interruption shall be immediately analyzed by the Contractor and the findings presented to the Engineer. The Engineer shall determine whether the Contractor shall perform a full repeat of the Reliability Run Test or continue the 30-day Reliability Run Test.

The Power Station will be operated by the Employer's Personnel with relevant experience under the responsibility and direction of the Contractor's Personnel during the Reliability Run Test. However, the Contractor, subject to the approval of the Engineer, shall be allowed to make any minor adjustments which may be necessary, provided that such adjustments do not result in reducing the output or decreasing the efficiency or in any way interfere with or prevent the commercial use of the Power Station by the Employer after the date stated in the Taking-Over Certificate.

38.3.6 TEST RESULTS

38.3.6.1 DATA REDUCTION

Prior to the Performance Tests calculations, the following procedures shall be followed:

1. All recorder, data logger and DCS test data shall be examined for consistency. Suspected inconsistent readings which are not substantiated by the trends of related data shall be evaluated using techniques of PTC 19.1 and the PTP. Outliers, as determined by the evaluation, shall be discarded.
2. Readings for each direct-reading instrument shall be averaged and instrument calibration factors applied as appropriate. Instrument calibration factors shall be determined prior to the Performance Tests.
3. Pressure readings shall be converted to bar(A) and water leg corrections shall be performed.
4. Totaliser or integrate flow readings shall be converted into kilograms per hour or other flow rate units as required.
5. Thermocouple output readings not already converted to temperature units shall be converted to degrees Celsius.

38.3.6.2 ADJUSTMENT OF PERFORMANCE TEST RESULTS TO GUARANTEE BASIS

All correction curves, equations and methods for adjusting test results to Project guarantee basis shall be a part of the final version of the PTP. All finalized correction curves, equations and methods for adjusting test results shall be provided six (6) months ahead of the commencement of the Performance Tests.

Primary Corrections

The Performance Test results shall be adjusted to account for conditions not in accordance with Table 1.12.1-1 of sub-clause 1.12.1, Chapter 1, Section 5 of the Contract. The values of the guarantee basis, for which the primary corrections are valid, shall be defined in the PTP. A preliminary list of factors for which adjustments to test parameters may be made are listed in Table 38.3.6.3-1 (Test Parameters Adjustment Factors). Any adjustments shall be calculated and applied to the test results after completion of the Performance Tests. Any additional correction curves, equations and methods shall be agreed by both Parties six (6) months ahead of the commencement of the Performance Tests.

Secondary Corrections

Under normal test conditions, deviations from design values of the guarantee basis are minimal and the primary corrections using correction curves adequately adjust the test results. However, if conditions exist beyond the control of the Contractor, which cause these deviations to become excessive, the primary correction functions may be invalid. As a result, secondary corrections may be required to adequately adjust the test results to the guarantee basis.

Typically, secondary corrections affect internal cycle parameters normally considered to be inside the envelope around the Plant. The situations when these internal parameters must be corrected for, include those instances when external parameters are far outside the design values or when factors beyond the control of the Contractor prevent the Power Station from being operated within the stipulated parameters based on the Contractor's design. The guarantee basis parameters, their primary design limits and methods for applying secondary corrections shall be indicated for each correction curve in the PTP.

Correction for Ageing

Ageing for the Power Station applies to the results of the Performance Test if the scheduled date of the Performance Test is delayed due to cause for which the Employer is responsible under the Contract. For each day of delay or part thereof the correction factors on the results of the Performance Test for ageing derived from IEC 60953-2 will be plus (+) 0.00128% of the Dependable Capacity for the Dependable Capacity and minus (-) 0.00128% of the Weighted Plant Net Heat Rate for the Weighted Plant Net Heat Rate. If delay due to cause for which the Employer is responsible under the Contract exceeds sixteen (16) months from the scheduled date of the Performance Test, constant correction factors on the results of the Performance Test will be applied and will be plus (+) 0.6% of the Dependable Capacity for the Dependable Capacity and minus (-) 0.6% of the Weighted Plant Net Heat Rate for the Weighted Plant Net Heat Rate.

38.3.6.3 PERFORMANCE TESTS REPORT

The Contractor shall submit to the Employer and the Engineer a preliminary Performance Tests report based on anticipated fuel analysis to quickly understand the final tests results immediately after the Performance Tests is performed.

A final Performance Tests report shall be submitted to the Employer and the Engineer in accordance with the Attachment A1 -Technical Schedule of Submittals of these Employer's Requirements. The report shall include, as a minimum, the following.

1. Executive summary of test results.
2. General information of the Project such as a description of the Power Station, identification of the responsible parties to the test, statements of the scope of test and objectives, and a statement that refer to the values in the Technical Schedule as applicable.
3. Description of conditions under which tests were conducted including diagrams indicating plant valve lineup and operating equipment status, unusual circumstances or variation during the test and a copy of the PTP.
4. Copies of all recorded raw data including fuel analysis reports.
5. Corrected test data.
6. Summary of instrument calibration data including signed and approved instrument calibration forms.
7. Test uncertainty analysis.
8. Test conclusions including discussion of Performance Tests results, determination of acceptance or rejection of test results and authenticated signatures (accept or reject) of parties responsible to the test. The tests will be successfully passed if the corrected results achieve the guaranteed values.
9. Appendices of supporting technical data as required.

Table 38.3.6.3-1
Test Parameter Adjustment Factors (Preliminary List)

Adjustment Factors	**Parameter Correction Source**
Site Design Conditions • Ambient air dry bulb temperature (ref. value 30.7°C) • Relative humidity (ref. value 88%) • Atmospheric pressure (ref. value 99.84kPa) • Raw water temperature (ref. value 32.2°C)	PTC 4, PTP Performance Correction Curves.
Ageing (as applicable)	Refer to Section 38.3.6.2
Fuel Parameters	PTC 4 and PTP
Auxiliary electrical loads	Basis load for equipment not continuously in

Table 38.3.6.3-1
Test Parameter Adjustment Factors (Preliminary List)

Adjustment Factors	Parameter Correction Source
	service in accordance with Table 3-2 of Attachment A3 of Section 5 “List of Auxiliary Power Consumers in service during Performance Tests”.
Power Factor (ref. value 0.85 lagging) Grid frequency (ref. value 50 Hz)	PTP Performance Correction Curves

38.4 REQUIREMENTS DURING THE DEFECT LIABILITY PERIOD (DLP)

38.4.1 FIRST INSPECTION

Steam Turbine and Generator

The First Inspection shall be undertaken by the Contractor after the completion of the recommended hours of operation. It shall be undertaken by the Contractor and the costs of corrections, repairs and replacements made by him shall be entirely at the Contractor’s cost.

For the first inspection the Contractor shall provide the supervisors with any required special tools and the Employer will provide labor, normal tools, and a crane with driver placed under the responsibility of the Contractor. Fuels, lubricants and wages for the local staff and for the crane will be paid by the Contractor.

Boiler and auxiliaries

A combustion inspection, with the same conditions applying as for the steam turbine generator sets, shall be carried out to the Boiler. The Plant to be inspected shall include, but not be limited to main steam, reheat steam and bypass systems, sootblower, air heaters, hopper, and other equipment to be agreed by the Employer.

Common Auxiliary Plant

Inspection shall also be performed to all Common Auxiliary Plant such as Water Treatment, Cooling Tower, etc.

Inspection Procedures

Inspection procedures shall be submitted to the Employer for review and approval not later than two (2) months before the scheduled inspection.

38.4.2 OVERHAUL INSPECTION

At the end of Defect Liability Period for each item or equipment, the Contractor shall perform overhaul inspection of the equipment as a condition for the Employer’s issuance of the Final Acceptance Certificate.

Any defective works during the defect liability period and any defective works discovered during this inspection shall be remedied free of charge by the Contractor. The inspection shall include, but not be limited to, the following:

- Dismantling of equipment
- Open and inspect internal equipment
- Inspect all bearings and alignment
- Check oil seals
- Inspect and clean filters
- Check rotors, blades, impellers, etc. for wear and clearances
- Inspect and alignment of couplings
- Inspect and clean all necessary parts
- Measure electrical insulation resistance and polarization index
- Inspect all control and protection functions and tripping devices
- Inspect of hot gas path
- Inspect of combustion chamber

The Contractor shall then test run the Plant to ensure that it is in the proper working order and that the performance is satisfactory.

The Contractor shall provide suitable practical instruction and allow the Employer to witness the dismantling and reassembly of the sets.

An inspection procedure shall be submitted to the Employer for approval not later than two (2) months before the scheduled inspection. The inspection shall be conducted according to mutually agreed conditions.

An inspection report shall be submitted for each piece of equipment or system inspected. This report shall include, but not be limited to, the following:

- Status of equipment or system
- Deviation from expected conditions
- Remedial action required
- Conclusions
- Mutually agreed correction procedures
- Photographs

A full and complete report of the inspection is to be produced by the Contractor and six hardbound copies issued to the Employer within one month of the completion of inspection of each steam turbine & generator. The reports shall include, as a minimum, the following details:

a) Full procedure adopted
a) Day to day record of work carried out
b) List of tools used for each operation
c) Result of inspection
d) Record of measurements of wear on critical parts of machine
e) Recommendations of parts replacement, operational procedure

38.4.3 DISPATCH SUPERVISORS

The Contractor shall provide, from date of Operational Acceptance through to the end of Defect Liability Period, one (1) mechanical engineer for steam turbine and generator, one (1) mechanical engineer for Boiler, one (1) mechanical engineer for ESP and FGD, one (1) mechanical engineer for BOP portion, one (1) I&C engineer and one (1) electrical engineer to provide supervision of and advice to the Employer's operation and maintenance personnel. These engineers shall have been qualified and their CVs shall be submitted for Employer / Engineer's approval.

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 39 – WORKSHOP AND WAREHOUSE

CONTENT

39 WORKSHOP AND WAREHOUSE

39.1 GENERAL

This Section of the Employer's Requirement cover the supply of workshop machinery, tools and associated equipment for use in the maintenance workshop and warehouse, and as intended to service minor maintenance requirements of the entire power plant.

The warehousing system shall be developed and specified, but will feature high rise storage racks and shelving, and palletized containment of spares. Customized storage racks for pipe, steel sections, plate and cabling shall be required.

This Section also covers the supply of tools and associated equipment for use in the servicing building. The equipment will be used to maintain service and carry out repair work.

This Section also covers the supply of mobile and portable lifting equipment suitable for lifting and transporting maintenance items in those areas of the power plant that areas not serviced by the power house overhead traveling crane, and in areas outside the power house.

39.2 SCOPE OF WORK

The scope of work for workshop and garage machinery, tools and mobile lifting equipment and warehouse, shall include but not be limited to the following:

39.2.1 WORKSHOP MACHINERY

a) Three kinds of centre lathe (Heavy, medium and precision duty lathe)
b) One universal milling machine
c) One surface grinding machine
d) One pipe-threading machine
e) One power hack-saw
f) One pedestal mounted grinder (Medium duty)
g) One pedestal mounted drill press
h) One oxy-acetylene gas welding equipment
i) One arc welding equipment with portable heater to keep welding electrode
j) One workbenches
k) One welding bench
l) One steel storage rack
m) Storage units
n) Power hand tools and manual hand tools
o) Safety equipment
p) Pipe Bender for maximum 150 diameter pipe
q) UV lamp non-destructive inspection equipment with 10 complete spare and chemicals

r) Surface replica marking sets with microscope
s) Surface roughness tester
t) Hardness Tester
u) 3 - Phase Slide Transformer (0 - 240 VAC, 3 - phase, 6.2 kVA)
v) Variable DC voltage source (0 -110 VDC, 10 A)
w) Conduit bender and threaded for pipe up to 32mm
x) Two Bench Vice (size 150mm)
y) Primary Injection Test Set (0 to 5000 A)
z) Secondary Injection Test Set
aa) Relay Test Set
bb) Synchroscope
cc) Oscilloscope
dd) Pneumatic Workstation with Pressure gauge and Bench
ee) Electric Workstation with bench
ff) Pressure Calibrator
gg) Vacuum test stand with vacuum pump
hh) Calibration pressure pump
ii) Hydraulic pressure pump
jj) Dead weight tester
kk) Temperature calibrator oven
ll) Constant temperature bath
mm) Calibration set for Turbine Supervisory Instrument Sensors

39.2.2 GARAGE EQUIPMENT

a) One compressed air installation including tools etc.
b) One bench grinder
c) Two trolley jacks
d) Three hydraulic jacks
e) Three axle stands
f) Two mechanic's creepers
g) One grease pump
h) One drum pump
i) One portable lubrication unit
j) One chain block
k) Portable air and power tools
l) Hand tools
m) Miscellaneous equipment
n) Safety equipment

39.2.3 LIFTING EQUIPMENT

a) Two load skates
b) Three chain hoists
c) Two load pullers
d) Two hydraulic jacks
e) Slings and shackles

39.2.4 WAREHOUSE

a) High rise storage racks
b) Pallets
c) Steel racks
d) Storage cabinets
e) Wire ropes
f) Shelves
g) Portable bunds - fiberglass
h) Wall boards
i) Horizontal plan cabinets
j) Power hacksaw
k) First aid kit
l) Two folded ladder (one big and the other small)

39.3 DESIGN AND OPERATING CONDITION

All machines supplied under this Contract shall be brand new, of well-established manufacturers and shall be suitably designed and constructed for safe, efficient, proper and continuous operation under all conditions described or implied in this specification without undue strain, vibration, corrosion, noise or other operating difficulties.

All machines supplied within the scope of this Specification shall be of standard, proven, economical and efficient design. Designs incorporating components which may be considered prototype in nature will not be acceptable.

Well run sales or service organization within reasonable distances of site shall already exist for the machines and equipment to be delivered. The Contractor shall state their respective names and addresses.

Parts subject to wear, corrosion or other deterioration, or requiring adjustment, inspection or repair shall be accessible and capable of reasonably convenient removal, replacement and repair. All such parts shall be of suitable material for keeping maintenance to a minimum.

Vibration, noise mechanical and thermal stresses, spillage and susceptibility to corrosion shall not be greater than with similar machines of first class design and workmanship operating under similar conditions.

All machines shall be fully tropically, fungus, vermin and rodent proof and designed to permit full load operation under all site conditions.

The number of different types and grades of lubricating oils and greases required shall be kept to a minimum.

As far as practicable, all lubricants shall be standardized and must be available in Bangladesh. A full list of equivalent lubricants from alternative manufacturers shall be supplied for all grades of lubricant specified.

The machines in standard form or equipped with any special equipment shall comply with all relevant industrial of the state of Bangladesh.

The main nameplate, controls and instruments of every machine shall be clearly labeled in Bangladeshi and English.

The electrical equipment of the machines shall be complete including motors, starters and controls. They shall be suitable for a 400 Volts phase or 230 Volts phase 50 Hz supply.

All machines and equipment shall be provided with (2) sets of their respective special maintenance and operation tools, packed in toolboxes.

The dimensions quoted in the specification are approximate and shall be used as a guide only.

39.4 DETAILED REQUIREMENTS

All plant, tools and equipment supplied under this Contract shall be of rugged construction and suitable for operation in tropical conditions. In some instances, operation of equipment may be by semi-skilled or unskilled staff, and simplicity of controls and ease of operation is of prime importance. It should be noted that all equipment will be used for maintenance duties only, machinery suitable for production purposes is not required. Specifications quoted for plant and equipment may be taken as nominal only, the Contractor shall submit his standard equipment which has a size or capacity closest to that called for in the specification.

The Contractor shall provide training for the Employer’s maintenance personnel in the operation and maintenance of the workshop equipment by the Contractor’s cost.

39.5 TERMINAL POINTS

The Contractor shall supply all necessary pipe work, mountings, fittings, electrical cable, fixing materials and grouts to install and/or mount the machinery and equipment in the workshop, garage and stores as applicable.

39.6 INFORMATION TO BE SUPPLIED WITH CONTRACT

The Contractor shall provide the following information:

a) Manufacturer’s catalogues or other literature stating make of machine, country of origin, dimensions, capacities, power requirements and standard colours.
b) A list of Employers of similar machinery, particularly in the town near the location of the plant.
c) The extent of spare parts and services facilities available, and the name, address and capabilities of the nearest service agent.

39.7 MATERIAL OF CONSTRUCTION

All materials of construction shall be of the manufacturer’s proven standard, with due allowance made for the environment in which the plant and equipment will be operated and stored.

39.8 NAMEPLATES AND INSTRUCTION BOOKS

All nameplates, capacity plates, operating and service instructions and the appropriate service and spare parts manuals shall be written in both English and the Bangladeshi language. The Contractor will provide the necessary Bangladeshi translation.

Four (4) sets of operating and service instruction manuals and parts lists shall be supplied for each workshop machinery, all major items of miscellaneous lifting equipment and garage equipment, power hand tool to be supplied under this Contract.

39.9 WORKSHOP MACHINERY

39.9.1 LATHE

a) Heavy Duty Lathe

The Contractor shall supply one (1) machine with the following features:

• Swing over bed	Contractor to provide
• Height of centre	ditto
• Distances between centers	ditto
• Range of spindle speeds	ditto
• Number of speed (min)	ditto

b) Medium Duty Lathe

The Contractor shall supply one (1) machine with the following features:

• Swing over bed	Contractor to provide
• Height of centre	ditto
• Distances between centers	ditto
• Range of spindle speeds	ditto
• Number of speed (min)	ditto

c) Precision Lathe

One (1) of the precision lathe shall be free standing and shall be completed with bed plate and chip tray. A bench mounted lathe is not acceptable.
The machine shall be supplied with the following features:

• Swing over bed	200mm
• Height of centre	100mm
• Distances between centers	500mm
• Range of spindle speeds	(40 - 2,500) rpm
• Number of speed (min)	Infinitely variable

39.9.2 UNIVERSAL MILLING MACHINE

The machine shall be multipurpose milling machines with detachable horizontal and vertical milling heads. It shall be have a worktable of at least 1,500mm x 300mm.

The longitudinal, cross and vertical transverse 1,000mm, 300mm and 450mm respectively spindle speeds shall be selected over the range of 40 - 1,500 rpm.

39.9.3 UNIVERSAL TOOL AND CUTTER GRINDER

The universal tool and cutter grinder shall be designed to deal with all types of milling cutters, taps, reamers, chasers, dies, etc. The machines shall have a capacity of 300mm diameter x 475mm long. It shall also be suited for surface, cylindrical and internal grinding.

The machine shall include but not limited to the following standard for features:

• Maximum size of cutter	300mm
• Distances between centres	475mm
• Work table	850 x 125mm
• Wheel head cross feed	250mm
• Swivel of grinding head	360º
• Swivel of work table	135º
• Work head graduated (two panels)	360º

39.9.4 PIPE THREADING MACHINE

One power-operated pipe and bolt threading machine, the Contractor shall propose the specifications.

39.9.5 POWER HACKSAW

One floor-mounted power hacksaw, the Contractor shall propose the specifications.

39.9.6 MEDIUM DUTY GRINDER

One medium-duty industrial pedestal mounted grinder, the Contractor shall propose the specifications.

39.9.7 DRILL PRESS

One pedestal mounted bench drill press, the Contractor shall propose the specifications.

39.9.8 GAS WELDING PLANT

One portable gas welding set of the oxy-acetylene type complete with regulators, gauge sand gas cylinders, the Contractor shall propose the specifications.

39.9.9 ARC WELDING PLANT

One portable electric welding plant including the transformer and two portable heaters for welding rod, the Contractor shall propose the specifications.

39.9.10 WORK BENCHES

Two general purpose work benches 1 x 2,000mm and 1 x 1,500mm of wooden construction, of the following specifications:

- Length: 2,000mm (1), 1,500mm (1)
- Width: 750mm
- High of work surface: 800mm
- Fixtures: Cast-steel engineer’s vices 150mm - quantity
  2 drawers, 200mm deep as shown fitted with padlock, hasp and staple

Finish shall be in natural timber. The work benches shall be fastened securely to the workshop floor.

One welding work bench of 2,000mm of steel construction, of the following specifications:

Finish shall be by wire brushing all steel and welds and painting with one coat of holding primer. The welding bench shall be fastened securely to the workshop floor.

39.9.11 STEEL STORAGE RACK

One rack for the storage of lengths of steel and pipe stock. The rack shall be fabricated from mild-steel section. Finish shall be by wire brushing all steel and welds and painting with one coat of primer and one finish coat in a colour to be advised. The steel rack shall be fastened securely to the workshop floor.

39.9.12 STORAGE UNITS

Storage units for bolts, nuts and other small engineering supplies, plus a storage board for hand tools and power hand tools shall be provided in the store area.

39.9.13 POWER HAND TOOLS

Power hand tools of the following types shall be supplied. All shall be of double-insulated construction, 230 V, single phase 50 Hz operation and shall complete with power leads, and 4 chuck and arbor keys for each tool.

- 10mm Electric Drill
  One 10mm capacity in mild steel, 2-speed (1,250/2,800 rpm) complete with one set of high speed drill bits

- 13mm Electric Drill
  One 13mm capacity in mild steel, single speed (750 rpm) complete with one set of high drill bits

- 32mm Electric Grinder
  One straight configuration to take 32mm diameter wheel

- 100mm Electric Angle Grinders
  One angle grinders to take 100mm diameter wheel, no load speed 11,000 rpm

- 180mm Electrical Angle Grinder
  One Angle grinder to take 180mm diameter wheel

- One set of wire brush Power tool.

39.9.14 HAND TOOLS

All hand tools shall be supplied from a reputable manufacturer. Tools may be supplied on an individual item basis as detailed below or alternatively, consideration will be given to manufacturer's standard sets of tools, provided that they substantially include the tools itemized below.

- Spanner Sets

a) One set of ring spanners 4mm to 36mm
b) One set of ring spanners 1/4" to 1 3/4"
c) One set of open-end spanners 4mm to 36mm
d) One set of ring spanners 1/4" to 1 3/4" A/F
e) One set of adjustable wrenches 4", 10" 24", 36"

- Pipe Wrenches

  One set 10", 24", 36"

- Socket Sets

a) One set 3/8" (10mm) drive, complete with ratchet, power bar, speed wrench, extensions and sockets 5mm to 19mm and 5/16" to 3/4" A/F.
b) One set 3/4" (9mm) drive, complete with ratchet, power bar, speed wrench, extensions and sockets 19mm to 55mm and 3/4" to 2 1/4" A/F.

- Torque Wrenches

  One of 160 N-m capacity
  One of 400 N-m capacity

- Pliers

  Two each of side cutting, slip-joint, long-nose, internal circlip, external circlip and self-locking pliers

- Hammers

  Three Engineer's ball-pin hammer of 0.125kg, 0.250kg and 0.900kg. Two cooper-faced mallets and two steel chipping hammer for clean-up welding.

- Screwdrivers

  Two sets screwdrivers with 3", 6", 10" and 12" blades.
  Two sets philips-head screwdrivers.
  Two sets cross-head screwdrivers.

- Miscellaneous Tools

  One hackshaw with ten (10) blades
  One set bolt cutter (24")
  One set of cold chisels 12mm, 25mm, 40mm
  One set of punches including centre punches (2) and pin punches (4)
  Cooper drifts (2)
  One external micrometer 0/50 mm
  One external micrometer 50/150 mm

One internal micrometer set
One set vernier calipers
One dial indicating gauge (metric) and Vee-blocks
One set of alphabet punches (10mm characters)
One set of alphabet punches (5mm characters)
One set number punches (10mm characters)
One set engineer’s files (10 pieces) complete with handles
Two set high-speed stell drill bits 1.6mm to 10mm
One set high-speed stell drill bits 10mm to 32mm with Morse tapers as appropriate to suit drill press item 8.7
One tap and die set M5 to M25
Two pairs of tin snips
Ten steel rules 300mm long
One steel straight-edge 1.5m long
Five “G’-cramps (200mm throat)
Five “G’-cramps (100mm throat)
Two soldering gun
Three electrical protective Gloves maximum 7000 V
Battery Testing Kit
Three Inspection lamp holder with 10m cable
Three Transformer for Inspection Lamp (110/250 V, 400 VA)
Dial gage indicator with magnetic base
Compound dial gage with magnetic base
Portable Hydro testing set (50 kg/cm^2)
Digital Insulation Resistance Tester (0 to 2000 MΩ)
Mega-ohm meter (500 V, 1000 MΩ)
Universal Protective Relay Test set
Digital multimeter
Transformer Turn Ratio Tester
Micro - ohm meter
Earth Resistance Tester
Transformer Oil Test Set
DC High Voltage Test Set
Phase Angle Meter
Phase Rotation Indicator
Digital Clamp - On Meter
AC Ammeter
AC Voltmeter
Wattmeter
Frequency meter
Thermometer Set
Dry Bulb/Wet Bulb Thermometer Set
Optical/Digital RPM meter
Stroboscope set
Portable Sound Level Meter

39.9.15 SAFETY EQUIPMENT

Equipment supplied under this Section shall be supplied from a reputable manufacturer. Replacement items shall be readily available especially in local market.

Six pairs of full-length overalls (cotton/gabardine)
Four Welding helmets
Six pairs of welding gloves
Four pairs of welding goggles
Six pairs of clear safety goggles
Six pairs of steel-capped rubber safety boots
One first-aid kit of suitable size and content

39.10 MISCELLANEOUS LIFTING EQUIPMENT

39.10.1 LOAD SKATES

Two of 20tons load skates

39.10.2 CHAIN HOIST

Two 2,000kg and one 5,000kg capacity hand-operated chain hoists, complete with chain, hooks and lifting beam push trolley.

39.10.3 LOAD PULLERS

Two of 1,000kg hand-operated load pullers, complete with chain and hooks.

Nominal pulling capacity:	1,000 kg
Chain length:	3,000mm minimum
Finish:	Manufacturer’s standards

39.10.4 HYDRAULIC JACKS

Two hydraulically operated jacks of 10tons capacity and 200mm lift, complete with hand operated pump unit and hoses.

39.10.5 SLING AND SHACKLES

Eight wire rope slings complete with eyes, each of 2,000kg capacity and 3.5m overall length.

Eight wire rope slings complete with eyes, each of 500kg capacity and 2.5m overall length.

Sixteen ‘D’ shackles of 2,000kg capacity
Sixteen ‘D’ shackles of 500kg capacity

39.11 GARAGE EQUIPMENT

39.11.1 COMPRESSED AIR INSTALLATION

One receiver mounted reciprocating air compressor to the following specification:

Capacity: 15 liters/sec (at 0^{o}C & 1.0325 bar abs)

The compressor to be completed with motor starter, mounting feet, intercooler, air intake filter/silencer, pressure gauge, safety valves, pressure-activated automatic stop/start control, and self-draining water trap fitted to that receiver.

The compressor shall be connected to permanently installed pipe work, which shall be completed with blow down valves, water traps, coupling points and a pressure regulator as required.

39.11.2 BENCH GRINDER

One general purpose bench-mounted grinder to the following specification:

Wheel Diameter: 150 mm

39.11.3 TROLLEY JACKS

Two hydraulic operated trolley jacks of 1.5ton capacity and 600mm lift.

One Hydraulic operated trolley jack of 5ton capacity and 600mm lift.

39.11.4 HYDRAULIC JACKS

Two hydraulic jacks of 1.0ton capacity and 350mm lift.

One hydraulic jacks of 5ton capacity and 350mm lift.

39.11.5 AXLE STANDS

Three adjustable axle stands of all-steel construction and of 2ton capacity and maximum height of 600mm.

Two mechanic’s creepers of wooden or fiberglass construction, fitted with castor wheels and padded head-rest.

39.11.6 GREASE PUMP

One manually operated grease pump to suit a 20kg grease pail.

39.11.7 DRUM PUMP

One manually operated oil drum pump to suit 200 litre oil drums.

39.11.8 PORTABLE LUBRICATION UNITS

One portable hand-pressurized lubrication units fitted with a grease gun and 2m of grease hose.

39.11.9 CHAIN BLOCK

One 1,000kg capacity hand-operated chain block complete with chain and hooks, and a chain length of 5,000mm.

39.11.10 PORTABLE AIR & POWER TOOLS

Air tools shall be capable of operating at a pressure range of 3.5 to 9 bar (g). Power tools shall be of double-insulated construction, 230 Volt single phase 50 Hz operation and complete with power lead.
All portable tools shall be supplied with 4 (four) chuck and/or arbor keys for each tool.

- Impact Wrenches
  Two air impact wrenches 0.5” (12mm) square drive.

- Air Guns
  Two trigger-operated air duster guns.

- Electric Drill
  One 10mm capacity in mild steel, 2 speed (900/2,400 rpm) complete with one set of high speed drill bits. One 13mm capacity in mild steel, single speed (750 rpm) complete with one set of high speed drill bits.

- Angle Grinder
  One electric angle grinder to take 100mm diameter wheel.

39.11.11 HAND TOOLS

All hand tools shall supplied from a reputable manufacturer. Tools may be supplied on an individual item bases as detailed below, or, alternatively, consideration will be given to manufacturer’s standard sets of tools, provided that they substantially include the tools itemized below.

- Spanner Sets
  One set of ring spanners 4mm to 36mm
  One set of open-end spanners 4mm to 36mm

Two sets of adjustable wrenches 4”, 6”, 15”.

- Sockets Sets

  One set 3/8” (10mm) drive, complete with ratchet, power bar, speed wrench, extensions and sockets 5mm to 19mm and 5/16” to 3/4” A/F.
  One set 0.5” (12mm) drive, complete with ratchet, power bar, speed wrench, extensions and sockets 19mm to 38mm and 3/4” to 1.5” A/F.

- Torque Wrench

  Two torque wrenches of 160 N-m capacity

- Pliers

  Two each of side cutting, slip-joint, long-nose, internal circlip, external circlip and self locking pliers, plus one automotive electrical crimping tool.

- Hammers

  Engineer’s ball-pin hammers of 0.125kg, 0.250kg and 0.900kg. Two copper-faced mallets.

- Screwdrivers

  Two screwdrivers with 3”, 6”, 10” and 12” blades
  One set Philips-head screwdrivers

- Miscellaneous Tools

  Two hacksaws with ten (10) blades
  One set of cold chisels 12mm, 25mm, 40mm
  One set of punches including centre punches (2) and pin punches (4)
  Cooper drifts (2)
  One external micrometer 0/50 mm
  One set vernier calibers (200mm range)
  One dial indicating gauge (metric) with magnetic base
  Two hex wrench sets 2-10mm
  One set 3 jaws and 2 jaws wheel/gear pullers One tap and die set M3 to M16
  Two soldering guns 230 V, 100 W instant heat
  Two soldering iron 230 V, 600 W
  One set stud removers
  One set high speed steel drill bits 1.6 to 10 mm

39.11.12 MISCELLANEOUS EQUIPMENT

a) Three inspection lamps, complete with 230 Volt, 75 W rough duty bulbs and 5m of lead
b) Two cast-steel engineer’s vice with 150mm jaws
c) One reel-mounted electric extension leads, length 20 meters, complete with plugs
d) One electric extension leads, length 10 meters, complete with plugs
e) Two sets of heavy-duty jumper leads, 3m long complete with alligator clips

f) Four nylon or hemp towropes, 4m long, complete with towing eyes.

g) Breaking strain 2,000kg

39.11.13 SAFETY EQUIPMENT

Equipment supplied under this Section shall be supplied from a reputable manufacturer. Replacement items are to be readily available.

Six pairs full-length overall (cotton gabardine)
Two pairs of welding goggles
Two pairs of clear safety boots
One first aid kit of suitable size and content

39.12 WAREHOUSE

		Total No. Required
a)	High rise storage racks for pallets	500
	Dexion Shelves or as equivalent (840 W x 2,700 L x 5,000H)	
b)	Pallets	
	Timber 1,160 mm square	1,000
	Small timber frames	200
	Medium timber frames	400
	Large timber frames	400
c)	Steel racks for storing pipe, rod and bar stock	4
	8 shelves - 1,200 W x 6,000 L x 2,100 H	
d)	Storage Cabinets: 710 W x 750 L x 1,500H	2
e)	Wire ropes:	
	for small pallet frame	200
	for medium pallet frame	200
f)	Shelves (modules)	70
	8 shelves - 300W x 2,380L x 920 H	
g)	Portable bunds fibreglass for liquid spills	2
h)	Wall boards with hooks store V bolts 1,220 W x 2,750 L	3
i)	Horizontal Plan Cabinets for storing gaskets	3
j)	500mm Power Hacksaw	1

k)	First aid kit for minor injure treatment 600 x 600 x 200 wall mounted	1
l)	Folded ladder:	
	big	1
	small	1

The above items has been prepared on the basis that the Warehouse and shall be constructed with a high roofed storage area, and shall incorporate a layout with provision for a service counter area, goods receipt delivery area, an outdoor secure storage area (man - proof wire fencing), open floor area for storage of large items of equipment, chemical hazardous store, hot store for mechanical equipment, cold store for electrical and I&C equipment. All these area shall have vehicular access.

The Storage Area shall have quality mercury vapour roof lighting, a compressed air supply, fire-fighting system (with fire hoses and reels), a clean domestic water supply, with single phase and 3 - phase power supplies to General Power Outlets and Welding Power Outlet.

Especially, the Contractor shall maintain the following conditions.

a) Hot store

Temperature	4.5^{o}C to 60^{o}C, at least 5.5^{o}C above the dew point
Relative humidity	50% or less

b) Cold store

Temperature	20^{o}C to 25^{o}C
Relative humidity	50% or less

The suitable equipment and materials shall be confirmed by the Contractor for the Employer’s review and approval.

39.13 INSTALLATION

39.13.1 WORKSHOP MACHINERY

The Workshop Machinery as described in sub-clause 39.9 shall be installed as follows:

a) Installation in the workshop and store to positions, using manufacturer’s recommended procedures for holding down, fixing and grouting into position as necessary.
b) Removal of all shipping protective coatings, and connection to the electrical supply, filling with all lubricants, greases and coolants.
c) Run all equipment through all cycle of operation as relevant, including the machining of test work-pieces.

d) Check all connections, fittings, motors, drives, levels and fastenings after completion of the running period.

39.13.2 TOOLS

Tools as described in sub-clause 39.9.13 and 39.9.14 shall be delivered to the workshop and fitted to the storage racks specified in sub-clause 39.9.12, using suitable clips and retainers.

39.13.3 SAFETY EQUIPMENT

Safety equipment as described in sub-clause 39.9.15 shall be delivered to the store.

39.13.4 MISCELLANEOUS LIFTING EQUIPMENT

The Chain Hoists, Load Pullers, Hydraulic Jacks, Slings and Shackles shall be delivered to the workshop, all shipping protective coatings removed, and each item shall be tested with a static load of 1.5 times its rated load.

39.13.5 GARAGE EQUIPMENT

The garage equipment as described in sub-clause 39.10 shall be installed and commissioned as follows:

a) Installation in the garage using manufacturer's recommended procedures for holding down, fixing and grouting into position as necessary.
b) Removal of all shipping protective coatings, and connection to the electrical supply, filling with all lubricants, greases and coolants.
c) Run all equipment through all cycles of operation as relevant.
d) Check all connections, fittings, motors, drives, levels and fastenings after completion of the running period.

39.13.6 HAND TOOLS

Hand tools as described in sub-clause 39.11.11 shall be delivered to the garage and fitted to the storage racks.

39.13.7 MISCELLANEOUS AND SAFETY EQUIPMENT

Miscellaneous and safety equipment as described in sub-clause 39.11.12 and 39.11.12 shall be delivered to the garage.

39.14 PAINTING

Before shipment, all parts of the equipment shall be thoroughly cleaned of all mill scale, rust, grease and other foreign matter, and shall be given one prime coat of paint, suitable for the specified operating and environment conditions. The color of the prime coat shall be the manufacturer's standards. No paint having an asphaltic based shall be used.

The Contractor shall ship a sufficient quantity of paint of touching up where prime coat has been damaged during shipment and erection. Paint shall be the same kind and quality as used for each piece of equipment in the shop.

39.15 TESTING

39.15.1 SHOP TEST

Test procedures shall be in accordance with sub-clause 3.11.3 of Chapter 3 of Section 5 and the QA/QC specified in sub-clause 39.16 below.

The equipment shall be completely assembled in the manufacturer's premises. All motors, controls and machinery shall be connected and operated under its own power at rated voltage and the volts, amperes and watts recorded for each operation. Electrical circuits and interlocks shall be tested for correct operation and sequence, motor shall be merger, and all tests shall be subject to witness and approval by Employer.

Before disassembling, the shop assembly of the equipment shall be subject to approval by the Employer. Connecting parts shall be match-marked to facilitate field erection. Match–mark shall be shown on erection drawing finished by the Contractor. Each part designated on the erection drawings by a mark number shall be clearly and legibly marked in a cons pious place with the appropriate number if it is to be shipped separately.

39.15.2 SITE TEST

Test procedures shall be in accordance with sub-clause 3.11 of Chapter 3 of Section 5.

39.16 QUALITY ASSURANCE/QUALITY CONTROL

Quality Control shall conform to the requirements of sub-clause 3.11 of Chapter 3 of Section 5.

SECTION 5 – EMPLOYER’S REQUIREMENTS

CHAPTER 40 – NON-FUNCTIONAL AND OTHER FACILITIES

CONTENTS

40 NON-FUNCTIONAL AND OTHER FACILITIES

40.1 GENERAL

The Contractor is required to provide a comfortable accommodation and amenities suitably located within the Site for the Employer and the Engineer. Proposed location is indicated in drawing no. 10-PM-PAY-01, but the final location will be decided prior to award to Contract.

The buildings shall be reinforced concrete with center courtyard under one roof concept. All facilities/amenities indicated in the drawings shall be provided by the Contractor with prior approval of the Employer/the Engineer. The Contractor shall provide the detailed drawing for approval to the Employer/the Engineer prior to implementation. The details for each building are provided in the sections below. However, the final layout and details of these buildings / facilities shall be subject to the acceptance of the Employer.

40.2 ADMINISTRATION BUILDING

General:
The proposed Administration Building is to house the management and other administrative and support staff for the proposed power station. The building shall be 3 (three) storey reinforced concrete building with brick walls as internal / external walls. A typical layout of the proposed floors are shown in drawings no. 10-PC-PAY-9, 10-PC-PAY-10 and 10-PC-PAY-11 in Attachment D of Section 5. The Bidder to note that the proposed layouts are preliminary and subject to the changes for the full acceptance of the Employer. The proposed layouts have also included space and facilities for the future extension of the power plant.

Description of building:

- Structure: Reinforced concrete structure
- Floors: 3 floors (Minimum)
- Flooring: See below
- Foundations: according to the soil investigation report and Special Technical Requirements of Foundations
- External wall: 230 mm thick brick walls
- Internal wall: 115 mm thick brick walls or autoclave aerated concrete blocks or autoclave aerated concrete blocks with plaster finish
- Access: Internal stairways / one lift (12 persons)
- Doors: composite steel plate door , fireproof door
    - o External: representative double plain door
    - o Internal: aluminium glazed doors and wooden doors with steel frames
- Windows: Double glazed aluminium with internal sun
- Air conditioning: Shades centralized air conditioning,
- Ventilation Natural/mechanical

• Sanitary equipment in the office area:	-Showers in changing room -WC with cleaning brush in toilet -Bowl urinal in male toilet -Wash basins in toilet
• Finishes:	For this building prestigious finishes shall be provided. The offices shall have vitrified tile flooring; in the manager's flooring, office fabricwall carpet coverings, and decorative suspended ceilings with lighting fittings embedded. Floor and walls of the kitchen future shall be fully tiled. Entrance hall and stairs with polished granite stone flooring. The shower cabins to have partition walls with doors

Furniture:
Bidder shall also include the supply of suitable furniture / desks / conference tables etc. for the various facilities shown in the layout plans.

Computers / computer server etc. shall be excluded from the Bidder's scope.

40.3 TOWNSHIP

40.3.1 EXECUTIVE GUEST HOUSE

The single storey building shall consist of a reinforced concrete structure with concrete block walls, reinforced concrete floors and roof. A high quality accommodation for twenty (20) international guest / staff on three star hotel standard. A typical layout of this facility is shown in the drawing no. xx in Attachment D of Section 5. The Executive Guest Houses shall include living room space, air-condition, satellite/cable televisions, telephone system, cable and wireless internet (WIFI), attached bathroom with heater and toilets. The rooms have to be fully furnished with king size bed sets, cupboard, desk & chair, refrigerator, table lamps and lightings, tile flooring and all necessary fittings.

One (1) duty diesel generator shall be supplied to provide stable power supply for the guest house. The Contractor shall provide the detailed drawing for approval of the Employer/the Engineer prior to implementation.

The following rooms shall be accommodated in this building:

- entrance hall/lobby
- fully furnished and equipped management office
- 20 nos. guest house rooms
- fully equipped kitchen
- fully equipped laundry room
- store

- fully furnished lounge
- fully furnished dining hall
- fully equipped gymnasium
- sanitary rooms (toilets)

Apart from the above:

- A practical kitchenette and equipment with electrical sockets and space for a fridge and microwave oven. Material must be robust, durable and corrosion-resistance finishes. The area has to be bright, well-ventilated interiors conforming to safety standards.
- The accommodations to have doors, windows for optimum daylight ambient and adequate ventilation system, kitchen and dining hall.
- Adequate dining tables and chairs.
- A furnished lounge space with sofa sets, tables and chairs and large screen television set.
- An appropriate landscaping around the accommodation for serene environment.

40.3.2 VVIP REST HOUSE

The single storey building shall consist of a reinforced concrete structure with concrete block walls, reinforced concrete floors and roof. A high quality accommodation of four (4) five star hotel standard VVIP Rest Houses with living room space, dining area, air-condition, satellite/cable televisions, telephone system, cable and wireless internet (WIFI), attached bathroom with heater and toilets. The rooms have to be fully furnished with king size bed sets, cupboard, desk & chair, refrigerator, sofa sets, table lamps and lightings, tile flooring and all necessary fittings. A typical layout of this facility is shown in the drawing no. 10-PC-PAY-06 in Attachment D of Section 5.

One (1) duty diesel generator shall be supplied to provide stable power supply of the guest house. The Contractor shall provide the detailed drawing for approval of the Employer/the Engineer prior to implementation.

Apart from the above:

- A practical kitchenette and equipment with electrical sockets and space for a fridge and microwave oven. Material must be robust, durable and corrosion-resistance finishes. The area has to be bright, well-ventilated interiors conforming to safety standards.
- The accommodations to have doors, windows for optimum daylight ambient and adequate ventilation system, kitchen and dining hall.
- Adequate dining tables and chairs.
- An appropriate landscaping around the accommodation for serene environment.

40.3.3 TENNIS COURTS

The Contractor shall provide One (1) tennis court within close vicinity of the rest house. The Contractor shall provide the detailed drawing for approval of the Employer/the Engineer prior to implementation.

40.3.4 SWIMMING POOL

The Contractor shall provide One (1) swimming pool within close vicinity of the rest house. The minimum dimensions of the swimming pool shall be, length: 25meters, width: 19meters and depth: 1meter to 2meters fall. The Contractor shall provide the detailed drawing for approval of the Employer/the Engineer prior to implementation.

40.4 OTHER FACILITIES

40.4.1 CLINIC

The single storey building shall consist of a reinforced concrete structure with concrete block walls, reinforced concrete floors and roof. A high quality fully equipped clinic complete with air-condition, telephone system, cable and wireless internet (WIFI) and toilets. The clinic have to be fully furnished with medical furniture, cupboards, desk & chair, refrigerator, lightings, tile flooring and all necessary fittings. A typical layout of this facility is shown in the drawing no. 10-PC-PAY-07 in Attachment D of Section 5.

The following rooms shall be accommodated in this building:

- Register/Dispensary
- Consultation room
- Treatment room
- Store room
- Tea kitchen
- Rest room
- Waiting area
- sanitary rooms (toilets)

Apart from the above:

- An appropriate landscaping around the clinic for serene environment.

40.4.2 HELIPAD

The Contractor shall provide two (2) helipads with compliance to all international aviation standards. The Contractor shall provide the detailed drawing for approval of the Employer/the Engineer prior to implementation.

40.5 EMPLOYER'S AND ENGINEER'S OFFICE

An Employer's and Engineer's office as shown in drawing no. 10-PC-PAY-08 in Attachment B4 of Section 5 shall be provided and maintained throughout the construction period.

Every working place shall be equipped with a computer, connected to a local network with common printer.

These offices shall be semi-permanent reinforced concrete structures, according to the civil specifications. The offices shall be ready for occupation latest 8 weeks following the commencement of the works at the site.

Kitchen shall be equipped with cupboard, refrigerator and heating plate, or electric oven, china and tools, dish washer, glasses and coffee machine, etc.

Sun shaded car parks, septic tank and cesspool shall be included as well as a temporary elevated water tank. AC window units and sufficient power supply shall be included.

The following additional equipment shall be made available in sufficient number:

- automatic telephone exchange (domestic lines)
- telephone installed in each room
- CAD work stations
- colour printer for drawings up to A0 size
- colour printers for documents size A4 & A3
- photocopying machines for A4 & A3
- PC's with related processor and standard office software.

This equipment shall be state-of-the-art and furniture shall be of 1st class standard; all are subject to approval by the Engineer. The Contractor shall provide the offices with electricity, water, coolers and refrigerators.

All office supplies, operating and maintenance costs for the offices and the installed equipment shall be at the period of contract the full service of the equipment with consumables (toner cartridges, paper, etc.) and the billing cost of telephone, telefax and internet browsing.

40.6 MINI FIRE STATION

The mini fire station operating on the Plant shall adhere to NFPA requirements and shall have the necessary equipment to perform firefighting during a fire breakout. Sufficient training will be provided to the on-site firefighting personel who will respond in the event of a fire emergency.

40.6.1 ORGANIZATIONAL RESPONSIBILITIES

The Contractor shall propose an organizational structure for the mini fire station. The organizational structure would indicate the number of firefighting personnel required and their duties and responsibilities. The organizational structure must be designed to establish a line of authority. Based on the organizational structure suggested, the Employer will hire the necessary staff.

Furthermore, appropriate trainings and fire drills shall be conducted to ensure the team is fully prepared in the event of a fire breakout. The type, amount and frequency of training is to be determined by the Employer, based on the organizational structure provided by the Contractor. The type of training has to be based on the responsibility and duties of each firefighting personnel.

40.6.2 FIRE FIGHTERS EQUIPMENT

The firefighting personnel shall be provided with the appropriate equipment to enable them to perform their responsibilities as indicated in the organizational structure. The equipment distribution is based on the personnel's responsibilities. Below is a list of appropriate equipment based on NFPA standards:

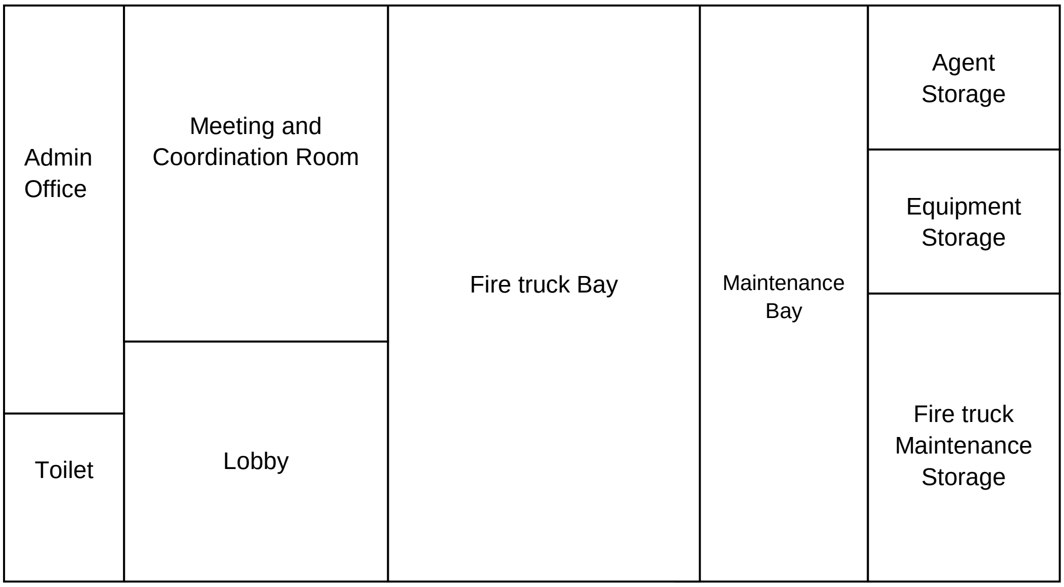
a) Thermal protective clothing and protective equipment
b) Helmet, gloves and footwear in accordance with NFPA 1971
c) Self-Contained Breathing Apparatus (SCBA) that is accordance with NFPA and NIOSH
d) Personnel Alert Safety System (PASS) in accordance with NFPA 1982
e) Other relevant protective equipment

The PPE must be used in accordance to manufacturer's instructions. There must be a clear inspection and maintenance schedule as well as a responsible person for the PPE. All equipment must be stored appropriately in the fire station and be made easily available in the event of an emergency.

The Contractor shall further suggest any other additional equipment that will be needed for firefighting in a coal fired power plant and its facilities. The quantity of equipment needed will be suggested by the Contractor based on the organizational structure. There must also be sufficient spare equipment.

40.6.3 FIRESTATION LAYOUT

Below is a proposed layout for the mini firefighting station



Agent Storage:
This is where all firefighting agents such as fire extinguishers are stored.

Equipment Storage:
All PPE's are stored in this room. It has to be in proper order and be easily available during an emergency.

Fire truck maintenance storage:
This room is where all spare parts for the fire truck is stored.

Maintenance Bay:
This area is where all maintenance of firefighting equipment and fire extinguishers are done. A portion of this area shall be specifically allocated for disinfecting the protective equipment and discharging the SCBA.

Fire truck Bay:
The fire truck bay is where the fire truck will be parked. The bay needs to be designed in accordance with the size of the fire truck, as each fire truck varies in size. The bay needs to have vehicle exhaust removal system and proper ventilation. The bay door must be large enough to allow the fire truck to enter and it must also be able to be operated manually, in case of a power failure.

Meeting and coordination room:
The meeting and coordination room will include information regarding the responsibilities of each firefighting personnel. It will also be used for briefings and meetings.

40.6.4 WELL EQUIPPED FIRETRUCK

The recommended specification for a well-equipped fire truck is as below. The Contractor shall suggest other additional specifications that may be required for firefighting in a coal fired power plant and its facilities.

Requirements	Recommended Specification
Type	Aerial type fire truck
Ladder height	25m horizontal reach
Elevation range	Minimum 80°
Tank Capacity	Water 3500 L / Foam 1500 L
Flow rate	Pump and generator must be able to achieve the requirements below: 1.0 MPa (Normal Pressure) 80 L/s 2.0 MPa (Normal Pressure) 40 L/s
Spray Range	65m

40.7 VEHICLES

40.7.1 SITE TRANSPORTATION

The Contractor shall provide specified vehicles to the Employer.

Requirements of vehicles are as follows:

- Eight (8) Jeeps with capacity of (at least - 3000CC)
- Six (6) Pick-Ups with capacity of (at least - 3000CC)
- Two (2) Microbus with min. of (10 passengers)
- Two (2) Microbus with min. of (8 passengers)
- One (1) Truck with capacity of (10 tonnes)
- One (1) Helicopter with capacity of (6 passengers)
- One (1) Speedboat with capacity of (15 passengers)
- One (1) Speedboat with capacity of (10 passengers)
- One (1) well equipped Fire Brigade Truck

The Contractor shall also provide O&M cost with fuel (25 litters per car, per day in average) and drivers.

All vehicles shall be a new model and comply with the requirements outlined in this specification.

Jeep

- Minimum 5 speed auto/manual transmission with Four Wheel Drive (4WD)
- 5 Seated Station Wagon type
- Features shall include leather seats, dual safety air bags inflate and air conditioning
- Power Assisted Steering
- Heavy Duty Steel Wheel for on-road and off-road drive
- Anti-lock Braking System (ABS) with Electric Traction Control (ETC) and Dynamic Stability Control
- The jeep shall equipped with an central locking and alarm system that includes an engine immobilizer and a siren with backup battery to help prevent the possibility of theft
- Heavy Duty chassis (corrosion-resistant aluminium body panels) and suspensions
- Towing Winch capability of 3,500kg.

Pick Ups

- Minimum 5 speed auto/manual transmission with Four Wheel Drive (4WD)
- 5 Seated
- Features shall include leather seats, dual safety air bags inflate and air conditioning
- Power Assisted Steering
- Heavy Duty Steel Wheel for on-road and off-road drive
- Anti-lock Braking System (ABS) with Electric Traction Control (ETC) and Dynamic Stability Control
- The jeep shall equipped with an central locking and alarm system that includes an engine immobilizer and a siren with backup battery to help prevent the possibility of theft
- Heavy Duty chassis (corrosion-resistant aluminium body panels) and suspensions
- Towing Winch capability of 3,500kg.
- At least 1.68 meter long cargo deck

Micro Bus

- minimum 5 speed auto/manual transmission
- Central locking and Alarm System
- Features shall include leather seats, dual Safety Air Bags inflate and air conditioning
- The seats shall capable of configure in multiple ways so that it could accommodate any occasions and needs
- Power Assisted Steering
- Anti-lock Braking System (ABS) with Electric Traction Control (ETC) and Dynamic Stability Control

- The microbus shall equipped with an alarm system that includes an engine immobilizer and a siren with backup battery to help prevent the possibility of theft
- Towing Winch capability of 3,500kg.
- The microbus shall consist of First Aid Kit, jumper cables and a safety triangle in the event of any unforeseen emergencies.
- The micro bus shall be fuel efficient, requires low maintenance, offers great performance and durability, and is highly economical for various organizations to consider as a shuttle service.

Truck

- 6 cyl. In-line, Turbocharged Intercooler, Direct Injection
- The truck shall be 10 tonne wheelbase chassis to allow for cargo space up.
- The truck shall suitable for typical applications include construction, regional and local distribution as well as short-range transportation and services.
- Anti-lock Braking System (ABS) with Electric Traction Control (ETC) and Dynamic Stability Control
- The truck shall consist of First Aid Kit, jumper cables and a safety triangle in the event of any unforeseen emergencies.
- Features shall include Air Suspension Driver Seat, Dual Safety Air Bags inflate and air conditioning

Helicopter

Helicopter proposed to be deployed must be brand new meeting the following specification:

- Seating capacity (min): 1 (one) Pilot + 6 (six) Passengers
- Interior: Air Conditioned, Corporate interior and large windows for good visibility.
- Engine: 813 shp/606 kW, FADEC-controlled Rolls-Royce 250-C47B/8 turbine engine or equivalent
- Max Cruise speed: min 133 Knots

Note: (i) Bidder shall provide technical catalogue for the offered Helicopter.

- The helicopter shall equipped with Integrated Visual Flight Rules (VFR) equipment coupled with a Global Positioning System (GPS)
- The helicopter should be able to carry baggage at 10 Kg per passenger
- The helicopter and its operation & maintenance shall conform to the requirements as per CAAB (latest edition) and any other applicable regulation of such services.
- The helicopter is to be utilized mainly for transportation of passengers
- The helicopter should have certification of manufacturing company and the same should be acceptable to CAAB.
- The Helicopter should be equipped with all the necessary gadgets for safe flying operations such as navigational and communication equipment, life saving appliances, fire extinguisher, etc

Speed boat

The boats shall be delivered as per the following specifications:

Passenger Capacity: One (1) for 10 seater and One (1) for 15 seater

- This boat shall be used as an ordinary passenger speed boat and as a rescue boat / ambulance boat in case of emergencies
- The boat shall have hard top cover and nonskid fiber glass flooring.
- The 10 and 15 passenger boats hull shall be constructed with fiberglass reinforced plastic (FRP) and be fully strengthened.
- The boats shall be tested for safety of passengers with accordance to maritime standards.
- The boats shall be swam tested, and be provided with full buoyancy.
- The boat shall have a provision for storing emergency first aid kits,
- The boats ideally be powered by two (2) of 4 Stroke out board engine of 200 HP, with remote control.
- Lockers for general storage and general items.
- The boat shall be equipped with DC lights, DC fans, emergency lamp points/sockets.
- The boats shall have fire extinguishers (DCP & Foam type), life jackets, life buoys, search light, horn , etc
- The boats shall be equipped with adequate maritime navigation and communication systems.
- Propose to use the Jetty facility for embarking / disembarking of passenger.

40.7.2 MAINTENANCE VEHICLE

The Contractor shall provide the following maintenance vehicle to the Employer as part of the operational and maintenance requirement of the Plant:

a) Mobile Crane
b) Diesel Forklift
c) Cargo Truck
d) Platform Truck
e) Industrial Vehicle with Platform
f) Bull dozer

The Mobile Crane and Diesel Forklift shall be delivered to the warehouse, all unpacked and all shipping protective coatings shall be removed, tested through all lifting motions and carrying full rated load.

The Cargo Truck, Platform Truck, Industrial Vehicle and Load Skates shall be delivered to the store, unpacked and all shipping protective coatings removed.

40.7.2.1 MOBILE CRANE

One of 50 ton mobile crane shall be equipped with air conditioning for operator enclosure

40.7.2.2 DIESEL FORKLIFT TRUCK

One of 5,000kg forklift

40.7.2.3 CARGO TRUCK

One of 14 tons cargo truck

40.7.2.4 PLATFORM TRUCK

One of 2,000kg hand operated platform truck

40.7.2.5 INDUSTRIAL VEHICLE

Industrial vehicle with rising personnel
150kg Loading capacity and 12m maximum height

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 41 – BANK GUARANTEES AND CERTIFICATES

CONTENTS

41 BANK GUARANTEES AND CERTIFICATES

41.1 FORM OF PERFORMANCE SECURITY

..................................Bank's Name, and Address of Issuing Branch or Office ....

Beneficiary: ....*Name and Address of Employer* ....

Date:...

Performance Guarantee No.: ....

We have been informed that . . . . . ***name of the Contractor***. . . . . (hereinafter called "the Contractor") has entered into Contract No. . . . . . ***reference number of the Contract***. . . . . dated . . . . .with you, for the execution of . . . . . . ***name of contract and brief description of Works***. . . . . (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, a performance guarantee is required.

At the request of the Contractor, we . . . . . name of the Bank. . . . . hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of . . . . . name of the currency and amount in figures*. . . . . . (. . . . . amount in words. . . . .) such sum being payable in the types and proportions of currencies in which the Contract Price is payable, upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation(s) under the Contract, without your needing to prove or to show grounds for your demand or the sum specified therein.

This guarantee shall expire no later than the earlier of:

(a) twenty four months after our receipt of:

(i) a copy of the Operational Acceptance Certificate; or

(ii) a registered letter from the Contractor, attaching a copy of the notice to the project manager that the Facilities are ready for commissioning, and stating that 14 days have elapsed from receipt of such notice (or 7 days have elapsed if the notice was a repeated notice) and the project manager has failed to issue a Operational Acceptance Certificate or inform the Contractor in writing of any defects or deficiencies; or

(b) the ____ day of _____, 2___.

Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees, ICC Publication No. 758, except that subparagraph (ii) of Sub-article 20(a) is hereby excluded.

. . . .

Seal of Bank and Signature(s)

41.2 FORM OF ADVANCE PAYMENT SECURITY

.................................Bank's Name, and Address of Issuing Branch or Office ....

Beneficiary: ***..................................Name and Address of Employer ....***

Date:...

Advance Payment Guarantee No.: ....

We have been informed that . . . . . ***name of the Contractor****. . . . .* (hereinafter called "the Contractor") has entered into Contract No. . . . . . ***reference number of the Contract****. . . . .* dated . . . . .with you, for the execution of . . . . . . ***name of contract and brief description of Works****. . . . .* (hereinafter called "the Contract").

Furthermore, we understand that, according to the Conditions of the Contract, an advance payment in the sum . . . . . (***the Guarantor shall insert an amount representing the amount of the advance payment denominated either in the currency(ies) of the advance payment as specified in the Contract, or in a freely convertible currency acceptable to the Employer.)****. . . . . .* (. . . . . ***amount in words****. . . . .*) is to be made against an advance payment guarantee.

At the request of the Contractor, we . . . . . ***name of the Bank****. . . . .* hereby irrevocably undertake to pay you any sum or sums not exceeding in total an amount of . . . . . ***name of the currency and amount in figures*****. . . . . .* (. . . . . ***amount in words****. . . . .*) upon receipt by us of your first demand in writing accompanied by a written statement stating that the Contractor is in breach of its obligation under the Contract because the Contractor used the advance payment for purposes other than the costs of mobilization in respect of the Works.

It is a condition for any claim and payment under this guarantee to be made that the advance payment referred to above must have been received by the Contractor on its account number . . . . . ***Contractor's account number****. . . . .* at . . . . . ***name and address of the Bank****. . . . . .*

The maximum amount of this guarantee shall be progressively reduced by the amount of the advance payment repaid by the Contractor as indicated in copies of interim statements or payment certificates which shall be presented to us. This guarantee shall expire, at the latest, upon our receipt of a copy of the interim payment certificate indicating that 80% percent of the Contract Price has been certified for payment, or on the . . . day of . . . . . . ***(insert the expected expiration date of the Time for Completion. The Employer should note that in the event of an extension of the time for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Employer's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee").*** , ..., whichever is earlier. Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date..

This guarantee is subject to the Uniform Rules for Demand Guarantees, ICC Publication No. 458.

. . . .

Seal of Bank and Signature(s)

41.3 FORM OF MECHANICAL COMPLETION CERTIFICATE

Contract: [. . . . .***insert name of contract and contract identification details***. . . . .]

Date: ....

Certificate No.: ....

To: [. . . . .***insert name and address of Contractor***. . . . .]

Dear Ladies and/or Gentlemen,

Pursuant to GC Clause 24 (Mechanical Completion of the Facilities) of the General Conditions of the Contract entered into between yourselves and the Employer dated [. . . . .***insert date***. . . . .], relating to the [. . . .***brief description of the Facilities*** . . . .], we hereby notify you that the following part(s) of the Facilities was (were) complete on the date specified below.

1. Description of the Facilities or part thereof: [. . . .***description*** . . . .]

2. Date of Completion: [. . . .***date*** . . . .]

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

[. . . .***Signature*** . . . .]

Project Manager

41.4 FORM OF OPERATIONAL ACCEPTANCE CERTIFICATE

Contract: [. . . . .***insert name of contract and contract identification details***. . . . .]

Date: ....

Certificate No.: ....

To: [. . . . .***insert name and address of Contractor***. . . . .]

Pursuant to GCC Sub-Clause 25.3 (Operational Acceptance) of the General Conditions of Contract entered into between yourselves and the Employer dated [***date***], relating to the [***brief description of the Facilities***], we hereby notify you that the Functional Guarantees of the following part(s) of the Facilities were satisfactorily attained on the date specified below and that, in accordance with the terms of the Contract, the Employer hereby takes over the said part(s) of the Facilities, together with the responsibility for care and custody and the risk of loss thereof on the date mentioned below.

1. Description of the Facilities or part thereof: [***description***]

2. Date of Operational Acceptance: [***date***]

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

[. . . .***Signature*** . . . .]

Project Manager

41.5 FORM OF SUBCONTRACTOR / MANUFACTURER'S RECEIPT

Contract: [… … ***insert name of contract and contract identification details*** … …]

Date: ....

Reference No.: ....

From: [… … ***insert name and address of Sub-Contractor / Manufacturer*** … …]

To: [… … ***insert name and address of Contractor*** … …]

We herewith confirm that we have effectively received on [… … ***insert date*** … …] a purchase order along with down-payment for supply of [… … ***brief description of scope of supply / services*** … …] for Payra Thermal Power Plant (2 x 660MW).

We also confirm that, our Sub-Contract for the supply of above described items is effective and will be delivered as per the agreed schedule.

…………………………...

Authorized Signatory for

[… … insert name of Sub-Contractor / Manufacturer … …]

SECTION 5 – EMPLOYER'S REQUIREMENTS

CHAPTER 42 – CHANGE ORDERS

CONTENTS

42 CHANGE ORDERS

42.1 CHANGE ORDER PROCEDURE

42.1.1 GENERAL

This section provides samples of procedures and forms for implementing changes in the Facilities during the performance of the Contract in accordance with GCC Clause 39 (Change in the Facilities) of the General Conditions of Contract.

42.1.2 CHANGE ORDER LOG

The Contractor shall keep an up-to-date Change Order Log to show the current status of Requests for Change and Changes authorized or pending. Entries of the Changes in the Change Order Log shall be made to ensure that the log is up-to-date. The Contractor shall attach a copy of the current Change Order Log in the monthly progress report to be submitted to the Employer.

42.1.3 REFERENCES FOR CHANGES

1) Request for Change as referred to in GCC Clause 39 shall be serially numbered CR-X-nnn.
2) Estimate for Change Proposal as referred to in GCC Clause 39 shall be serially numbered CN-X-nnn.
3) Acceptance of Estimate as referred to in GCC Clause 39 shall be serially numbered CA-X-nnn.
4) Change Proposal as referred to in GCC Clause 39 shall be serially numbered CP-X-nnn.
5) Change Order as referred to in GCC Clause 39 shall be serially numbered CO-X-nnn.

Note:

a) Requests for Change issued from the Employer's Home Office and the Site representatives of the Employer shall have the following respective references:

Home Office	CR-H-nnn
Site	CR-S-nnn

b) The above number "nnn" is the same for Request for Change, Estimate for Change Proposal, Acceptance of Estimate, Change Proposal and Change Order.

42.2 CHANGE ORDER FORMS

42.2.1 REQUEST FOR CHANGE PROPOSAL FORM

[***Employer's Letterhead***]

To: [***Contractor's name and address***] Date:
Attention: [***Name and title***]

Contract Name: [***Contract name***]
Contract Number: [***Contract number***]

Dear Ladies and/or Gentlemen:

With reference to the captioned Contract, you are requested to prepare and submit a Change Proposal for the Change noted below in accordance with the following instructions within [***number***] days of the date of this letter [or on or before (***date***)].

1. Title of Change: [***Title***]
2. Change Request No./Rev.: [***Number***]
3. Originator of Change:
   Employer: [Name]
   Contractor (by Application for Change Proposal No. [Number]
4. Brief Description of Change: [***Description***]
5. Facilities and/or Item No. of equipment related to the requested Change: [***Description***]
6. Reference drawings and/or technical documents for the request of Change:
   Drawing No./Document No. ***Description***
7. Detailed conditions or special requirements on the requested Change: [***Description***]
8. General Terms and Conditions:
   (a) Please submit your estimate to us showing what effect the requested Change will have on the Contract Price.
   (b) Your estimate shall include your claim for the additional time, if any, for completion of the requested Change.
   (c) If you have any critical opinion regarding the adoption of the requested Change in connection with the conformability to the other provisions of the Contract or the safety of the Plant or Facilities, please inform us of your opinion in your proposal of revised provisions.
   (d) Any increase or decrease in the work of the Contractor relating to the services of its personnel shall be calculated.
   (e) You shall not proceed with the execution of the work for the requested Change until we have accepted and confirmed the amount and nature in writing.

[***Employer's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

42.2.2 ESTIMATE FOR CHANGE PROPOSAL FORM

[***Contractor's Letterhead***]

To: [***Employer's name and address***] Date:

Attention: [***Name and title***]

Contract Name: [***Contract name***]
Contract Number: [***Contract number***]

Dear Ladies and/or Gentlemen:

With reference to your Request for Change Proposal, we are pleased to notify you of the approximate cost of preparing the below-referenced Change Proposal in accordance with GCC Sub-Clause 39.2.1 of the General Conditions of Contract. We acknowledge that your agreement to the cost of preparing the Change Proposal, in accordance with GCC Sub-Clause 39.2.2, is required before estimating the cost for change work.

1. Title of Change: [***Title***]
2. Change Request No./Rev.: [***Number***]
3. Brief Description of Change: [***Description***]
4. Scheduled Impact of Change: [***Description***]
5. Cost for Preparation of Change Proposal: [***insert costs which shall be in the currencies of the Contract***]

(a) Engineering (Amount)

(i) Engineer _______ hrs x _______ rate/hr = _________

(ii) Draftsperson _______ hrs x _______ rate/hr = _________
Sub-total _______ hrs _________
Total Engineering Cost _________

(b) Other Cost _________

Total Cost (a) + (b) _________

[***Contractor's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

42.2.3 ACCEPTANCE OF ESTIMATE FORM

[***Employer's Letterhead***]

To: [***Contractor's name and address***] Date:

Attention: *[**Name and title**]*

Contract Name: *[**Contract name**]*
Contract Number: *[**Contract number**]*

Dear Ladies and/or Gentlemen:

We hereby accept your Estimate for Change Proposal and agree that you should proceed with the preparation of the Change Proposal.

1. Title of Change: [***Title***]
2. Change Request No./Rev.: [***Request number/revision***]
3. Estimate for Change Proposal No./Rev.: [***Proposal number/revision***]
4. Acceptance of Estimate No./Rev.: [***Estimate number/revision***]
5. Brief Description of Change: [***Description***]
6. Other Terms and Conditions: In the event that we decide not to order the Change accepted, you shall be entitled to compensation for the cost of preparation of Change Proposal described in your Estimate for Change Proposal mentioned in para. 3 above in accordance with GCC Clause 39 of the General Conditions of Contract.

[***Employer's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

42.2.4 CHANGE PROPOSAL FORM

[***Contractor's Letterhead***]

To: [***Employer's name and address***] Date:

Attention: [***Name and title***]

Contract Name: [***Contract name***]
Contract Number: [***Contract number***]

Dear Ladies and/or Gentlemen:

In response to your Request for Change Proposal No. [Number], we hereby submit our proposal as follows:

1. Title of Change: [***Name***]
2. Change Proposal No./Rev.: [***Proposal number / revision***]
3. Originator of Change: Employer: [***Name***] / Contractor: [***Name***]
4. Brief Description of Change: [***Description***]
5. Reasons for Change: [***Reason***]
6. Facilities and/or Item No. of Equipment related to the requested Change: [***Facilities***]
7. Reference drawings and/or technical documents for the requested Change: [***Drawing/Document No./Description***]
8. Estimate of increase/decrease to the Contract Price resulting from Change Proposal:

Amount
[***insert amounts in the currencies of the Contrac***t]

(a) Direct material ____________________

(b) Major construction equipment ____________________

(c) Direct field labor (Total hrs) ____________________

(d) Subcontracts ____________________

(e) Indirect material and labor ____________________

(f) Site supervision ____________________

(g) Head office technical staff salaries

Process engineer _______ hrs @ ______ rate/hr ____________________
Project engineer _______ hrs @ ______ rate/hr ____________________

Equipment engineer_______ hrs @ ______ rate/hr ____________________

Procurement _______ hrs @ ______ rate/hr ____________________

Draftsperson _______ hrs @ ______ rate/hr ____________________
Total _______hrs

(h) Extraordinary costs (computer, travel, etc.) ____________________

(i) Fee for general administration, % of Items ____________________

(j) Taxes and customs duties ____________________

Total lump sum cost of Change Proposal [***Sum of items (a) to (j)***]

Cost to prepare Estimate for Change Proposal [***Amount payable if Change is not accepted***]

9. Additional time for Completion required due to Change Proposal

10. Effect on the Functional Guarantees

11. Effect on the other terms and conditions of the Contract

12. Validity of this Proposal: within [Number] days after receipt of this Proposal by the Employer

13. Other terms and conditions of this Change Proposal:

    (a) You are requested to notify us of your acceptance, comments or rejection of this detailed Change Proposal within [Number] days from your receipt of this Proposal.

    (b) The amount of any increase and/or decrease shall be taken into account in the adjustment of the Contract Price.

    (c) Contractor's cost for preparation of this Change Proposal: [***. . . .insert amount. This cost shall be reimbursed by the Employer in case of Employer's withdrawal or rejection of this Change Proposal without default of the Contractor in accordance with GCC Clause 39 of the General Conditions of Contract . . . .***]

[***Contractor's Name***]
[***Signature***]
[***Name of signatory***]
[***Title of signatory***]

42.2.5 CHANGE ORDER FORM

[***Employer's Letterhead***]

To: *[* ***Contractor's name and address*** *]* Date:

Attention: *[* ***Name and title*** *]*

Contract Name: *[* ***Contract name*** *]*
Contract Number: *[* ***Contract number*** *]*

Dear Ladies and/or Gentlemen:

We approve the Change Order for the work specified in the Change Proposal (No. [***number***]), and agree to adjust the Contract Price, Time for Completion and/or other conditions of the Contract in accordance with GCC Clause 39 of the General Conditions of Contract.

1. Title of Change: [***Name***]
2. Change Request No./Rev.: [***Request number / revision***]
3. Change Order No./Rev.: [***Order number / revision***]
4. Originator of Change: Employer: [***Name***] / Contractor: [***Name***]
5. Authorized Price:

   Ref. No.: [***Number***] Date: [***Date***]

   Foreign currency portion [***Amount***] plus Local currency portion [***Amount***]
6. Adjustment of Time for Completion

   None Increase [***Number***] days Decrease [***Number***] days
7. Other effects, if any

Authorized by: ____ Date: _______________
Employer

Accepted by: ____ Date: _______________
Contractor

42.2.6 PENDING AGREEMENT CHANGE ORDER FORM

[***Employer's Letterhead***]

To: *[* ***Contractor's name and address*** *]* Date:

Attention: *[* ***Name and title*** *]*

Contract Name: *[* ***Contract name*** *]*
Contract Number: *[* ***Contract number*** *]*

Dear Ladies and/or Gentlemen:

We instruct you to carry out the work in the Change Order detailed below in accordance with GCC Clause 39 of the General Conditions of Contract.

1. Title of Change: [***Name***]

2. Employer's Request for Change Proposal No./Rev.: [***number/revision***] dated: [***date***]

3. Contractor's Change Proposal No./Rev.: [***number / revision***] dated: [***date***]

4. Brief Description of Change: [***Description***]

5. Facilities and/or Item No. of equipment related to the requested Change: [***Facilities***]

6. Reference Drawings and/or technical documents for the requested Change:

   [***Drawing / Document No. / Description***]

7. Adjustment of Time for Completion:

8. Other change in the Contract terms:

9. Other terms and conditions:

[***Employer's Name***]

[***Signature***]

[***Name of signatory***]

[***Title of signatory***]

42.2.7 APPLICATION FOR CHANGE PROPOSAL FORM

[***Contractor's Letterhead***]

To: [***Employer's name and address***] Date:

Attention: [***Name and title***]

Contract Name: [***Contract name***]
Contract Number: [***Contract number***]

Dear Ladies and/or Gentlemen:

We hereby propose that the below-mentioned work be treated as a Change in the Facilities.

1. Title of Change: [***Name***]
2. Application for Change Proposal No./Rev.: [***Number / revision***] dated: [***Date***]
3. Brief Description of Change: [***Description***]
4. Reasons for Change:
5. Order of Magnitude Estimation (amount in the currencies of the Contract): [***Amount***]
6. Scheduled Impact of Change:
7. Effect on Functional Guarantees, if any:
8. Appendix:

[***Contractor's Name***]

[***Signature***]

[***Name of signatory***]

[***Title of signatory***]