BANGLADESH POWER DEVELOPMENT BOARD

TENDER DOCUMENT

FOR

CONSTRUCTION OF 400 MW ± 10% COMBINED CYCLE (NG/LNG) POWER PLANT AT RAOZAN, CHATTOGRAM

VOLUME 2 OF 2 (PART A + PART B + PART C)

PART A – TECHNICAL REQUIREMENTS
PART B – TECHNICAL PARTICULARS [Schedules & Data Sheets]

December’2019
BANGLADESH POWER DEVELOPMENT BOARD

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CONSTRUCTION OF 400 MW ± 10% COMBINED CYCLE (NG/LNG) POWER PLANT AT RAOZAN, CHATTOGRAM

VOLUME 2 OF 2, PART A

TECHNICAL REQUIREMENTS

December’2019
Volume – 2 of 2 (PART A) Technical Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Description of the Project.</td>
<td></td>
</tr>
<tr>
<td>2. Scope of work.</td>
<td></td>
</tr>
<tr>
<td>3. Power Plant Arrangement</td>
<td></td>
</tr>
<tr>
<td>4. Gas Turbine and Ancillary Equipment</td>
<td></td>
</tr>
<tr>
<td>5. Heat Recovery Steam Generator &amp; Ancillary Equipment</td>
<td></td>
</tr>
<tr>
<td>6. Steam Turbine and Ancillary Equipment</td>
<td></td>
</tr>
<tr>
<td>7. Generator and Ancillary Equipment</td>
<td></td>
</tr>
<tr>
<td>8. Transformers</td>
<td></td>
</tr>
<tr>
<td>9. 230 KV Outdoor Switchgear, Equipment</td>
<td></td>
</tr>
<tr>
<td>10. 6.6 kV Switchgear and Low Tension Switchgear</td>
<td></td>
</tr>
<tr>
<td>11. Control and Protection.</td>
<td></td>
</tr>
<tr>
<td>12. Cabling and Grounding.</td>
<td></td>
</tr>
<tr>
<td>13. DC Power Supply System &amp; UPS</td>
<td></td>
</tr>
<tr>
<td>15. Fuel Handling Facilities.</td>
<td></td>
</tr>
<tr>
<td>17. Communication Facilities.</td>
<td></td>
</tr>
<tr>
<td>19. Tests and Inspections.</td>
<td></td>
</tr>
<tr>
<td>20. Civil works.</td>
<td></td>
</tr>
<tr>
<td>22. Spare Parts.</td>
<td></td>
</tr>
<tr>
<td>24. LONG TERM SERVICE AGREEMENT (LTSA)</td>
<td></td>
</tr>
<tr>
<td>25. Appendices</td>
<td></td>
</tr>
</tbody>
</table>
Section 1

Description of the Project
CONSTRUCTION OF 400 MW ± 10% COMBINED CYCLE (NG/LNG) POWER PLANT AT RAOZAN, CHATTOGRAM

TECHNICAL REQUIREMENTS

1.1 DESCRIPTION OF THE PROJECT:

A Combined Cycle Power Plant of total 400 MW ± 10% capacity at site conditions (35°C, 1.013 mbar, 98% R.H.) is intended to be set up by Bangladesh Power Development Board at Raozan, Chattogram, Bangladesh. Raozan Upazila is located in Chattogram District, 25 kilometers north-east from Chattogram on the south side of the Chattogram–Kaptai Highway.

Around 38 acres of land is available in the southern & eastern side of existing power station boundaries. Portion of this land will be used for Construction of Raozan 400 MW ± 10% Combined Cycle Power Plant Project (around 10 acres) and the remaining space will be used for future Power Plant expansion. The Combined Cycle unit shall be of single-shaft arrangement having 1:1:1 (One GT + One HRSG + One ST) configuration with synchro-self-shifting (SSS) Clutch for simple cycle operation of the gas turbine as well as shall be equipped with the bypass stacks and diverter dampers to allow continuous and reliable simple cycle operation and shall be capable to run on Free Governing Mode Operation.

The proposed Plant will be installed in the land as Shown in the site layout. The Project will be implemented on turnkey basis. Bangladesh has already started for importation of LNG. After importation and Re-gasification of LNG, this will be supplied to the national gas grid network. So Natural Gas/ RLNG will be used as fuel of this Power Plant.

At present there is no vacant Bay available in Raozan 230 kV Grid Sub-Station. But there is sufficient space is available at the southern side of existing substation within power plant premises. Generator step-up transformer would be connected with the 230 kV Raozan Grid Sub-Station (by extension of 230 kV bay) through underground cable with cable termination (if required) and other necessary electrical equipment.

Short-circuit rating shall be considered at least 30KA.

The following parameters are to be considered in plant design:
Sub-Tropical Monsoon.
Temperature: 5°C to 45°C.
Relative Humidity: 36% to 100%.
Annual Rain Fall: 120 cm to 345 cm.
Wind Velocity: As per Latest Wind Map.
Seismic Horizontal ground Acceleration: As per BNBC approved latest Seismic Map

Other parameters (e.g. soil & water to be analysed by the Tenderer at his own cost) as per Tender Requirement.

The project may be classified into the following broad areas. Details are however given later in the scope of work.
1. Survey preparation of drawing, land development, land improvement, landscaping of the proposed site.
2. The supply and construction of the Power plant equipment.
3. Extension of 230 kV Bay (2nos) and Incorporating 230 kV material/equipment at the power plant project and connection to the 230 KV Raozan Grid Sub-Station through underground cable. An indicative single line diagram enclosed.

4. Supply and Construction of all civil work for a power station complete in all respect.

5. Supply and construction of entire Gas Fuel system for the plant, fire protection system etc.
Section 2

Scope of Work
2. **Scope of Work**

2.0 Scope of work

2.1 Combined Cycle Power Plant

2.1.1 General

2.2 Gas Turbine Generating unit

2.3 Mechanical System

2.4 Electrical System

2.5 Heat Recovery Steam Generator

2.6 Steam Turbine Generating Unit

2.6.1 One (1) unit of steam turbine of mixed flow and condensing unit, and it shall be equipped with the following accessories.

2.6.2 One (1) lot of mechanical equipment designed to be compatible with steam system needs and consisting of the following components.

2.6.3 One (1) lot of other mechanical auxiliary equipment.

2.6.4 One (1) lot of other electrical system.

2.6.5 Emergency Diesel Generating Set

2.7 Natural Gas Supply System and Gas Booster Compressors

2.8 230 kV Switchgear, equipment and Transformers (CC)

2.8.1 230 kV Switchgear, equipment

2.8.2 Step up Transformers and Associated equipment

2.8.3 Station Transformers, Unit Auxiliary Transformer and Associated equipment

2.9 Control and protection Panels

2.10 Other Mechanical system

2.11 Other Electrical system

2.12 Maintenance Facilities

2.13 Fire Fighting Facilities

2.14 Building and Civil works

2.15 Training

2.16 Submission of Engineering Data
2.17 Manufacturer's Field Training Supervision
2.18 Tests
2.19 Commissioning
2.20 Operation & Maintenance During Warranty Period
2.21 Services for Schedule Inspections of GT
2.22 Transport
2.23 Spare Parts & consumables
2.24 Special Maintenance Tools
2.25 Electrical Workshop Tools
2.26 Machine Shop Equipment & Tools
2.27 Chemical Laboratory
2.28 Effluent Treatment Plant
2.29 Remote Monitoring System
2.30 Simulator for Power Plant operation Training
2.31 Supply of International Standard
2. Scope of Work

2.0 Scope of Work.

The work stated in this specification shall cover the complete design, engineering (including supply of all calculation & settings), manufacturing, inspection, testing, supply, delivery to the site, construction, erection installation, testing, commissioning, commercial operation and Warranty service including supply of spares & consumables for the first twenty four (24) months after satisfactory Operational acceptance and performance tests of Combined Cycle Generating Unit & associated equipment at Raozan, Chattogram, Bangladesh on full turnkey basis. However complete LTSA proposal from GTG package OEM shall have to be submitted with the offer by the tenderer.

The equipment provided shall be of proven type and design, having total net output at site condition (35° C, 1.013 bar, 98% relative humidity) of 400 MW ± 10% consists of One (1) heavy duty industrial indoor packaged type gas turbine (without any ancillary equipment, such as water/steam injection, evaporator, chiller etc. for increasing power output), One (1) heat recovery steam generator and one (1) steam turbine unit and One (1) Generator to meet the total combined cycle output. The Combined Cycle package unit shall be of single-shaft arrangement having 1:1:1 (One GT + One HRSG + One ST) configuration with synchro-self-shifting (SSS) Clutch, bypass stack & diverter damper for simple cycle operation (gas turbine).

The Tenderers will have to Supply Main (230 kV, 21KV or Generation voltage level) and Auxiliary (6.6 KV & 0.415 KV) Equipment, Materials & Systems including Installation, Testing, Commissioning of Equipment and Control system (including pre-close check systems & inter-lock systems, Protection system, Metering System etc.) accordingly, based on 1:1:1 configuration CCPP with synchro-self-shifting (SSS) Clutch, bypass stack & diverter damper to allow continuous and reliable simple cycle operation (if & when necessary). The unit shall be capable to run on Free Governing Mode Operation (FGMO).

The work shall be carried out in accordance with the conditions of this documents, and shall include but not necessarily be limited to the following major items.

2.1 COMBINED CYCLE POWER PLANT

2.1.1 General

(1) Total Net power station output (base load)
   At site conditions (35° C, 1.013 bar,
   98% relative humidity) : 400 MW ± 10%

(2) Number of units
   a. Gas turbine Generating unit : One(1)
   b. Heat recovery steam generator : One(1)
   c. Steam turbine Generating unit : One(1)

(3) Main Fuel : Natural Gas/ RLNG

(4) Operation mode
   a. Gas turbine unit : Base load as well as peak load
   and Free Governing Mode Operation (FGMO).
b. Combined cycle unit: Base load.

2.2 Gas Turbine Generating Unit

(1) Simple Cycle Net Power output at Site conditions (35°C, 1.013 bar, 98% relative humidity): 65% (±5% Variation is allowed) of CC net Power Output

(2) Number of Unit: One (1)

(3) Main fuel: Natural Gas/RLNG

(4) Operation mode: Base load as well as peak load and Free Governing Mode Operation (FGMO).

The unit of simple cycle heavy duty industrial type gas turbine suitable for burning gaseous fuel including the following:-

   a. Multi-stage, axial flow, corrosion protected compressor.
   b. Gas combustion system with Dry Low Emission combustor.
   c. Turbine with coated first stage buckets.
   d. Heavy duty, multi shaft accessory gear box.
   e. Continuous operation accessory gear driven essential pumps & Auxiliaries.
   f. Rotor turning device.
   g. Gas fuel system
   h. Electric motor/ SFC starting system.
   i. Ignition system with Latest version of Dry Low NOx Combustion system.
   j. Interconnection wiring in rigid metal conduits.
   k. Base-mounted terminal boxes.
   l. Vibration detectors.
   m. Thermocouples for measuring critical turbine temperatures.
   n. Borescope openings for maintenance inspection.
   o. Closed, forced feed lubricating oil system including:
      - Shaft driven/AC driven main lube oil, hydraulic pumps/AC pumps.
      - Oil to coolant heat exchangers.
      - Air intake filters
      - AC auxiliary lube oil pump and DC emergency lube oil pump.
      - Oil reservoir.
      - Control and instrumentation.
   p. Closed loop cooling system including
      - Water to oil heat exchangers.
      - Water to water heat exchangers
      - Temperature control valves.
      - Control and instrumentation.
   q. Inlet and exhaust plenums.
   r. Outdoor enclosure.
   s. Cooling and ventilating system.
   t. Fire detection by flame detectors, UV detectors and CO2 fire protection system.
u. On base piping.
V. Load coupling.
w. Compartment lighting
x. Compressor washing system (Off & On line)

1. **Generator Package**
   (One no. for Single Shaft Arrangement)
   a. Indoor/ outdoor enclosure.
   b. Stator winding with class F insulation.
   c. Cylindrical forged steel rotor with class F insulation.
   d. Air / Hydrogen cooled system.
   e. Lubrication system integral with gas turbine lubrication system.
   f. Platinum RTD temperature detectors imbedded in the stator windings.
   g. Structural steel base.
   h. Speed reduction gear (if required).
   i. Excitation system
   j. Generator space heater (s)

2. **Generator switchgear**
   a. Indoor/ outdoor enclosure.
   b. SF$_6$ Generator circuit breaker(s).
   b. Potential transformers.
   c. Current transformers.
   d. Lightning arresters.
   e. Neutral grounding transformers,
   f. Connections to generator power leads and unit step up transformer by phase segregated copper bus duct.
   g. Lighting and heating equipment.
   h. Ventilation system.
   i. Connections to auxiliaries transformer.
   j. 21 kV (or Generation voltage level) Generator breaker having adequate capacity to meet the requirements

4. **Inlet Air System.**
   a. Filter compartment with:
      - Support structure.
      - Multi-stage (3 stage) filtration system, complete in all respects.
      - High efficiency media filtration.
      - Pressure measuring instrumentation.
      - Inlet ducting.
      - Access door.
      - Lighting.
      - Air inlet system special corrosion protection.
      - Air inlet system bypass door.
   b. Inlet silencing.
   c. Transition piece from inlet duct to inlet plenum.
   d. Structural support.

5. **Exhaust System (Vertical)**
   a. Exhaust ducting.
   b. Exhaust silencing.
   c. Transition piece from exhaust plenum to exhaust ducting.
   d. Exhaust stack [as per environmental protection requirement but not
less than 50 m for GT with bypass damper and 50 m for HRSG].

e. Hydraulic operated/controlled diverter damper
f. Motor operated Guillotine damper
g. Thermal insulation and lagging.
h. The GT and HRSG Stacks shall be equipped with automatic Navigation lighting system

Exhaust system shall be designed to enable the Combined Cycle Power Plant to run as Simple Cycle mode and Combined Cycle mode as well.

6. **Control Compartment (for GT)**
   a. Indoor/Outdoor enclosure.
   b. Turbine control panel.
   c. Generator control panel and protection panel.
   d. Motor control centre.
   e. Heating and air conditioning system.

7. The bidder shall assess the potential impact of air quality, designs the air filter system appropriately and guarantees its long-term performance.

The Tenderer shall also supply, install & commission (a) Continuous Emissions Monitoring Module; (b) Remote Monitoring System and (c) standard weather station for measuring wind velocity & direction and ambient temperature, pressure & Relative Humidity. Sensors shall be installed in suitable location as per GT designer’s recommendation and calibrated & interfaced with plant control system. Ambient Temperature, Pressure & Relative Humidity shall be used during performance tests.

2.3 **Mechanical System**

a. Piping between the on-base equipment and the off-base equipment.
b. Painting, including finished coat and special paints required for corrosion protection and high temperature resistance.
c. Design, operation and maintenance manuals, including drawings.
d. All other work necessary for the proper operation and maintenance of the simple cycle and Combined Cycle Generating unit.
e. Lubrication oil for flushing and for the initial filling.
f. All lubricant and chemical additives.
g. Natural gas handling facilities including gas metering and pressure regulating station.
h. Overhead crane of proper capacity for heaviest piece of GTG & STG unit.
i. Closed Cycle cooling water and Circulating water system.

2.4 **Electrical System**

a. One (1)Set : 6.6 KV switchgear.
b. One (1) set : 415 V power centre.
c. One (1) set : 415 V common motor control centre.
d. One (1) set : 415 V unit motor control centre.
e. One (1) set : 6.6 KV XLPE power cables.
f. One (1) set : Low voltage power cables.
g. One (1) set : Control and instrument cables.
h. One (1) set : Race way materials.
i. One (1) set : Grounding system.
j. One (1) Set : IPBD (21 kV or Generation voltage level)
The Tenderer shall also supply, install & commission (a) Continuous Emissions Monitoring Module; (b) Remote Monitoring System and (c) standard weather station for measuring wind velocity & direction and ambient temperature, pressure & Relative Humidity. Sensors shall be installed in suitable location as per GT designer's recommendation and calibrated & interfaced with plant control system. Ambient Temperature, Pressure & Relative Humidity shall be used during performance tests.

2.5 Heat Recovery Steam Generator

One (1) unit of heat recovery steam generator of triple pressure steam cycle suitable to utilise exhaust gas from the gas turbine unit including followings:

a. The steam drum and heat transfer sections which consist of the Economiser, Evaporator and Super-heater of the steam generator.

b. The support structure for the steam generator and ducting.

c. The stairs, platforms and ladders required for maintenance, inspection and operation of the heat recovery steam generator.

d. The heat recovery steam generator circulating water system for the HP and LP drums.

e. The steam generator valves and devices which consist of indications, switches, transmitters and sampling nozzles. Motorised valves as required for remote or automatic operation.

f. The feed-water control valve system.

g. Flow nozzles for water and steam.

h. Deaeration system complete in all respect

i. Feed water & preservation Tanks

j. The steam generator control system to provide control capability for transient, steady state and protective conditions.

k. Insulation and lagging.

l. Foundation plates and bolts.

m. Any other equipment/ material/ system required for HRSG complete in all respect.

Note: Supplementary firing for HRSG shall not be allowed.

2.6 Steam Turbine Generating Unit

2.6.1 One (1) unit of steam turbine and condensing unit, and it shall be equipped with the following accessories.

a. Inlet stop valve (s) with coarse and fine mesh steam strainer.

b. Control valves with necessary bypass system.
c. High pressure steam bypass valve with actuator and position feedback device.
d. Motorised drain valve for turbine casing, Gland steam, seal system and above/below stop valve seats.

e. Automatic gland steam seal system.
f. Shaft packing vent system with blower and gland condenser.
g. Turbine exhaust hood water spray system and motorised vacuum breaker valve.
h. Steam turbine control.
i. Hydraulic system with duplex pumps, coolers, filters and integral fluid conditioning unit.
j. Over-speed governor with solenoid trip.
k. Lube oil system with tank, shaft driven/ Ac driven main lube oil pump, AC auxiliary lube oil pump, DC emergency pump, Jacking oil pumps, Hydraulic pumps, coolers, valves, oil conditioner, vapour extractor, gauges, pressure and temperature control devices.
l. Closed circuit cooling water system, Aux. cooling water system with AC motor and pump of adequate capacity.
m. Steam jet Ejectors/ Vacuum pumps in the air extraction system.
n. Turning-gear, motor operated with provision for automatic engaging and manual cranking.
o. Insulation and lagging.
p. Foundation plates and bolts.
q. Piping
   Piping is factory treated, prefabricated in shippable assemblies, ready for installation, (field welds by Contractor) as follows:
   - Main steam line (s) connecting the emergency valve (s) and turbine inlet (s).
   - Steam seal system - all necessary piping connection the factory supplied turbine-generator components.
   - Oil system-all necessary oil feed return piping connecting the factory supplied turbine-generator components.
r. Turbine special tools.

2.6.2 One (1) lot of mechanical equipment designed to be compatible with steam system needs and consisting of the following components:
   a. 1 set of shop tubed surface condensers.
b. 3 x 50% or 2 x 100% capacity motor driven condensate pumps.
c. 3 x 50% or 2 x 100% capacity motor driven HRSG feed pumps.
d. 2 x 100% capacity motor driven vacuum pumps.
e. 3 x 50% or 2 x 100% capacity motor driven circulating water pumps.
f. 3 x 50% capacity motor driven river water intake pumps.
g. 3 x 50% or 2 x 100% capacity motor driven CCC water pumps.
h. 1 lot of circulating water pipework and associated valves.
i. 1 lot of pipework, associated valves, tanks, pumps, heat exchangers, etc.
j. 1 lot of compressed air equipment (two nos. for instrument air and two nos. for service air)
k. 1 lot of chemical dosing equipment.
l. 1 set of deaerator.
m. 1 set of water treatment plant with laboratory.

2.6.3 One (1) lot of other mechanical auxiliary equipment

a. Piping between the equipment.
b. Painting including finished coat and special paints required for corrosion protection and high temperature resistance.
c. Design operation and maintenance manuals, including drawings.
d. All other works necessary for the proper operation and maintenance of the combined cycle plant.
e. Lubrication oil for flushing and for the initial operation.

2.6.4 One (1) lot of other electrical system

a. One (1) lot of 415 V switchgear.
b. Cables and wiring for interconnection between the equipment.

2.6.5 Emergency Diesel Generating Set

One (1) set of emergency diesel generating set shall be as per plant requirement for safe shutdown of the Combined Cycle Power Plant but not less than 1500 kVA [pf 0.80] for supplying power to essential auxiliaries complete with all ancillary equipment to safe shutdown of the plant having diesel storage capacity for 24 hours of continuous operation. EDG shall be of automatic starting system [compressed air/ Battery] including quick start & loading capability. The starting system shall be capable of carrying out at least five (5) consecutive starts without auxiliary power supply. In case of power failure in 0.4 kV bus, EDG will start and supply power to 0.4 kV emergency bus in auto mode. EDG synchronizing facility with 0.4 kV live bus is also required.

EDG is required for the safe shutdown of the plant/ equipment under emergency condition and in case of power failure for certain essential applications like battery chargers, emergency lighting and all auxiliaries necessary for safe coasting down of equipment and turning gear/ barring operation of the turbines.

2.7 Natural Gas Supply System and Gas Booster Compressors

The Contractor shall design, manufacture, inspect, test, delivery to the site and install of natural gas handling facilities (including gas booster compressors) with all accessories as specified hereunder for the plant.

There are 2 pipe lines (each one 20” dia.) coming from adjacent Karnaphuli Gas distribution Company’s CMS to the existing power plant. Each pipe line goes to supply header of existing each 210 MW Steam Turbine Unit to run the units. Now BPDB will install & run the 400±10% MW CCPP by connecting with the existing 2 Gas pipe lines keeping existing 2X210 MW Steam Turbine Unit in standby mode. The contractor shall design the gas supply system and make necessary arrangement with adequate capacity in a way that the incoming 2 pipe lines will be converted to 3 outgoing pipe lines (1 line will go the RMS for GT, the remaining 2 lines will go to supply header of existing 2x210 MW ST Units). Proper arrangement
(Header, valves, meters, pipes etc.) should be made by the contractor so that as per requirement of BPDB either Upcoming 400±10% MW CCPP or existing 2x210 MW ST Units can run independently.

The plant shall require centrifugal type gas booster compressors (GBC manufacturer will be ATLAS COPCO, USA or Germany / MAN TURBO, Germany/ INGERSOLL RAND, USA) as the supply pressure of natural gas is in the range of 80 - 150 psig. Bypass system will be installed by the Contractor, if the gas supply pressure is sufficient to run the power plant, then bypass system will be used instead of operation of GBC.

The capacity of the compressors have to be 3 x 50% for maximum gas requirement of the plant including auto changeover system without interrupting operation of the plant with rated pressure & flow and at all modes of operation & at any temperature prevailing in the site of the GTG unit.

The gas booster compressors have to be centrifugal type, 6.6 KV motor driven. Appropriate control, sealing, cooling & anti-surge system with all necessary ancillaries and auxiliaries shall have to be provided including compressor house.

All the technical specification, parameters and construction philosophy shall be followed as per Guideline of Karnaphuli Gas Distribution Company Limited.

Typical Composition of natural gas is shown on Annexure for Tender purpose only. However during design period the Tenderer should collect the appropriate specification of natural gas from competent authority/ Karnaphuli Gas Distribution Company Limited. Detail description and scope of work mentioned in Section 15 of Vol. 2 of 2 (Part A).

2.8 230 kV Switchgear Equipment And Transformers (CC)

[Equipment to be provided as per 1:1:1 configuration (single shaft configuration) of the plant]

2.8.1 230 kV Switchgear Equipment

1) 1 (One) lot of 230 kV circuit breaker
2) 1 (One) lot of 230 kV Current Transformer
3) 1 (One) lot of 230 kV Voltage Transformer
4) 1 (One) lot of 230 kV Lightning Arrester
5) One (1) lot of steel structures for supporting the switchgear, equipment, posts and beams and gantry structures.
6) One (1) lot of 230 kV underground cable and if required cable with termination
7) One (1) lot of suspension/post insulator string sets, tension insulator string sets and station post supporting insulator set with necessary hardware.
8) One (1) lot of shield wire connectors and necessary hardware.
9) 1 (One) lot of 230 kV Isolator with earthing blade.
10) One (1) lot of 230 KV Bay equipment (for extension of 2 nos. bay) such as but not limited to Circuit Breaker, isolator, earth switch, CT, PT, LA, bus coupler etc. as per requirement of PGCB (Power Grid Company of Bangladesh).

11) One (1) lot [for interconnection & integration] of equipment and materials for interconnection & integration with Load Dispatch Centre (LDC) of PGCB (Power Grid Company of Bangladesh) and said power plant, SCADA, telecommunication facilities such as Compatible Multiplexer with optical fiber, RTU (Remote Terminal Unit) as per respective IEC standard, IP telephone set with accessories and others. All necessary interconnection & integration will be done by the Contractor as per PGCB guideline & related cost for the interconnection shall be borne by the Contractor. 

Note: No./ set of equipment will be finalized during detail design stage.

2.8.2 Transformers and Associated Equipment

1) One (1) Set of 3 single phase bank step-up transformers and one spare transformer total 4 nos. single phase bank Step-up transformers with associated equipment having capacity to match the Combined Cycle Power Plant output (at any ambient temperature) with the following features:
   - Type: Oil immersed One phase, outdoor power transformer
   - Rating: To meet the requirement
   - Voltage ratio of transformer at full load: 21(or as per Generation Voltage) / 230 kV
   - Connection: Ynd₁
   - Rated insulation level: 1050 kV (Peak) As per IEC
   - Lighting impulse Withstand Voltage (1.2/50 micro sec.): 1050 kV (Peak) As per IEC
   - Power frequency withstand Voltage (for 1 min.): 460 kV As per IEC
   - Impedance voltage: Shall be within the range of 15% and 18%
   - Tap changer: On load at high tension winding +8 x 1.25% to -12x1.25%
   - Termination: Outdoor bushing for Cable Pot Head connection
     - High tension side
     - Low tension side: Isolated & insulated phase copper bus duct and XLPE cables.

Note: Above mentioned one (1) Set of 3 single phase bank step-up transformers and one spare transformer total 4 nos. are envisaged for single-shaft arrangement having capacity to match the power output of combined cycle (at any ambient temperature).
2.8.3 Unit Auxiliary Transformers, Station Transformers and Associated Equipment

1) Two (2) set of unit auxiliary transformer (At least 120% of total aux. power requirement including all residential and non residential load but not less than 25 MVA) and associated equipment with the following features:
   - Type: Oil immerse, three phase, outdoor power transformer.
   - Rating: As mentioned above
   - Rated high voltage: 21 kV (or as per Generation Voltage)
   - Rated low voltage: 6.9 kV
   - Connection: Dyn1
   - Rated insulation level:
     - HV Winding
     - LV Winding
   - Lighting impulse Withstand voltage (1.2/50 micro sec): As per IEC 60 kV(Peak)
   - Power frequency Withstand voltage (For 1 mm): As per IEC 22 kV
   - Impedance voltage: shall be within the range of 5% and 7.5%
   - Tap changer: Off-current on high tension winding ± 2 X 2.5%.
   - Neutral grounded: Earthing Resistor

2) Required sets of station transformer (In each location there will be 02 no. of 0.4 kV buses, loads in that location will be divided into these 02 buses, each 0.4 kV bus will be feed through one 6.6/ 0.4 kV transformer, each 6.6/ 0.4 kV transformer capacity shall be 120% of total loads of these 02 buses. One of two 6.6/ 0.4 kV transformers can be isolated without disturbing 0.4 kV loads) and associated equipment with the following features:
   - Type: Oil immersed, three phase and two windings, outdoor power transformer
   - Rating: As per requirement
   - Rated high voltage: 6.9 kV
   - Rated low voltage: 415 V
   - Connection: Dyn11
   - Rated insulation:
     - HV Winding
     - LV Winding
   - Lighting impulse Withstand voltage (1.2/50 micro sec): 60 kV(peak) As per IEC
   - Power frequency:
     - 22 kV(peak) 4kV
Withstand voltage (for 1 mm).

- Impedance voltage: Not less than 5%, but not more than 7.5%.
- Tap changer: Off Load on high tension winding ± 2 x 2.5%.
- Neutral grounded: Solidly grounded.

2.9 Control and Protection Panels

In addition to the unit local control and protection panels, the following panels shall be provided in the central control room.

a. One (1) Gas turbine generating remote unit control boards/ HMI.
b. One(1) Heat recovery steam generator control boards/ HMI.
c. One (1) Steam turbine generating unit control board/ HMI.
d. One (1) latest version DCS system as per requirement of the offered Plant from ABB, Germany, USA, Singaore/Foxboro or Schneider, USA, Singapore/Siemens, Germany/ Alstom, France/ GE,USA or EU/ Mitsubishi, Japan. All the Hardware & software i.e. Controller Processors, I/O Module, terminal assemblies, work stations, Cabinets, terminal box, Cables etc. shall be supplied from the mentioned countries.
e. 230 kV control and protection panels.
f. Transformer control and protection panels.
g. 6.6 kV common switchgear and emergency diesel generator control boards as per requirement.
h. Auxiliary power supply control boards as per requirement.
i. Synchroniser panel / HMI [Auto & Manual system].

2.10 Other Mechanical System

a. Piping between the on-base equipment and the off base equipment.
b. Painting, including finished coat and special paints required for corrosion protection and high temperature resistance.
c. Design, operation and maintenance manuals, including drawings in English.
d. All other work necessary for the proper operation and maintenance of the gas turbine generating plant.
e. Lubricating oil for flushing and for the initial filling.
f. All lubricant and chemical additives.
g. Natural gas handling facilities including Gas Regulating and Metering Station (RMS).
h. Renovation of Existing portable Water Piping Network with replacement of all required pipes, valves & other with new one.
i. There are 2 (two) nos. of existing pipe lines alongside of Chattogram- Rangunia highway coming from water intake system (situated beside Kurnophuli river) around 8 K.M away from Power Plant. 3 x50% nos. of Water intake pumps with each pump capacity minimum 600 m³/hr but not less than the requirement are installed with each intake pipe line. Through these pipelines water is storing into 3 nos. reservoirs (pond) inside power plant premises. The contractor has to renovate one of these two water intake system by changing Pipe (600-800mm dia or as per BPDB requirements), required valves, Pumps (3x50% capacity) etc. complete in all respect. Also required renovation of the existing reservoirs has to be done by the Contractor.
2.11 Other Electrical System

a. One (1) 415V power Centre.
b. One (1) 415 V common power Centre.
c. One (1) Lot 21 kV (or Generation voltage) isolated (Insulated) Phase (solid) copper bus duct.
d. One (1) Lot 6.6 kV XLPE power cables (Copper).
f. One (1) Lot Control and instrument cables (Copper).
g. One (1) Lot Race way materials
h. One (1) Lot Grounding system.
i. One (1) Lot lighting and small power supply
J. One (1) Lot Communication system including, PABX, paging, Telemetering, SCADA equipment system.
k. One (1) Lot DC power supply system, UPS and other associated facilities.
l. One (1) Lot 230 KV Control & Relay Panels.
m. One (1) Lot 415 V Power cables

2.12 Maintenance Facilities

a. Four (4) Overhead electric crane (for GTG, STG, CW Pump House & GBC house) complete with gantry structure, weather protection shed, control, power supply etc. GT & ST EOT main hoist capacity minimum 125 ton and auxiliary hoist capacity minimum 20 ton. All EOT crane must have capacity required for lifting the heaviest single piece with 20% margin.
b. One (1) 30 ton or above (as required) mobile cranes.
c. One (1) 5 ton truck with 3 ton jib crane
d. One (1) 5 ton fork lift (Engine driven)
e. One (1) 5 ton truck/ lorry
f. One (1) 1 ton half truck
g. One (1)lot Special tools etc.

2.13 Fire Fighting Facilities

a. One (1)lot Auto-Release C02 fire fighting facilities for GT (if applicable).
b. One (1) lot Hydrant system including motor driven and diesel engine driven fire-fighting pumps, jockey pump, water main, hydrant stands, hoses, water sprinkler system, Deluge system etc..
c. One (1)lot Portable fire fighting equipment.
2.14 Building and Civil Works

Site preparation, soil investigation, cleaning and levelling of site, land filling, land development, land improvement, reclamation, setting out of, design and construction of all foundations for the equipment provided by the Contractor.

The design and construction of the Power house, Control building, Administration building, Rest house building, Medical Centre, Dormitory buildings, Tower Buildings, EDG house, workshop, Store, Guard rooms, Water reservoirs, Water Treatment plant with Chemical Laboratory, River water intake pump house, Fire fighting pump house, Cooling Tower pump house, fencing, internal roads, boundary wall, drainage system etc. The design and construction of all major foundations and buildings shall include piling. Contractor’s scope of work will also include supply of adequate standard office/home furniture to the building as mentioned in section 21.2 of vol. 2 of 2 part A.

- Outdoor lighting, passage ways, access ways for transporting of equipment during overhaul, and re-routing of existing passage way for the site if necessary.
- Surface water drainage system including oil interceptors.
- Removing of debris, surplus excavated materials and rubbish, etc. resulting from the works.
- Water distribution system including one overhead tank on top of the control building.
- All internal roads.
- Piling, Foundation, building as per section 21.

2.15 Training

a) The training at the Manufacturer's factory by the Contractor including:

- **30** (Thirty) round trip air fares from Dhaka, Bangladesh to the Manufacturer's factory.
- **63** (Sixty three) person-months of training.
- Local transportation, meals, lodging costs etc. and pocket expenses (Pocket expenses @ US dollar 100 per day per person).

b) Local on job training for 40 (Forty) persons and total man-months 20 (twenty).

- Pocket expenses (Pocket expenses @ BDT 1000 per day per person).
- Beside the field training on supplied equipment, the Contractor shall have to give training by supplied Simulator under this Contract so that the trainees get acquainted themselves with the CCPP plant and will be able to operate the plant accurately and efficiently.
2.16 Submission of Engineering Data
Drawings and other engineering data for the specified equipment and materials are essential to the design and subsequent construction of the entire generating unit.

The contractor shall be required to submit drawings and engineering data in accordance with the Schedule and requirements specified herein to assure compliance with the overall construction and operating Schedule.

2.17 Manufacturer's Field Training Supervisor
From the date of commencement of initial operation of the major equipment, the Contractor shall dispatch manufacturer's supervisor (s) who shall be technically competent, factory trained, experienced in the operation and maintenance of the equipment to the site.

The supervisor (s) shall be responsible for providing instruction and guidance to Board's staffs in the operation and maintenance of the equipment. The supervisor (s) shall not be responsible for any duties required by the test and commissioning program of the equipment during training duty.

The supervisor (s) must be able to fluently understand, speak, read, and write the English language.

2.18 Tests
The Contractor shall be responsible to all testing of equipment and systems supplied under this contract. The Contractor shall submit with his proposal a list of those tests, which in his opinion will satisfactorily check the operating characteristics of the equipment and determine all values necessary for evaluation of guarantees.

In the event of an award of contract, the Contractor shall submit within sixty days of the date of notice of award details of the proposed procedures for each test. All test procedures shall be subject to the Engineer's modification and approval.

2.19 Commissioning
The Contractor shall be responsible for the commissioning of all equipment in his supply, and shall provide necessary commissioning engineers to carry out all operations from first making alive of auxiliary equipment until the full commissioning has been completed.

The schedule shall cover all necessary inspections, adjustments and tests from no load to full rated capacity.

The Board shall provide his operating and maintenance staff to gain familiarity with the installation but the Contractor shall remain fully responsible for safe operation of all equipment in his supply during the commissioning periods, and until the completion certificate have been issued.

2.20 Operation & Maintenance During Warranty Period
The Contractor shall provide One (1) Competent Operation Engineer who will be in overall in charge of the Plant, one (1) Engineer for Electrical Maintenance (Generator, Transformer, Substation, Switchgears etc.) & one (1) Engineer for I&C, one (1) Engineer for Mechanical Maintenance (BOP),
one (1) Engineer Gas Turbine Maintenance and One (1) Engineer for Steam Turbine & HRSG Maintenance during 24 months warranty period for smooth maintenance and operation of the Plant.

During the Defect Liability Period, contractor will also provide normal operation spares & consumables (Lube Oil, Air Filters, Chemicals & others), wear & tear spares, spares required for schedule/ unscheduled maintenance and services required for complete combined cycle power plant & their auxiliaries (with all electrical equipment and control system) except schedule inspections’ spares for GTG & their auxiliaries (Spares for day to day, unscheduled, breakdown & others maintenance shall have to supplied by EPC contractor). During the Defect liability period the contractor will engage required manpower in addition to the above stated personnel.

During warranty period the above mentioned Engineers jointly with BPDB’S Engineers/Staff shall have to perform the operation & daily maintenance of the plant. For this purpose, quarterly progress report of BPDB Personnel shall have to be submitted to the authority by the above mentioned Engineers showing the progress of BPDB Personnel for safe & reliable operation and maintenance of the plant independently.

2.21 Deleted

2.22 Transport: Deleted

2.23 Spare Parts and consumables

2.23.1 Spares & consumables during Warrantee period

The Defect Liability Period shall be twenty four (24) months from the Operational Acceptance of the Facilities. Contractor will provide all spares & consumables whether listed or not in the contract for smooth operation of the plant during Defect Liability Period. During the Defect Liability Period, contractor will also provide normal operation spares & consumables (Lube Oil, Air Filters, Chemicals & others), wear & tear spares, spares required for schedule/ unscheduled maintenance and services required for complete combined cycle power plant & their auxiliaries (with all electrical equipment and control system) except schedule inspections’ spares for GTG & their auxiliaries (Spares for day to day, unscheduled, breakdown & others maintenance shall have to supplied by EPC contractor). In preparation of the list the tenderer have to consider plant factor as 80% and 50 nos. start/stop per year.

2.24 Special Maintenance Tools

The contractor shall provide all special tools including a Videoscope with 3D phase measurement & touch screen (Manufacturer country: Japan /USA/ England) required for installation and maintenance of the units and hand them over in good condition to the Board at the completion of the Project. A list of all such tools shall be incorporated with tender.

Worn out tools or damaged tools shall be replaced with new one without any cost. As well as contractor shall provide Special lifting & handling appliances and dismantling & assembling tools for GT, ST, HRSG, Generator and others as required,
2.25 **Electrical workshop tools**
Current injection test set, Megger(HV: 2.5 to 6 KV, LV: 250V,500V,1000V), Multimeter, Level Gauge(600mm), Mega Ohmer(ZC-25B), Portable Milliammeter (BMA-1), Mimmivoltmeter (BMV-1), Wire Buffing Machine, Hand Shares, Hydraulic Press(5 Ton), Pneumatic, Grease Gun, High Pressure Water Cleaner, Bearing Puller Kit, Bearing heater, Pistol Drill(medium), Temperature Probe, Power Meter Set(Include: Phase Rotation Meters, AC&DC Ammeters), Micrometers(Small, Medium and Large), Hydrometer, Tachometers, Hydraulic Crimpers, Insulating Oil Tester, Heat Gun, Portable Air blower, Portable Vacuum Cleaner, Ladder(Medium), Drawing, Consumable, Equipment Storage Cabinets(suitable sizes), Work Benches, Hand Equipment Trolley, Power Frequency LV, SF6 Gas Detector, Loss Factor Meter, Primary Current Protection Injection test Set etc.

2.26 **Machine Shop equipment & Tools**

Laboratory Equipment (Testing Bench): Pressure Meter (0-60 kgl m²), Temperature Meter (0-150⁰ C-PT50, 0-150⁰ C-PT100)

2.27 **Chemical laboratory with standard apparatus for Combined cycle Power Plant**
Necessary laboratory instruments, glass wares, laboratory test reagents essential for the process control and quality control of the Chemical plant shall be supplied by the contractor as per needs.

2.28 **Effluent Treatment Plant**
Effluent Treatment Plant/ system to be provided to maintain the standards of Industrial Waste as mentioned in The Environment Conservation Rules, 1997. A Central Monitoring Basin (CMB) of RCC construction shall be provided to collect all the plant effluents. Quality of the effluents shall be measured, monitored and treated. Through a set of Waste effluent disposal pumps and piping, the same shall be disposed of from CMB up to final disposal point at a safe distance.

2.29 **Remote Monitoring System**
Contractor will supply necessary hardware, software for Remote Monitoring System (RMS). Contractor will install Remote Monitoring System (RMS) at the OEM Central Control room (GTG manufacturer) and provide necessary connectivity with Cyber Security facility. Remote Monitoring System (RMS) will be used for remotely monitor and Health Check-up of the GTG unit through Remote Monitoring System from OEM Central Control room.
2.30  **Simulator for Power Plant operation Training**

Contractor shall supply one proven Simulator for Power Plant operation Training with Eight (08) Work stations and one Engineering Stations with simulation license. Supplied Simulator shall be comprise of same parameter, data, specification and configuration of said CCPP in such way that the trainee get acquainted themselves with the CCPP plant and will be able to operate the plant after getting simulation training.

2.31  **Supply of International Standard**

The Tenderer shall supply all relevant international standards (ISO, IEC, ASTM, IEEE, ASME, NFPA etc.)

**Note:** All the Equipment's name plate Data (Manufacturer Name & Technical Parameters), Technical Specification, Operational Manual including OEM parts list & Drawings shall be in English language. Contractor has to handover all the Equipment's complete Technical Specification, Operational Manual including OEM parts list & Drawings before performance test of the plant. Operational Acceptance Certificate may not be issued in case of failure to submit/handover the above required documents.
Section 3

Power Plant Arrangement
3. Power Plant Arrangement
   3.1 General
   3.2 Guarantee
   3.3 Combined Cycle and Auxiliary Equipment
      3.3.1 Basic Equipment Requirement
      3.3.2 Main Steam System
      3.3.3 Feed water System
      3.3.4 Condensate System
      3.3.5 Cooling System
      3.3.6 Closed circuit cooling water system for Auxiliary Cooling
      3.3.7 Chemical Feed System
      3.3.8 Instrument Air System
      3.3.9 Steam Turbine Drains
      3.3.10 Condenser Air removal System [Air Extraction System]
      3.3.11 Boiler Drains and Sample Coolers
      3.3.12 Fire Protection System
      3.3.13 Water Treatment System
      3.3.14 Potable Water system
   3.4 Electrical System
      3.4.1 Electrical system interrupting capacity
      3.4.2 Generators
      3.4.3 6.6 kV Switchgear
      3.4.4 Balance of Plant
   3.5 Functional Requirements
      3.5.1 General
      3.5.2 Control
      3.5.3 Cooling System
      3.5.4 Noise Level
      3.5.5 Vibration Severity
      3.5.6 Critical Speed
      3.5.7 Spare parts
      3.5.8 Special Maintenance Tools
3.0 **Power Plant Arrangement**

3.1 **General**

The arrangement of the plant equipment shall be generally as described below:

The Combined Cycle package unit shall be of single-shaft arrangement having 1:1:1 (One GT + One HRSG + One ST) configuration with synchro-self-shifting (SSS) Clutch for simple cycle operation of the plant. GT, ST & Generator shall be in a single package with FGMO facilities.

Gas Turbine Power Plant (Simple Cycle) with a continuous total net generating capacity of 65% (+ 5% variation is allowed) of combined cycle net output shall be accommodated in the location proposed.

The Combined Cycle (GT+ST) Power Plant with a continuous total net generating capacity at site conditions (35°C, 1.013 bar, 98% relative humidity) of 400 MW ± 10% shall be accommodated in the location proposed (as per drawing attached) with required number of auxiliary system.

This specification covers the complete design, engineering, manufacturing, inspection, testing, supply, delivery to the Site, construction, erection, installation, testing, commissioning, commercial service and supervision for the first twenty four (24) months after satisfactory performance tests of a combined cycle power plant of total 400 MW ± 10% at site conditions (35°C, 1.013 bar, 98% relative humidity).

Cooling water Temperature from cooling tower at inlet of Steam Turbine Condenser and auxiliary cooling water Coolers is to be of 38°C at site condition (35°C, 1.013 bar, 98% R.H). However, the net output of complete Combined Cycle Power Plant shall not be less than the guaranteed figure at site condition.

The combined cycle power plant concept shall be based on using the exhaust heat from the gas turbine for heat recovery steam generator, which supply steam to the steam turbine.

The major equipment of combined cycle plant shall include the one (1) Gas turbine generating set, one (1) Heat Recovery Steam Generator, and one (1) Steam Turbine set, and a comparable array of auxiliaries. The Steam Turbine unit shall be sized to accommodate steam from the heat recovery steam generator with exhaust heat collected from Gas turbine.

For single-shaft arrangement, both Gas turbine and Steam Turbine drive one Generator. Depending on the station operation mode desired, exhaust gas diverter dampers shall be able to control flow to either the bypass stack for simple cycle operation of the gas turbine generating set, or to the heat recovery steam generator for combined cycle operation, as and when needed as per system requirement. All of these components shall be selected to provide low capital and operating costs for mid-range or base-load application. The unfired heat recovery steam generator shall be pre-
assembled in modules to reduce field erection works. The turbine shall be chosen so that the maximum plant efficiencies can be obtained.

The steam turbine shall be supplied for indoor installation in the powerhouse. An overhead electrical crane shall be supplied for maintenance of the Gas Turbine Generator and steam turbine.

The major steam cycle mechanical and electrical auxiliaries shall be located in the powerhouse. A pipe trestle shall carry the main steam line from the heat recovery steam generators to the steam turbine and interconnect other mechanical and electrical systems between the gas turbine area and the steam turbine area.

A central control room shall be provided in the powerhouse. The gas turbine/heat recovery steam generator control panels or HMI, the controls for the steam turbine and associated auxiliaries as well as 230 kV switchgear controls shall be accommodated in the central control room.

The Site is located at at Raozan, Chattogram, Bangladesh. Raozan Upazila is located in Chattogram District, 25 kilometers north-east from Chattogram on the south side of the Chattogram–Kaptai Highway.

The equipment covered by this specification shall be designed to operate at temperatures ranging between 45°C in summer and 5°C in winter. It should be noted that the area is subjected to heavy rain from May to September. The Contractor shall, therefore, take all precautions to protect the sensitive equipment from humidity, both in regard to method of packing for shipment and to design.

3.2 Guarantee

The net output and heat rate of the Unit shall be guaranteed by the contractor at the following conditions:

a. Ambient temperature : 95°F (35°C)
b. Site elevation : less than 100 ft (msl)
c. Relative humidity : 98%
d. Barometric pressure : 1.013 bar
e. Generation voltage : 21kV (or as per Generation Voltage)
f. Power factor : 0.85 lagging (at HT side of Step up Transformer)
g. Frequency : 50 Hz

The contractor shall guarantee the starting reliability of the Combined Cycle Plant including all ancillary equipment. The guaranteed reliability shall be stated in the Tender form together with the number of consecutive starts to which the Unit(s) will be subjected to demonstrate this reliability (This is for a starting reliability of 95 %, the Unit(s) shall be subjected to 20 consecutive starts of Which 19 shall be successful). The maximum speed rise after full load rejection is to be guaranteed.

(1) Guaranteed net total base load capability at site Condition (35°C, 1,013 bar, 98% relative humidity) : 400 MW ± 10% (for Combined cycle)
(2) **Minimum KVA rating of generators**: The generator KVA rating at 0.80 power factor shall match or exceed Combined Cycle output under all load operating conditions.

### 3.3 Combined Cycle and Ancillary Equipment

#### 3.3.1. Basic Equipment Requirements

The Combined Cycle unit shall be of single-shaft arrangement having 1:1:1 (One GT + One HRSG + One ST) configuration with synchro-self-shifting (SSS) Clutch, bypass stack & diverter damper to allow continuous and reliable simple cycle operation (if & when necessary). The unit shall be capable to run on Free Governing Mode Operation (FGMO).

The Generating units (Simple Cycle and Combined cycle) shall be of well-proven design. The following equipment shall have satisfactory operating experience outside manufacturer’s country for at least 2 (two) years.

1) **Offered model of Gas Turbine manufactured by proposed manufacturer.**  
   [Evolution of frame shall not be accepted]

2) **Offered model or higher capacity of Steam Turbine manufactured by proposed manufacturer;**

3) **Offered model or higher capacity of Generator manufactured by proposed manufacturer;**

4) **Offered model or higher capacity of HRSG manufactured by the proposed manufacturer;**

5) **Offered or higher capacity Generator Step up Transformer (Unit Transformer) manufactured by proposed manufacturer and**

6) **Offered or higher capacity Generator Circuit Breaker (GCB) manufactured by proposed manufacturer**

Tenderer shall have to submit separate end user certificate in this respect, otherwise Tender shall be rejected.

The extent of supply shall include, but not be limited to, the equipment described herein. All equipment comprising the gas turbine & steam turbine package shall be pre-assembled in the factory.

(1) The total net base rated output of the power station at site conditions (35 °C, 1.013 bar, 98% relative humidity) shall be 400 MW ± 10%. Cooling water Temperature from cooling tower at inlet of Steam Turbine Condenser and auxiliary cooling water Coolers is to be of 38°C at site condition (35°C, 1.013 bar, 98% R.H). However, the net output of complete Combined Cycle Power Plant shall not be less than the guaranteed figure at site condition.

No Tender which proposes less than 360 MW output at site conditions will not be accepted. Excess output more than 440 MW at site conditions shall not be evaluated.
(2) Number of generating units : One (1) gas turbine generating unit and one (1) unit of steam turbine generating unit.

(3) Operating pattern

- Simple cycle mode : Base load as well as peak load and Free Governing Mode Operation (FGMO).
- Combined cycle mode : Mid-range load and base load Operation.

3.3.2 Main Steam System

The main steam system for the combined cycle unit coming from main header fed from heat recovery steam generator.

Super heater outlet on heat recovery steam generator shall be fitted with a safety valve, non-return valve, by-pass valve and header shut-off valve.

The feeder shall also be fitted with motor-operated vents and drains which shall be operated from central control room.

The main steam header shall be pitched for draining of condensate. As the heat recovery steam generators are brought into service, the main steam line must be drained form drain legs which are fitted with motor-operated valves, and through the turbine above seat drain, which is fitted with a motor-operated valve and a steam trap assembly. The heat recovery steam generator feeder temperatures shall be monitored by thermocouples and pressure by pressure transmitters and pressure switches. Flow from each heat recovery steam generator shall be measured by a flow nozzle and flow proportional signals shall be transmitted to the control panel.

In addition, super heater outlet shall be fitted with a steam sampling connection as well as an acid cleaning connection, each feeder also shall have manual free blow for maintenance purposes.

A motor operated relief valve shall be provided in the common main steam header. A control switch for remote operation of this relief valve shall be provided in the control room.

The main steam header shall deliver steam to the steam turbine stop valve, bypass system, steam seal/gland regulator, and condenser ejector system.

As a part of the main steam system, a turbine bypass shall be provided. The bypass system shall be placed in operation at start-up when the motor operated shut of valve is opened. Bypass line shall be fitted with relief valves for overpressure protection.

3.3.3 Feed water System

Steam generator feed water shall be supplied with condensate from a surface condenser, deaerated in the Deaerator. Suitable chemicals will be added in the feed water cycle for oxygen scavenging and Ph control. Demineralized water will be used as make up to the plant.
The boiler feed water pump of steam turbine generating plant shall be composed of 2 x 100% or 3 x 50% capacity (plus a margin to cover boiler swing) motor driven pumps.

Each pump shall be horizontal, multi-stage, centrifugal type. Provision shall be made for standby pump to run automatically on failure of the running pump. The rated pressure of the feed pump should be derived from the system resistance of the feed system at rated feed flow. This system resistance shall include a static portion, incorporating the drum design pressure, the pressure drop through the feed regulating valve and the height of the economizer.

Each boiler feed pump shall be equipped with a minimum flow re-circulation system, consisting of a flow orifice, differential pressure transmitters and control valves. Recirculation water shall be returned to the Deaerator.

Each feed water supply line to the respective heat recovery steam generator shall be fitted with a flow nozzle and its differential pressure transmitter which alone with the feed water regulator form a part of the heat recovery Steam generator drum level controls. A motorised shut-off valve shall be provided ahead of the feed water regulator as well as motorised bypass valve.

In the main header, a pressure transmitter shall indicate header pressure while a pressure switch shall be used to automatically initiate operation of a standby pump.

The feed water shall be circulated in each heat recovery steam generator drum by the circulating pump. The circulating pump shall take suction from the drum and shall discharge through the evaporator back to the drum. Each drum shall be provided with two local level gauges and two level transmitters. A level transmitter shall send a signal to the level controller and to a recorder.

3.3.4 Condensate System

The condenser shell be located underside or alongside the turbine, with an integral hot well located under condenser shell.

2 x 100% or 3 x 50% capacity condensate pumps shall take their suction from the hot well. Condensate may also be used for the following secondary use:

- Spray water for the condensate receiver and flash chamber.
- Vacuum pump seals.
- Turbine exhausts hood spray.
- Chemical injection units.
- Gland seal emergency spray.
- Auxiliary cooling water make-up
- Bypass steam de-superheater spray
- Condenser sparging de-superheater spray.

Pressure transmitters shall be used to provide condensate pump discharge pressure indication. A pressure switch shall be used to switch to the standby condensate pump when the operation pump or its motor has failed.

In order to ensure a minimum flow through the gland seal condenser, the condensate flow shall be measured by a flow nozzle and differential pressure transmitter, which in turn controls the re-circulation flow to the condenser through a control valve.
The condenser hot well level shall be controlled by split range level transmitters located on the hot well. The control signals from these controllers shall be programmed so that condensate shall be dumped to the make-up water tank to prevent high level in the hot well.

3.3.5 **Cooling System**

Circulating water (Condenser cooling water and cooling water for closed loop heat exchangers) will be cooled by Cooling Tower. Additional 25% of cooling tower cell to be kept as standby.

Condenser cooling water and cooling water for closed loop heat exchangers is supplied by 2 x 100% or 3 x 50% capacity horizontal/vertical, circulating water pumps located in the pump house adjacent to cooling tower basin. Auto Change-over system among the pumps shall be provided.

The circulating water pumps shall take suction from Cooling Tower basin and feed the cooling water to the condenser and cooling water to closed loop heat exchangers.

The pumps shall be installed in the pit below minimum water level of cooling tower. A circulating water pump house shall be provided.

A manual operated butterfly valve shall be provided at each circulating water pump discharge and suction.

Motor operated vent valves shall be provided at the top of condenser waterbox to vent and shut the air automatically.

A motor operated reversals valve shall be provided for condenser backwash purpose. A EOT crane shall be provided in circulating water pump house.

Each water cooling pump shall be furnished complete with all accessories including electric motor drive, non-reverse rotation shaft couplings, baseplates, sole plates and all other accessories as required for a complete unit. The pump sets shall be so designed that they are capable of operating under reverse rotation, continuously. The basis to be taken is the case of full delivery pressure with fully open combined shut-off non-return valve. Reverse rotation protection (instrumentation) has to be provided.

3 x 50% capacity intake pumps shall be provided in the river water pump house to supply water to the chemical plant, a portion of which will be used to produce demi water. Make up water to cooling tower basin and to closed loop cooling water systems will be supplied from chemical plant after required chemical treatment.

3.3.5.1 **Cooling Tower**

**Design**

The cooling tower shall be of the counter flow type. The cooling tower shall be capable of cooling the main cooling water flow to a cold water temperature required to maintain condenser vacuum within allowable operating limits over the full range of ambient and operating conditions and with the plant operating in full bypass.
mode. The cooling tower design shall be based on providing 100% cooling capacity with one cell isolated and inoperative.

The cooling towers shall be designed in accordance with the standards of the Cooling Tower Institute (CTI). In terms of fire protection the cooling towers shall comply with the requirements of NFP A 214. Air flow shall be by induced draft fans operating at variable speed through electronic solid state speed controllers. The Contractor shall allow in his design for any recirculation or interference which may occur due to the proximity of buildings and as a result of wind conditions.

The cooling tower and all components shall be of non-combustible or fire retardant materials to the extent practical. Plastic materials (PVC and CPVC) used in tower construction shall be of special formulations to promote rigidity and shall be low in plasticisers and highly resistant to ultraviolet exposure.

The cooling tower and access roads shall be designed and located to provide mobile crane access from ground level for lifting gear reducers, blades, and motors of every cell. A permanent hoisting crane shall be located on the fan deck to support maintenance activities.

Fan stack height shall achieve optimum pressure recovery and good plume dispersion, but the height shall not be less than 2.4 metres. If required, the cooling tower shall be equipped with a plume abatement system to minimise visible plume as required by local or state regulations and permits.

Cycles of concentration shall be consistent with the make-up water quality and to maintain cooling blowdown to within allowable wastewater discharge permit limits and practical maximum limits of concentration of dissolved salts.

The cooling tower basin shall be constructed in reinforced concrete and have sufficient volume to meet NFPA 850 requirements for provision of a minimum of two hours fire water in the worst case fire situation.

Cooling noise levels shall meet regulatory limits at the site boundary. No fire suppression equipment is to be fitted to the cooling tower.

On commissioning, the cooling tower shall be tested in accordance with ASME Power Test Code for of Atmospheric Water Cooling Equipment PTC 23 to verify design performance.

**Structure**

The material for the cooling tower structure, top deck, access stairs, fan stacks and cladding shall be FRP enhanced with ultra-violet ray blocking and fire retarding properties. The cooling tower shall be divided into ~single cells, each capable of being operated and taken out for maintenance independently, by full-width partition walls.

All connectors, supports and hardware shall be of AISI 316 stainless steel (L grades, if welded). Load bearing tower supports within the basin or around the perimeter shall be above water level. Structural framing shall be through bolted. Glued and/or nailed joints shall not be used.

The fan deck shall be capable of supporting fan components, driving motor, gearbox and shafting during overhaul. The Contractor shall ensure that the mobile crane supplied as part of the Contract can safely lift these items from their perma-
The cooling tower shall also have a fixed lifting frame at one end of the upper desk to lower and raise equipment to and from the ground.

**Fill and Drift Eliminators**

Fill material shall be of sufficient thickness and be adequately supported so that it is rigid enough not to sag, up to a water temperature of 60°C. Design of the fill system shall provide freedom for expansion and contraction without overstressing the fill material; however, sufficient restraint shall be provided to prevent the fill from working loose under the continuous effects of water splash and tower draft. The fill selection should take into account the quality of the make-up water and the type of chemical treatment system being provided. When used as fill material, plastics shall have the following flame characteristics:

<table>
<thead>
<tr>
<th>Flame spread rating:</th>
<th>Not over 25, as rated by Underwriters Laboratories, and in accordance with ASTM Test Method E 84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-extinguishing</td>
<td>In accordance with ASTM Tunnel Test D 635</td>
</tr>
<tr>
<td>Fuel contributed</td>
<td>0</td>
</tr>
</tbody>
</table>

Fill design shall allow for walking on during maintenance or alternatively provision shall be made for installation of temporary platforms below and around fill areas.

Drift eliminators shall operate without vibration or flutter. Construction shall promote ease of maintenance, inspection and replacement. Drift eliminators shall be multi-pass type to limit drift to a maximum guaranteed value 0.002% (should be verified by a functional test) and designed to drain water back to the cold water basin. Eliminators shall be PVC, FRP or a suitable neoprene coated material. Cooling tower drift shall meet permit limits and not impact plant equipment, substation, operations, or offsite areas.

**Hot Water Distribution System**

Hot water shall be distributed to the fill in each cell via a system of headers, laterals, branch arms, and nozzles installed in the region above the fill and beneath the drift eliminators. The joint between branch arms and nozzles shall be threaded so nozzles can be easily removed for cleaning of the branch arms. There shall be a means of cleanout provided at the ends of all headers and branch arms. Nozzles shall be heavy duty and not prone to breakage of components.

The water distribution system shall be capable of operating with water quantities varying between 15% below and 15% above the design water flow per tower cell or quadrant. The distribution of water to individual nozzles shall be such that the flow to each nozzle does not deviate from the average flow per nozzle by ±5%.

The distribution system shall include valves for sectionisation, permitting removal of each individual tower cell or quadrant from service for inspection, cleaning, or repair. Isolatable cells shall be designed to accommodate routine online cleaning and maintenance activities.

The risers and distribution pipe work shall be manufactured from FRP and provided with adequate supports. Pipe work in each cell shall be identical and provided with flanges so that sections are interchangeable and can be removed for maintenance.
**Fans, Gear Reducers and Motors**

Each fan shall be directly connected to its motor through a totally enclosed, heavy duty gear reducer and drive shaft. Fan, gear, shaft bearings, and motor shall be mounted on a common galvanised and epoxy coated steel base frame, designed and constructed to prevent misalignment of the drive train and fan. Fan motors shall not be located in the fan stack or air plenum.

Fans shall be adjustable pitch, manufactured from compression moulded fibre-glass reinforced polyester resin or equivalent, with aerofoil profile. The number of blades shall not be less than six.

Blade clamp material shall be stainless steel or cast iron with stainless steel bolts and nuts.

The driveshaft tubes and flanges shall be of AISI 316 L stainless steel or carbon fibre. Shafts shall be prevented from major displacement by retaining straps just clear of the shafts.

Gear reducers shall have an oil level sight glass, fill line, vent line, drain line, low level switch and grease fitting connections all located outside the fan cylinder for convenient maintenance access. All lines shall be fabricated from AISI 316 L stainless steel.

Motors shall have easily removable couplings, located outside the fan cylinder. The drive tube shall be capable of being withdrawn through the fan cylinder for maintenance.

Two accelerometer type vibration transducers shall be installed on each motor/gearbox/fan unit. One shall be fitted to the gearbox and the other to the motor. Both shall be connected to the ICMS.

The cooling tower vibration monitoring equipment shall be Bentley Nevada 1900-65 or equivalent. The monitoring equipment shall be mounted at the base of the tower in common enclosures suitable for the harsh environment. Lightning protection surge suppressors (SDS brand preferred) shall be provided in the transmitter enclosures in circuit between the accelerometers and the transmitter inputs. Gear reduction units shall be capable of operating in either forward or reverse with equal facility. Speed reduction units using external oil pumps shall not be used. Gear reducers shall meet or exceed the requirements of CTI STD-III and the service factor shall not be less than 2.0. A vibration switch shall be mounted on the gear box to protect mechanical equipment from excessive damage due to vibration of rotating members. A breather line shall be provided for each gear reducer and fitted with a filter at the air intake.

**Access**

One end wall of the cooling tower shall be equipped with a stairway rising from the level of the cold water basin curb to the fan deck. Landings shall be provided at 1,800 mm intervals. A fire escape ladder shall be provided at the other end of the cooling tower.

Each cell shall have a lift-off access hatch in the fan deck floor and a ladder leading down to a landing at the drift eliminator level. Each landing shall have a lift-off hatch for entry to the top of the fill and distribution level.
Fan stacks shall have easily removable external hatches of sufficient size to allow removal of all mechanical equipment and components. One temporary access catwalk to the centre of the fan stack shall be provided for use in each cell.

### 3.3.6 Closed circuit cooling water system for Auxiliary Cooling

A closed loop fresh water-cooling system shall be provided for equipment components requiring cooling water. The system shall consist of 2 x 100% or 3 x 50% capacity cooling water pumps. Cooling water head tank, 2 x 100% capacity auxiliary cooling water heat exchangers, and required piping system including its valves, etc.

Cooling water may be used for the following components:

- Steam turbine lube oil coolers.
- Steam turbine hydraulic unit.
- Instrument air compressors.
- Boiler feed pump coolers.
- Heat recovery steam generator circulation pump coolers.
- Sample coolers.
- Gas Compressor lube oil system.

Thermo control valves shall be provided on the outlet of each component requiring cooling so that system flows and pressures can be balanced.

Make-up water shall be supplied from the condensate system to the cooling water head tank.

### 3.3.7 Chemical Feed System

The heat recovery steam generator system shall be provided with chemical feed packages for the injection of amines and hydrazine into feedwater and caustic/phosphate into the steam drums. Each package shall consist of a solution tank with accessories. One (1) adjustable simplex pump (with identical standby pump) will be provided for each injection unit.

### 3.3.8 Instrument Air & Service Air System

#### 3.3.8.1 General

One instrument air and one service air system shall be provided each consisting of 2 X 100% capacity reciprocating/ screw air compressors each with necessary desiccant type air dryer, air humidifier, air filters, after cooler and receiver. One dual tower shall be furnished with the system. Each compressor shall be furnished with automatic controls locally mounted. Instrument air and service air system shall be interconnected.

#### 3.3.8.2 System Description

The plant compressed air system is mainly consists of instrument air system and service air system. Instrument air is required for the various pneumatically operated valves and instruments in the power plant, while service air is required for general plant services like operation of pneumatic tools, cleaning etc.

Plant compressed air system shall consist of Air Compressors, Air-Drying Plants
(ADP), Air Receivers & complete compressed air piping and would cater to the requirements of Instrument Air & Service Air of the plant.

Instrument air is dehumidified & dried to requisite level before use. Oil free air is required from the compressors especially for instrument air service. The instrument air-piping arrangement shall be such that any compressor & ADP can be selected in case of non-availability of anyone equipment. This selection may be possible through proper selection of valves from the PLC. These interconnecting valves shall be motorized valves. The instrument air distribution will be through main header & it will be ensured that sudden leakage in any part of the instrument air lines will not affect instrument air supply to any of the other supply points.

Service air is taken from the compressed air header after air compressors and is supplied to the Service Air Receiver. Instrument air header and the service air header are interconnected (upstream of driers). Quick closing valve shall be provided in the interconnection line, which shall close supply to service air network as soon as the instrument air pressure falls below a certain level. The plant service air system will be designed & provided suitable manifolds to allow adequate discharge points in all operation & maintenance areas.

The instrument and service air plants shall be housed in the compressor station. The instrument air and the service air shall be fed to two separate pipe networks. These networks shall bring air to various utilities located at various places throughout the entire plant.

For the instrument air system, the important utilities shall be connected by twin full load air lines and the remaining utilities by a single full load air line. For service air, the utilities shall be connected by a single full load air line.

3.3.9 **Steam Turbine Drains**

Various high pressures drains including those from the stop valve and the steam supply to the steam seal regulator shall be taken to the flash chamber of the condensate receiver. The turbine drain lines required for a fast start-up of the steam cycle shall be fitted with motor-operated shut-off valves.

Various drains from auxiliary steam systems, which shall not be highly essential to a fast start-up, but shall be considered to be required for steam piping drains, shall be fitted with steam traps and shall be taken to the condensate receiver. The following steam turbine drains shall be taken to the condenser.

- Steam chest drain
- First stage shell drain
- Inner valve steam drain
- High pressure packing leak-off
- Exhaust casing drains.

3.3.10 **Condenser Air removal System [Air Extraction System]**

The air-removal for the steam surface condenser shall consist of two (2) full capacity vacuum pumps/ steam jet air ejector and the appropriate air removal piping system. Provision shall be kept for start-up stage both vacuum pumps or steam jet air ejectors. When vacuum is established, the vacuum pumps or steam jet air ejectors are operated in a primary back-up relationship from the control panel. The back-up vacuum pump or steam jet air ejector will start up if the pressure
switch at the condenser indicates that the vacuum has decayed to an alarm lever.

### 3.3.11 Boiler Drains and Sample Coolers

The drains of each heat recovery steam generator shall be taken to the blowdown tank where the high energy is dissipated by flashing the liquid by steam. The flashed steam shall be vented to atmosphere and the water shall be discharged to the blow-down tank drain.

The drain lines from the heat recovery steam generator steam lead and the superheater inlet drain and superheater inlet and outlet shall be located at this station along with coolers for the feedwater samples from the boiler feed pump discharge.

### 3.3.12 Fire Protection System

A CO₂ fire protection system shall be provided for the gas turbine generating units complete with CO₂ cylinder kept in a container/shed/room. Proper water hydrant system shall also be provided for other area, equipment and facilities. Fire protection wall and Deluge system is required for all outdoor transformers. Required nos. of portable DCP/ CO₂/ Foam cylinders to be provided in different areas of the power plant.

### 3.3.13 Water Treatment System

The treatment of water in order to make it suitable for industrial use includes a complex of physical, chemical and biological methods, which change the initial composition of water.

As the critical first stage in the water purification process, clarifiers remove large quantities of suspended and organic matter from the raw water. The type of clarifier to be used is dependent on the level of suspended solids, type of suspended materials of the raw water.

Filters (after clarification) are required removing a large percentage of suspended particulate matter from the intake water by straining it through various media. The type of filters to be used will be based on flow rate, the quality of water and properties of intake water. The bidder may conduct water analysis if deemed necessary at his own cost before submission of the bid. However, after signing of Contract the water analysis at the cost of the Contractor is mandatory for detailed design of Water Treatment Plant.

Deminerisation is the 3rd step of this process. There are two basic steps of deminerisation system: roughing deminerisation and polishing deminerisation. Roughing removes a bulk of mineral contamination and brings the water quality close to desired purity.

Polishing used after roughing stage to reduce any residual minerals and ionic content. The type of Roughing and Polishing De-mineraliser to be used is dependant upon feed water quality and water quality produced.

The demineralizer shall be sized to handle the steam cycle make-up. The deminerizer system shall consist at least of 2(two) clarifiers each of 100% capacity, 2(two) Filters each of 100% capacity, a dual-train demineralizer, consisting of a roughing demineralizer unit and a polishing demineralizer unit with a share forced
draft decarbonator.

Condensate Polishing is a must for using recycling boiler water. Condensate Polishing removes ionic contamination, trace hardness, silica and other corrosive agents. The type of Condensate Polishing to be used is dependent upon feed water quality, water quality produced, level of Sodium and water temperature for the process.

The water treatment system shall be designed preferably to use (if necessary) HCl, NaOH for regeneration of demineralizers and HCl, NaOH, FeSO4 etc. for dosing the clarifier. This is however, may not be applicable to the water treatment system using other advanced system of water treatment.

**De-mineralized Water Plant**

De-mineralized water plant shall have two (2) X100 % capacity trains, each consists of activated carbon filter, cat ion exchanger, de-gasser tower, anion exchanger and mixed bed ion exchange unit. Also chemical storage and feed system, chemical waste neutralization system and treated water storage and feed system shall have to be provided.

A complete duplex train ion exchange type of de-mineralized system shall be provided for producing required quality water. Equipment shall be provided with piping, valves, instrumentation and controls for automatic and manual operation. The design parameter of water quality at mixed bed outlet shall be as follows;

- Conductivity < 0.5 μS/cm
- Silica as SiO2 < 0.02 ppm

A carbon filter shall be provided to remove suspended solids, residual chlorine and organic contaminants.

The cation, anion and mixed bed ion exchangers shall be provided to remove ions from feed water and produce highly purified water.

One regeneration system for common use of two trains shall be provided. Acid and caustic chemical dosing system shall consist of storage tank, preparation tank, agitator, two pumps and associated equipment.

The produced DM water will flow to DM water storage tank. Two (2) 100% capacity DM water transfer pumps taking suction from DM water storage tank distribute the DM water to condensate tank, water wash skid and closed cooling water make-up.

During the regeneration, chemical wastes are led to neutralization pit. Collected wastes shall be neutralized by using the acid and caustic regeneration facilities to meet the emission limits. The treated wastes are discharged to storm water drain system.

Total water treatment system will be controlled and monitored by Programmable Logic Controller (PLC) installed at local room. Following automatic operation shall be foreseen.

- Whole regeneration process initiated by an operator shall automatically be carried out.
- Water production shall automatically be controlled by monitoring the water level of storage tank.

- If any fault and/or abnormal conditions are detected by remote measurement, programmed interlock system shall indicate alarms and act to protect the equipment and system.

System fault (common) alarm can be monitored by DCS

Complete Bill of Materials (e.g. Raw water tank, demi water tank, semi-demi water tank, filtered water storage tank, chemical storage tank, condensate tank etc. having adequate capacity) / type of equipment (e.g. clarifier, filter, roughing demineralizer, polishing demineralizer, condensate polishing system etc.) required for a particular water treatment plant shall have to be provided by the Bidder according to the system of water treatment plant proposed (depending on property of available river water) for the combined cycle plant. Raw water Tank capacity shall be for 24 hrs continuous operation (full load) of Steam Turbine. Two (2) nos. of Demi water Tank (HRSG reserve water tank) are to be installed. Materials will be stainless steel (SS) and capacity of each Demi water Tank will be 600 M$^3$.

Chemical Laboratory

The laboratory installations and equipment shall be installed for routine control of:

- service water
- water-steam-condensate water
- waste water and

in a Combined cycle Power plant.

The scope of supply comprises all necessary supplies and services even if no special reference is made to these.

The instruments and equipment to be delivered shall be as up-to-date as possible the laboratory shall be designed in accordance with general safety stipulations.

Analysis

The scope of supply shall include all necessary equipment to analyze parameters as follows:

Service water analysis

- pH-value
- conductivity
- suspended solids
- chemical oxygen demand
- $\text{KMNO}_4$ -demand
- Iron
- manganese
- total hardness
- alkalinity/acidity
- microbiological quality
- chlorine
- Water-steam-condensate circuit
- oxygen($O_2$)
- iron
- sodium
- silicate ($SiO_2$)
- phosphate

Waste-water
- pH-value
- conductivity
- suspended solid
- chemical oxygen demand
- biological oxygen demand
- ammonia
- heavy metals (Cd. Hg. Cr. Ni. Cu. Ph. In)
- chloride
- sulphate
- sulphite
- sulphide
- oil content

**Laboratory instruments**

The laboratory equipment shall comprise all instruments and apparatus necessary for the analytical investigations listed above including all necessary accessories. Minimum requirements for instruments and apparatus are as follows:

- UV/visible spectrophotometer, electrically operated for accurate routine colorimetric analysis
- analytical balance, with digital display, fully automatic calibration and multi-application key board. Weighing capacity 200 g, sensitivity 0.1 mg
- electronic top-loading balance, sensitivity 0.01 g, max capacity 5000 g
- BOD analyser
- elementary analyser
- laboratory bench centrifuge for analysis
- portable pH-meter
- portable conductivity meter
- analysing equipment for measuring microbiological water quality
- muffle furnace microprocessor controlled rated temperature 1100°C.
- automatic heating and drying oven
- magnetic stirrer hotplates
- portable dissolved oxygen meter
- turbidity meter
- portable cooling boxes
- electric rotator shakers
- electrically heated baths, for use as water, oil or sand bath
- universal laboratory mill for grinding
- bunsen burners with all necessary equipment
- laboratory stirring apparatus
- vacuum pump
- digital camera system
- light microscope
- personal computer system with high resolution colour printer for photo documentation.

3.3.14 Potable Water system

Potable water system to the plant area and other plant related area should be included with the Tender.

3.4 Electrical System

The electrical system shall consist of apparatus required to operate the gas turbine generating units, the heat recovery steam generators, steam turbine generating set, associated equipment, and step-up transformer and 230kv switchgear equipment necessary to delivery power to the 230KV national grid system.

3.4.1 Electrical system interrupting capacity

In this specification, the system and equipment ratings and characteristics are based on the following preliminary data:

- 230 kv switchgear : 40 kA
- Generator switchgear : As per IEC standard
- 6.6 kv switchgear : 40 kA
- 415 V switchgear : 50 kA

3.4.2 Generator

The generator shall be of hydrogen/air cooling type.

Generator shall have a complete rotating rectifier type excitation system or static excitation system mounted in a suitable enclosure including rectifiers, static voltage regulator and required control functions. If rotating rectifier type excitation system is not used and external static excitation is used, separate excitation transformer shall have to be provided for each generator.

The generator shall be connected to the low voltage windings of its step-up transformers by IPB (copper).
3.4.3 6.6 kV Switchgear

The 6.6 kV common switchgear will consist of metal clad circuit breakers and fed through Unit auxiliary transformer. The 6.6 kV switchgear shall supply auxiliaries and common auxiliary power. In addition of present requirement, two(2) nos. of spare 6.6 kV circuit breakers to be installed for future requirement.

3.4.4 Balance of Plant

The auxiliary for the gas turbine generating set and the steam turbine generating set shall be fed through either the unit auxiliary transformer or the station transformers. The unit auxiliary transformer shall step down the generator voltage to 6.6 kV to feed the auxiliary equipment. The station transformers shall step down the medium voltage of 6.6 kV to 415/230 V to feed gas turbine generator unit MCC and the heat recovery steam generator MCC and steam turbine generating unit MCC and common station load. The motor control centers shall contain all the motor starters and circuit breakers to supply the low voltage auxiliaries of the gas turbine generating units, the steam turbine generating unit and the heat recovery steam generators.

Electrical installation materials shall be chosen for power plant service including lighting, lighting transformers, panel boards, switch's, outlets, receptacles, power and control cable, conduit, conduit elbows, bushings, couplings, lockouts, cable trays, wire ways, pull boxes, floor ducts, junction boxes, cable accessories, copper bar and ground rods connections, and various devices for the safe operation of the system.

A main ground grid made up of copper conductor and an adequate number of driven ground rods to give a low grounding resistance shall be provided.

The power and control, cable provided shall be constructed with insulation and jacketing in accordance with the latest IEC standard.

3.5 Functional Requirements

3.5.1 General

Combined cycle shall be designed for operation as a base load generating unit. The gas turbine unit shall also be suitable for peak load operation as well as base load plant and Free Governing Mode Operation (FGMO).

3.5.2 Controls

The combined cycle generating plant shall be capable of semi-attended operation under local unit control, and shall also be capable of remote control from the central control room within the site area. The automatic start-up and shut down sequences shall be initiated by DCS either from the local control room or the central control room. Synchronisation shall be automatic with provision for local and remote manual control.

3.5.3 Cooling system

The units shall be designed for water cooling of the condenser, lubrication oil system, etc. The cooling system for generator shall be closed cycle cooling water and air cooling system.
3.5.4 Noise Levels

The Noise level shall not be more than the values specified as per applicable Environmental standard of DoE as per Annexure.

3.5.5 Vibration Severity

Vibration severity of the units shall not exceed 8.0 mm/sec. In normal operation measured at any bearing pedestals both in vertical and horizontal plane.

3.5.6 Critical Speed

The Critical speed of the rotor assembly as a complete unit shall be at least 20% above or below the operating speed range of the units.

3.5.7 Spare Parts and consumables

As mentioned in clause 2.23.

3.5.8 Special Maintenance Tools

As mentioned in clause 2.24.
Section-4

Gas Turbine and Ancillary Equipment
4.0 Gas Turbine and Ancillary Equipment

4.1 General
4.2 Guarantee
4.3 Gas Turbine and Ancillary Equipment

4.3.1. Basic Equipment Requirements
4.3.2 Gas Turbine and Auxiliaries
  4.3.2.2 Starting System
  4.3.2.3 Turning Gear
  4.3.2.4 Load Gear and Accessories Drive Gear
  4.3.2.5 Compressor Wet Washing System
  4.3.2.6 Governor System
  4.3.2.7 Lubrication Oil system
  4.3.2.8 Natural Gas Fuel system
  4.3.2.9 Air Inlet system
  4.3.2.10 Exhaust system
  4.3.2.11 Instrument Air Supply
  4.3.2.12 Unit Enclosure
  4.3.2.13 Fire Protection Equipment
  4.3.2.14 Casing design
  4.3.2.15 Insulation and lagging
4.0 Gas Turbine and Ancillary Equipment

4.1 General

The arrangement of the plant equipment shall be generally as described below:
Gas Turbine generating unit with a continuous total net generating capacity approx. 65% of combined cycle output shall be accommodated in the location proposed.

4.2 Guarantee

The net output and heat rate of the Unit shall be guaranteed by the contractor at the following conditions:

a. Ambient temperature : 95°F (35°C)
b. Site elevation : less than 100 ft(msl)
c. Relative humidity : 98%
d. Barometric pressure : 1.013 bar
e. Generation voltage : 21 kV (or other level)
f. Power factor : 0.8 lagging
g. Frequency : 50 Hz

The contractor shall guarantee the starting reliability of the Unit(s) including all ancillary equipment. The guaranteed reliability shall be stated in the Tender form together with the number of consecutive starts to which the Unit will be subjected to demonstrate this reliability.

4.3 Gas Turbine and Ancillary Equipment

4.3.1 Basic Equipment Requirements

The gas turbine generating unit shall be of well proven design and the offered model of gas turbine generating unit (evolution of frame will not be accepted) shall have satisfactory operating experience outside manufacturer's country for at least 2 (two) years. Tenderer shall have to submit separate end user certificate in this respect, otherwise Tender shall be rejected.

The extent of supply shall include, but not be limited to, the equipment described herein. All equipment comprising the gas turbine package shall be pre-assembled in the factory.

4.3.2 Gas Turbine and Auxiliaries

The gas turbine generating unit shall be of heavy-duty industrial packaged type with incorporating latest version of Dry Low NOx Combustion system suitable for indoor installation and operation under the site conditions as specified in Art. 4.2 & Schedule B of Volume 2 of Part B.

4.3.2.1 Vibration Critical Speed

The radial amplitude of vibration of any rotating shaft under steady state conditions at normal operating speed shall not exceed the value specified in API Standard 616 when measured at the shaft local to the bearing. The critical speed shall be beyond ± 20 % of the operating speed of the engine.

All compartments in the gas turbine generating unit(s) shall be accessible for
inspection and maintenance.

The gas turbine unit shall be designed to burn natural gas as specified.

The unit shall be capable of frequent starts and stops without damage to the hot gas path components and shall be able to run for base load.

### 4.3.2.2 Starting System

The gas turbine shall have motor driven starting equipment capable of sustaining the complete starting cycle. The starting motor shall be capable of carrying out at least Five (5) consecutive starting without any harmful effect. Tender can also propose SFC starting. In that case SFC transformer (if required) shall have to be provided.

### 4.3.2.3 Turning Gear

A rotor turning gear shall be provided to minimise thermal distortion of the rotor after operation and to permit rapid reloading of the unit after a shutdown.

Necessary oil piping and appurtenances shall be included. Turning gear oil piping system shall be a part of the turbine lubrication system and shall be complete with all necessary pressure switches or other interlocks to prevent turning gear operation if lubricating oil pressure drops below than pre-set valve. Suitable housing and safety guard shall be provided for all moving parts of the turning gear. Turning gear operation shall be indicated on the remote control panels. The turning gear shall have automatic engaging and disengaging mechanisms. Additional arrangement for hand turning shall be provided for use in case the automatic turning system fails to operate.

### 4.3.2.4 Load Gear and Accessories Drive Gear

The turbine shall be equipped with good quality and suitable load gear equipment of proper rating if required to match the generator speed for 50 Hz generation. Load gear shall be totally enclosed and be equipped with forced lubricating device to the gear.

The turbine shall also be equipped with suitable accessories driven gear unit.

### 4.3.2.5 Compressor Wet Washing System

#### 1. System Descriptions

The compressor wet washing system (On & Off line) shall basically comprise of wash water tank with accessories, detergent hopper, interconnecting piping & valves, spray water manifold and spray nozzles. The various components of the system are shown in schematic diagram enclosed. Wash water tank shall be used to draw and mix wash water and detergent to the required dilution, compressed air taken from existing instrument air header shall be used to pressurise this fluid and to forward to the spray water manifold. The spray nozzles shall make a high velocity jet spray to clean the compressor blades while the rotor shall be kept in spinning operation.

i) Wash water tank shall be a cylindrical pressure vessel with dished ends on both sides. This tank shall be provided with necessary appurtenances and accessories such as
a) Compressed air inlet.
b) Water inlet with isolation valve and inlet strainer.
c) Breather vent with isolation valve.
d) Drain line with isolation valve.
e) Detergent inlet nozzle with isolation valve.
f) Pressurised water outlet with isolation valve.
g) Level gauge glass with isolation valves.
h) Hand holes with covers.
i) Pressure relief valves.
j) Pressure gauge connection.

ii) Detergent hopper to hold the detergent for every wash cycle.

iii) Interconnecting piping between wash water tank and compressor spray system. This line shall be provided with strainer, drain valve, pressure gauge, and orifice plate.

iv) Water wash manifolds. This manifold shall be located within the compressor inlet and it shall distribute the wash water into the compressor inlet air stream. The manifold shall be equipped with a drain valve.

v) Set of spray nozzles shall effectively spray water, detergent water for efficient cleaning.

To introduce the above-mentioned wet washing system for compressor cleaning of gas turbine generating unit. The following works shall be reformed:

a) Installation of the wash water system.
b) Providing spray nozzle on compressor inlet manifolds.
c) Taking a tapping from instrument compressed air header to supply compressed air for washing system.
d) Routing the wash water to the Gas Turbine Compressor.
e) Providing various drain lines with isolation valves at drain points from the compressor and turbine to drain the wash water during washing cycle.
f) Providing bearing seal air piping to protect bearing during washing cycle.
g) Drainage system to drain out the water.

2. Compressor wash water quality

Total trace elements in compressor wash water (after adding detergent) will preferably be limited as follows.

<table>
<thead>
<tr>
<th>No.</th>
<th>Trace Metal</th>
<th>For Million Parts of Water by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sodium &amp; Potassium</td>
<td>30 ppm</td>
</tr>
<tr>
<td>2</td>
<td>Calcium</td>
<td>10 ppm</td>
</tr>
<tr>
<td>3</td>
<td>pH</td>
<td>7.5 to 8.0</td>
</tr>
</tbody>
</table>

The Tenderer shall design, manufacture and supply all the components (Viz. water tank, piping, valves, strainer, drains, manifolds, injection nozzles etc.) of the above mentioned compressor wet washing system of suitable
grade of material to handle the above wash water without any deterioration. The Tenderer shall clearly specify the proposed grade of materials of the above components. The Tenderer shall provide complete system.

4.3.2.6 Governor System

The gas turbine unit shall be provided with a complete governing system which shall be capable of maintaining a required constant speed under conditions of load variations, control the turbine load, combustion gas temperatures and prevent turbine over-speed.

The speed governing system shall be provided with speed changing device capable of local and remote control. Provision shall be made to shutdown the turbine under emergency by local and remote control. The speed regulation shall be adjustable (from no load to full load) between plus and minus 5%. The rated speed at no load condition shall be adjustable within ±0.5% for easy synchronising. The governing system for the unit shall also be provided with automatic over-speed trip devices adjustable up to 110% of the rated speed, and a load limiter.

The governing system shall include an adjustable load limit control, minimum fuel regulator, temperature limit control, temperature increment rate control and necessary protection equipment.

The governing system shall be suitable for parallel operation with a large power system and also for completely isolated and independent operation. In addition to the automatic speed governing system, a separate emergency over-speed trip mechanism and over combustion gas temperature trip system shall be furnished on the unit. These systems shall operate to shut the emergency fuel trip valves. The unit shall not trip with voltage fluctuation of ±10% and frequencies variation ±4%.

Over-speed occurring under any conditions shall not have any harmful influence on the turbine generating unit or on its auxiliaries. The governor shall have adjustable (±2%) droop setting.

4.3.2.7 Lubricating Oil System

The lubrication system of the unit shall be equipped with the main oil pump, auxiliary motor driven oil pumps, delivery pipes, return pipes, reservoir, strainer, oil cooler, pressure gauges and thermometers, and all necessary oil piping for the system.

The unit shall be equipped with a gear/ AC driven main oil pump, a full capacity motor driven auxiliary oil pump and an emergency DC motor driven oil pump. The emergency DC motor driven oil pump shall have sufficient capacity to prevent damage the turbine generator during an emergency shutdown. Each oil pump shall be equipped with a section strainer. Pressure switches/ transmitter shall be provided as required to permit automatic sequential starting of the auxiliary oil pump, and emergency DC oil pump in case of oil pressure drop. Auxiliary contacts required for indication shall also be furnished on pumps and pressure switches.
Each oil reservoir shall be furnished complete with, vapour extractor, level indicator, high and low level alarm switches, strainer, drain valves, overflow pipe, manhole, valves, and piping.

The system shall include oil pressure and temperature alarm, and trip mechanism, each bearing shall be provided with thermocouple cell and a thermometer in pocket of oil drain.

Complete oil coolers each for 100% capacity shall be provided. One of two oil coolers shall normally be in service, change over from one oil cooler to the other during operation shall be possible. It shall also be possible to use both oil coolers at same time. The oil coolers shall be of either air cooling type or water cooling type. The oil coolers shall be provided with blowers or water pumps, depending upon the type of cooling.

4.3.2.8 Natural Gas Fuel System

The unit shall be provided with gas fuel system. The natural gas system shall have the necessary pressure regulating valves, piping, shut off valves, metering device, pressure gauges, and other indicating instruments including flow meter with integration. The gas fuel system shall be provided with necessary protective equipment for proper control and safe operation of the gas turbine generating unit.

Specification of Natural Gas has been furnished in Annexure. The system shall comprise at least, the following major items including gas booster compressor:

- Shut off valve.
- An inlet strainer.
- A flow-meter with bypass system.
- Pressure regulating equipment.
- Pressure gauges on before and after regulating equipment.
- A gas conditioner (scrubber and demister).
- A knock out drum if required.
- Drain tank.
- Inert gas purging system

Each unit shall have guaranteed capacity, which matches or exceeds the gas turbine needs under all load-operating conditions at site conditions.

Typical Composition of natural gas is shown on Annexure for Tender purpose only. However during design period the Tenderer should collect the appropriate specification of natural gas from competent authority/Karnaphuli Gas Distribution Company Limited.

All the technical specification, parameters and construction philosophy shall be followed as per Guideline of Karnaphuli Gas Distribution Company Limited. Contractor will bear all cost related to supply, installation, construction and necessary connection to the CMS of Karnaphuli Gas Distribution Company Limited.

Nitrogen will be used as inert gas and purge gas. Nitrogen pressure inside storage bottle will be of 200 bars. N₂ station consisting bottles will be furnished with necessary instruments and valves for proper handling.
4.3.2.9 **Air Inlet System**

The air filtration arrangement shall be Multistage static Type.

Air Intake filter System comprising:

a) Pre filter Pad  
b) Pad coalescer  
c) High Efficiency Filter

Brief technical specification:

a) One filtration unit for compressor air intake of Gas Turbine.  
b) Flow rate: According to requirement  
c) Pressure droop: clean: 38mm water and dirty: 76 mm water.  
d) Filter media: Glass fibre/ Synthetic fibre.

The Tenderer shall supply 1 filter unit for Gas Turbine complete in all respects including necessary supporting structures, holding frames, fasteners, pressure switches, gauges etc. whichever are necessary. The Tenderer shall also submit necessary design documents and drawings for this filtration system.

Each air inlet system shall be provided with silencer if required capable of keeping the sound pressure level of 45 dB when measured at a distance of 100 meter from the plant operating at full load as per ISO standard.

4.3.2.10 **Exhaust System**

Gas turbine unit shall be equipped with an exhaust duct and a suitable by pass stack (not less than 50 m) with hydraulic diverter damper for prolonged continuous simple cycle operation. The exhaust system shall have a silencer to reduce the sound level of 65 dB when measured at a distance of 100 meter from the plant when operating at full load.

The duct shall be supplied complete with all necessary expansion joints thermal and acoustic insulation, manholes, drains, supports, bolting and jointing. It shall be arranged in such a way that normal maintenance can he carried out on any component without dismantling the duct.

The Emission level of exhaust is less than 30 ppm for NOx.

4.3.2.11 **Instrument air supply**

The gas turbine unit shall be equipped with an instrument air supply system which includes instrument air compressor, air reservoir, oil separator, air drier etc. and complete in all respect.

4.3.2.12 **Unit Enclosure**

Except as otherwise specified, all equipment shall be enclosed in a minimum number of prefabricated metal enclosures. The enclosures shall be constructed in a neat and work manlike manner and shall present an attractive appearance.
Enclosures shall be weather proofed and shall for wind loading as per latest approved Wind Map of BNBC.

Enclosures shall be designed to permit easy accessibility to the equipment and to provide necessary protection for maintenance personnel. Sound absorbing insulation shall be provided on the enclosures. Enclosures shall be provided with walkways, steps, strains, and equipment doors of the locking type.

Enclosure insulation, ventilation, and cooling shall be provided to maintain temperatures suitable for personnel and for all systems whether standby or operating. Unit control rooms shall be ventilated and air-conditioned.

Turbine compartment and generator compartment shall be adequately ventilated utilising forced ventilation with louvers and bug screens as required for protection of the houses equipment from outdoor environmental conditions.

Adequate interior lighting shall be provided, and emergency DC lighting shall also be provided, and those shall be energised through an automatic throw over contractor when AC source fails.

Enclosures shall be provided with 240 volt AC service outlets. The noise level at 1 (one) meter distance will not be more than 85 dB and less than 65 dB at 100 meters.

4.3.2.13 Fire Protection Equipment

The entire gas turbine generating unit including all auxiliary compartment shall be automatically protected from fire with complete fire protection system complete with C0₂ gas system, fire detectors, pipeworks, control and safety device. Actuation of the fire protection system shall be indicated at the control compartment and by a visual and an audible alarm to warn any personnel in the compartments.

4.3.2.14 Casing Design

The casings of all the rotary parts on the main unit shall be spilt horizontally for easy dismantling and inspection. Lugs for lifting the upper casing shall be provided at points which will lift the casing half well balanced. Complete lifting gear together with lifting drawing and instruction shall be furnished.

4.3.2.15 Insulation and Lagging

Thermal insulation shall be provided where necessary and is to include such parts as the combustion chambers, exhaust ducts and hoods. Removable insulation blankets shall be provided in all parts where insulation must be removed for maintenance purposes.
Section-5

Heat Recovery Steam Generator and Ancillary Equipment
5. **Heat Recovery Steam Generator and ancillary equipment**

5.1 **General**

5.1.1 Type of Unit  
5.1.2 Steam Conditions  
5.1.3 Maximum Continuous Rating (MCR)  
5.1.4 Design Pressure  
5.1.5 Feed Water  
5.1.6 System Temperature Control  
5.1.7 Forced Circulation  
5.1.8 Acid Cleaning  
5.1.9 Steam Purging

5.2 **Heat Recovery Steam Generator**

5.2.1 Heat Transfer Section  
5.2.2 Steam Drum  
5.2.3 Super-heater  
5.2.4 Economiser  
5.2.5 Soot Blowers: Deleted  
5.2.6 Casing and Insulation  
5.2.7 Steam Generator Fittings and Mountings  
5.2.8 Structural Steel  
5.2.9 Pipe Work  
5.2.10 Valves  
5.2.11 Instrumentation & Control  
5.2.12 Stairways, Galleries, Ladders and Handrails  
5.2.13 Off-load Cleaning Equipment  
5.2.14 Gas Ducts

5.3 **Special Tools and Spare Sprats**

5.3.1 Special Tools  
5.3.2 Spare Sprats
5. Heat Recovery Steam Generator and ancillary equipment

5.1 General

5.1.1 Type of Unit

The heat recovery steam generator unit shall be of outdoor, forced/ Natural circulation and water tube type arranged for using exhaust gas from the gas turbine unit.

The steam generator shall be of welded construction throughout. The entire steam generator (exclusive of minor boiler component parts) shall be either suspended from a steel framework located above the unit proper or bottom supported. Supports at intermediate levels shall not be used.

The major components of each steam generator shall be as follows:

a. The steam drum and heat transfer sections which consist of the economiser, evaporator and super heater tube bundles of the steam generator.
b. The support structure system for the steam generator and ducting.
c. The stairs, platforms and ladders required for maintenance, inspection and operation of the heat recovery steam generator.
d. The steam generator circulating water system for the evaporator and drum circuits.
e. The steam generator valves and devices which consist of indicators, switches, transmitters and sampling nozzles. Motorised valves as required for remote or automatic operation shall be included.
f. The feed water control valve system.
g. Flow nozzles for feed water and steam.
h. A duct system to guide efficiently the turbine exhaust gas to and from the steam generator.
i. A hydraulic controlled diverter damper system to control exhaust gas flow during start up and to accommodate simple cycle or combined cycle operation. A guillotine damper (motor operated) shall also be provided.
j. The steam generator control system to provide control capability for transient, steady state and protective conditions.

5.1.2 Steam Conditions

The steam conditions shall be determined by the Tenderer and be clearly indicated in the "GUARANTEE SCHEDULE" and "TENDERER’S DATA SHEET" (Part B, Vol. 2).

5.1.3 Maximum Continuous Rating (MCR)

The maximum continuous rating (MCR) of the steam generator shall meet the maximum exhaust gas from the gas turbine generating unit at base rating at any site conditions.

The steam generator shall be capable of meeting the output efficiently for extend-
ed periods with normal on-load cleaning only and without having to be shut down for overhaul of off-load cleaning of the gas paths and heating surfaces.

The tenderer shall submit calculations showing how the MCR of the steam generator is derived.

5.1.4 Design Pressure

All pressure parts of the steam generating unit shall be designed to withstand the design pressure to be stated in "TENDERER'S DATA SHEET" and shall conform to the requirements of relevant standards.

5.1.5 Feed water

Steam generator feed water shall be supplied by condensate from a surface condenser, desiccated in the condenser or a desiccating feed water heater. Suitable chemicals will be added in the feed water cycle for oxygen scavenging and pH control. Demineralized water will be used as make up to the plant cycle.

5.1.6 System Temperature Control

Steam temperature at the superheater outlet shall be automatically controlled to ± 10 °C with adequate cooling method such as feedwater spray.

The tenderer shall state the rates of loading which the steam generator will be capable of achieving while maintaining the superheated steam temperature within the limits stated above. Control may be effected by either spray type or surface type desuperheater.

Steam temperature curves below the control point shall be as flat as possible and shall be provided by the Tenderer.

The control equipment shall automatically maintain the superheat steam temperature within the control range as specified in this Clause. Manual control of superheat steam temperature shall be possible over the full range of steam generator output.

5.1.7 Forced Circulation/ Natural Circulation

The forced circulation/ Natural circulation system shall be adopted to give proper circulation in the evaporator circuit and start up flow to the economiser.

5.1.8 Acid Cleaning

Provision shall be made to facilitate acid of the pressure parts. Vents and drains shall be of ample size and suitable connections shall be provided for feeding acid flushing headers after the wash.

The Contractor shall assume full responsibility for ensuring that the acid cleaning is to be carried out effectively and in a manner to prevent damage any part of the steam generator or other plant.

All necessary equipment, for this process, external to the boiler such as tanks, pumps and piping, shall be provided by the Contractor. All necessary chemicals for the process shall be recommended and provided by the Contractor.
5.1.9 Steam Purging

Following acid cleaning the steam generator and associated steam legs will be steam purged. The Tenderer shall state his recommended operating procedure for the various phase for steam purging and the disturbance factors to be expected in each phase.

The Contractor shall provide details of connections for temporary steam purge pipework and valves, which shall be provided by the Contractor and which include suitable blanks for the protection of the turbine-generator.

5.2 HEAT RECOVERY STEAM GENERATOR

5.2.1 Heat Transfer Section

The major components of the steam generator shall include:
- Steam drum
- Complete Lot of heat transfer surfaces for the HP/IP/ LP super heater
- Complete Lot of heat transfer surfaces for the HP/IP/ LP evaporator
- Complete Lot of heat transfer surfaces for the HP/IP/ LP economiser

Each assemble shall be designed and fabricated to the ASME Code Section I and will be subjected to a witnessed shop hydrostatic test at a minimum pressure of 1.5 times the design pressure of the system. The final hydrostatic test of the erected and assembled components shall be performed by the Contractor.

The steam generator shall be of the forced circulation type. It shall be the function of the circulation water pump to maintain a positive water flow through the evaporation section of the steam generator at all operating conditions.

The super heater section shall be positioned to absorb the heat from the high temperature gases. The super heater, composed of rows of tubes in multiple passes, connecting the inlet and outlet headers shall be specifically designed to meet the performance requirements of steam flow and superheat temperature. Steam flow through the super heater shall be counter flow to the exhaust gas flow for maximum heat transfer.

A multiple row two-pass evaporator provides for unrestrained tube expansion during temperature swings through the use of free-floating return bends (U-bend type construction) at one end of the evaporation.

The economiser tube circuits shall be arranged to provide counter flow heat transfer between the water and the exhaust gas flow. Free expansion of the tubing shall be allowed for by the use of a suspension type arrangement with the headers fixed in position. Economiser heat transfer surfaces shall be selected to prevent excessive economiser steaming which may lead to vapour locking of some of the economiser tube circuits.

(1) Tubes

All tubes shall be of seamless steel, conforming to the specified code requirements. Tubes shall be treated to be free of all mill scale. After cleaning, tube ends shall be protected with non-metallic caps, outside swabbed with oil or sprayed with a suitable rust preventative. Tube connections at headers shall be so arranged as to permit full strength welding of all joints.
All tubes be hydrostatically tested at a pressure as required by the appropriate standard but in no case less than 1.5 times the boiler design pressure for at least thirty minutes.

The arrangement of tubes shall be such as to follow for easy withdrawal and replacement with minimum distance of the remaining tubes and for this purpose, and in order to facilitate erection, the tubes may be site welded.

It shall be the responsibilities of the Contractor to provide such tests or evidence as will satisfy the Board/the Engineer, that all butt welds in tubes, whether carried out in the works or at the site, are in satisfactory condition to withstand the working conditions to which they are subjected.

2) Water Wall

Water walls shall confirm to specified code requirements. All drums and headers shall have tube stubs strength-welded thereto in the manufacturer's works in accordance with the relevant current standards. The tube stubs shall be butt welded to the tubes on site. Water wall headers shall be provided with suitable handhold openings designed for seal welding for cleaning. Should any water wall header extend outside the setting, it shall be insulated by approved means with provision for movement and sealing.

5.2.2 Steam Drum

The steam generator drum shall be of fusion welded construction, fabricated from steel plate. NDT to be done as per ASME guideline and shall be tested with X-ray and stress relieved in annealing furnace. The interiors shall be cleaned by shot blasting for removal of mill scale and foreign matters. The drum headers shall be tested hydrostatically at the manufacturer's work in accordance with the relevant code.

The steam drum shall be equipped with necessary internals so that the total dissolved solids in steam leaving the drum will not exceed 0.1 ppm.

The drum shall be fitted with a manhole door at each end designed to open inwards. The drum shall be provided with all nozzles. Connections and openings required for operation, testing and maintenance. The number, location and size of all connections shall be subject to the approval of the Engineer. Particular attention shall be paid to the design of the down comer nozzles, in order to avoid thermal stressing of the nozzle welds the drum shall be self draining into the down comers. If siphon tubes are provided they shall be of adequate number and size to completely drain the drum.

1) Feed water pipe

The heated feed water from the economiser shall enter the drum through the feed water pipe, which extends nearly the full length of the drum. This pipe shall distribute the feed water uniformly over the length of the drum and the water shall enter with sufficient penetration to ensure complete mixing of drum and incoming.
(2) **Chemical Feed Pipe**

The chemical feed pipe shall be strategically placed in relation to the feed water pipe so that there will be complete mixing of the chemicals and feed water before the mixture leaves the steam drum and passes through the evaporator section. Chemical injection may be either intermittent or continuous, as required.

(3) **Continuous Blow-down Pipe**

The continuous blow-down pipe shall be located just below the surface of the water. Its function shall be to reduce the drum water concentrated near the upper surface of the drum water.

(4) **Intermittent Blow-down**

The intermittent blow-down through shall be located at the bottom of the drum and shall be used to remove the sludge and scale that has settled there. It can also be used to reduce excessive water concentration and, in case of emergency, high drum water level. Drum water condensation may be reduced by this method; however, the controlled continuous blow-down shall be determined by the operating personnel. The intermittent blow-down valves shall be used to drain the steam drum for maintenance and repairs.

(5) **Water Level Gauges**

Two water level gauges, one at each end of the boiler drum, shall be provided with each gauge including an approved form of lighting fitting suitable for use on 110 volts AC. Both gauges shall be of an approved bicolour type and both gauges shall provide a direct indication of the water level in the form when viewed at boiler drum level. The gauges shall be fitted with drain and self closing check valves, together with valves for shutting off and blowing through. Each gauge glass fitting shall be forged steel or other approved material designed so that it can be removed from the drum as a complete unit. The gauge glass shall be easily replaced without removing the gauge from the drum.

Two water level transmitters, one at each end of the drum for remote level indication and control purposes, shall be provided by the contractor.

A system to allow the water level in the drum to be seen from a convenient point shall be provided by the contractor.

(6) **Steam Purifiers**

Steam/water separation shall be accomplished in several stages to assure delivery of clean, dry steam to the super heater under all normal operating conditions.

The steam water mixture shall leave the evaporator through short pipe connections and enter a distribution baffle tray area of the drum, where the return mixture is distributed over the length of the steam drum. Water shall discharge directly downward to the liquid surface, while steam leaves the distributor through perforations in the back wall. The steam then shall travel across the width of the drum and turn upward away from the water into the moisture separator. The centrifugal force generated by the turning action will remove a further portion to the entrained moisture in the steam.
The final stage of separation shall occur in a separating device consisting of an agglomerating mesh and vane-type separating element. The function of the wire mesh screen shall be to provide a surface on which moisture particles will impinge and coalesce. The enlarged moisture particles thus formed shall be more readily removed from the steam as it passed through the final stages of separation.

The vane-type separation element shall force the steam to pass through a number of closely spaced vertical baffles. The baffles shall be shaped to provide constant obstruction to the steam flow. Liquid particles which are still entrained in the steam will impinge on the baffle surface due to centrifugal force, the moisture thus accumulated will flow downward to drainage pockets by gravity through the drain pipes which extend well below the minimum water level in the steam drum.

(7) Steam Sampling

A steam sampling nozzle shall be installed at the inlet and outlet to the superheater. Steam sampling especially between the drum and superheater inlet, is a very important and useful tool, it will not only indicate any malfunction of drum equipment, i.e. water columns, purifiers, continuous blow down, etc. but will also indicate faulty boiler water treatment. The sample readings must be taken systematically if they are to be meaningful.

5.2.3 Super-heater

The super-heater shall be capable of maintaining the final steam temperature at the steam flow range stated by the Tender.

The super-heater shall be designed and positioned in the steam unit with special reference to the high steam temperature at the superheater outlets. Means shall be provided to ensure balanced conditions at the superheater outlets under any condition of service.

All interconnecting piping between the various sections of the superheater shall be welded.

Superheater headers shall have nozzles for drains and vents.

Provision shall be made on the super heater outlet for the fitting of temporary test pressure gauges including permanently installed valves, piping and mounting plates to enable the gauges to be conveniently red for setting safety valves.

The header shall be located and arranged to facilitate an economical arrangement of steam piping.

The design of the superheater shall be such that any individual tube element can readily be removed and replaced. The superheater shall be of the self draining type.

Adequate access facilities to all parts of the superheater and fittings for routine inspection, cleaning and maintenance shall be provided to approval.

Provision shall be made in the unit casing for the insertion of permanent thermocouples for obtaining the temperature of the gases before the superheater sections when bringing the unit up to load or when picking up load under emergency conditions.
5.2.4 Economiser

The economiser shall preferably be of the continuous tube type located in the boiler casing. Economiser headers shall be provided with welded connections for inlet, outlet, drains and vents.

The outlet connections from the economiser shall be directed to the steam generator drum without any intermediate valves. The distribution of the feed-water in the drum shall be uniform over the full length of the drum. The connections to the drum and distribution of the feed-water shall be such that the connections and the drum are unaffected by variations in the temperature of the water and the danger of corrosion fatigue cracking is avoided.

5.2.5 Soot Blowers: Deleted

5.2.6 Casing and Insulation

The contractor shall furnish all insulation materials and casing as required for all equipment included in the scope of this specification.

The casing shall be sufficiently tight at full steam generator rating and recommended internal pressure, so that leakage is reduced to a negligible amount. The Tenderer shall give details in his Tender of the methods he proposed to ensure minimum leakage.

The casing shall be lagged until a pressure test of approved method has been successfully completed and full allowance shall be made in the construction programme for this test.

The exterior surfaces of casing and other insulation shall have a surface temperature not over 70°C with ambient temperature of 50°C and air velocity of 15m/min.

The outer steel casing shall not be less than 4.5 mm thick, stiffened and reinforced. Stiffeners and backstays shall be rounded at corners. The design of the entire casing system shall be submitted to the Engineer for approval.

The Contractor shall provide insulated inspection doors of approved material. These shall be of airtight design, lockable with frames and steel latched handles which will not blow open under maximum pressure. These door shall be located as required for proper access to various parts of the unit and for observation of tube bundles and boiler conditions.

The insulation of all casings, flues, ducts, pipes and valves shall be such as to reduce the heat loss to a minimum and adequate means shall be provided to ensure satisfactory foxing of the insulation.

All heat insulation material of approved type shall be asbestos free and chemically inert and remain so in the event of being saturated with water.

The Tenderer shall in this Tender thickness of each layer of heat insulating material to be applied to the various parts of the unit.

The contractor shall ensure that the final Finnish of all material prior to painting has a first class smooth surface.
In mixing insulating or covering compounds no salt or brackish water shall be used.

Unless otherwise approved the heat insulation for all casings, flues and ducts shall as its main constituent, magnesia or glass fibre and shall consist in the main of preformed slabs. Particulars of the insulation shall be stated in the Tender.

Where a hard setting compound is used as an outer coating, suitable provision must be made against the possibility of cracking when in service.

All pipework lagging shall be provided with sufficient expansion joints of approved design to prevent any cracking of the completed lagging.

5.2.7 Steam Generator Fittings and Mountings

The Contractor shall furnish the following fittings, valves and mountings.

Pressure and temperature ratings of all item shall be suitable for intended service.

(1) Safety Valves on Drum and Superheater

An approved number of safety valves of approve design and capacity shall be furnished as required by the relevant Boiler Code or ASME. In addition electrically assisted valves and associated gate shut off valves shall be furnished at the superheater outlets.

The safety valves shall be set to blow in a predetermined sequence staring with the valves at the superheater outlet. In determining the capacity of the safety valves due allowance shall be made for the back pressure which will occur in the safety valve escape pipes and silencers where appropriate. The location of the safety valves shall be selected so that there will be no detrimental unbalancing of steam flow caused by their co-operation. Where in order to achieve this condition, the valves are required to be mounted on steam piping then the piping to which these valves are connected shall be provided under this contract.

The safety valves shall be designed to ensure clean and certain opening at the set pressure and rapid and certain closing at the reseating pressure with neither simmering nor the necessity to reduce boiler pressure below the reseating pressure to firmly seat the valve.

Irrespective of the type of safety valve used each valve shall open within \( \pm 1.0 \) bar of its set pressure of its set pressure and shall have a blow-down which can be adjusted independently of the set pressure to any desired value.

In the design and manufacture of the safety valves every care shall be taken to ensure repeatability of the safety valve's operation and the practicable minimum of maintenance to prevent leakage of steam past the seat. It shall also be designed to permit maintenance of the valve and seat to be carried out in a short time with the practicable minimum expenditure of labour.

The safety valve installation shall be complete with all necessary stand pipes, connections, piping, supports and other items necessary for their satisfactory operation. These safety valves may have welded inlet connections.

An approval system of safety valve escape pipes with expansion joints, anchors
and supports shall be provided to exhaust above the steam generator. The location and arrangements of the outlets of these pipes shall be such that when the safety valves are operating there will be no danger personnel who may be in the vicinity of the outlets.

(2) **Feedwater Stop and Check Valve**

An approved number and type of stop and check valves at the inlets to the steam generator shall be furnished as required by arranged of piping.

(3) **Feedwater Regulation**

One 100% duty feedwater regulators and one 25% duty start up feed regulator of approved design shall be provided. The type shall be such as to maintain a constant water in the drum during start up and varying load conditions and feedwater pressures. For 100% duty feedwater regulator, the Contractor shall provide one motorised valve with motorised by pass valve at the inlet. For the 25% duty feedwater regulator, the Contractor shall provide one motorised valve at the inlet and one isolation valve at the outlet.

(4) **High and Low Drum Water Level**

Separate alarms of external type for high drum water level, low drum water level and low drum water level trip shall be provided and arranged with contacts which can be used to initiate alarms. Provision shall be made for one high water level trip alarm if necessary. The connections to the steam generator of these external alarms and tripping facility shall be fitted with full bore valve capable of being locked in the open and closed positions. A separate set of tapping points shall be provided for these alarms.

The alarm system to be initiated by the level alarm shall be supplied and installed by the Contractor.

(5) **Drain and Vent Valves**

An approved number of waterwall, superheater, economiser drain valves and drum superheater vent valves shall be burnished. The valves will have two valves in series and shall be located in approved positions for convenient operations.

(6) **Blow-down and Drain Piping System**

A blow-down and drain piping system shall be provided complete with a drainage receiver designed to cater for all blow-downs and drains from the plant. The receiver shall be provided with drains, drain valves, outlet piping and vent piping. The vent piping shall exhaust all vented steam to a safe location above the top of the steam generator. It shall be of corrosion resistant material or treated in an approved manner so that there will be no deterioration particularly in the outside appearance of this pipe after long periods of use. It is preferred that it will be of stainless steel. The vent pipe should be fitted with a suitable silencer, the design of which is to be approved.

The outlet piping for normally draining the water from the receiver shall be in the form of an inverted U and shall discharge into a pipe below ground level. The inlet of this outlet piping shall be continuously submerged. The top of the U-bend shall be connected to the vent piping through a small bore line which shall act as a si-
Blow-down connections shall be provided and the location of the connections shall be to the approval of the Engineer, being selected so as to enable the quality of the steam generator water to be corrected as rapidly as possible and to enable steam generator level to be quickly lowered without affecting adversely the normal circulation within the steam generator.

A main isolating valve followed by a main blow-down valve shall be provided for each blowdown connection and a by-pass consisting of an orifice between two isolating valves shall be provided around the blowdown valves. All valves shall be suitable for safety operating at full steam generator pressure.

Drain valves and piping to the drainage receiver shall be provided at all points of the steam generator where it is necessary to remove sludge and similar accumulations and to drain the water walls, steam generator and economiser (if necessary.) Drain valves and a separate piping system to the drainage receiver shall be provided to drain the superheater headers.

All drain valve shall consist of two valves in series.

(7) Steam Valve

An approved number of saturated steam supply valves, main steam outlet valve shall be furnished.

(8) Instrument and Connections

The contractor shall provide all instrument and connections as required for sound operations of the steam generating unit.

(9) Nitrogen Sealing: Deleted

5.2.8 Structural Steel

Design methodology (combination of Load) shall be followed as per section 2.7 of BNBC (Bangladesh national building code).

The Contractor shall furnish all necessary items or structures for the support of the steam generator unit and associated equipment this shall include, but not be limited to, the supply of the following:

(a) All columns, beams and bracing necessary to support the steam generator unit. The steel supporting structure shall be mounted on foundations and apart from the neighbouring building columns, beams or bracing members.

(b) All supporting structures required for auxiliary equipment whether supported by the steam generator supporting steel work or mounted separately.

(c) All platforms and walkways with the appurtenant chequered plate or grating toe plates and railing, ladders and stairways to insure safe accessibility to all parts of the steam generator and related equipment.

(d) A sufficient quantity of erection bolts and proper welding rod for site assembly.
(e) All special supporting hangers, struts, braces, frames, etc. between other building frame and any steam generator equipment component parts located outside the steam generator equipment component parts located outside the steam generator perimeter.

The above steel shall include all built-up girders, beams and other rolled sections, connections, hangers, stiffeners, buckstays and plates as required to properly support the equipment. Stiffeners and buckstays shall be rounded at corners and meeting points.

The Contractor shall furnish to the Engineer all loading, design calculations and detail drawings of the steel framing adjacent to the steam generator, the main suspension steel framing at the top of the drum all other supports, steel work for approval by Engineer.

Weights of water and other normal loads imposed during operation, construction, maintenance and testing shall be included in the design loads, Seismic reactions, and expansion limits shall also be indicated on the drawings.

All structural steel furnished shall be in accordance with relevant standards and subject to approval.

All structural steel furnished shall be designed fabricated and detailed in accordance with the relevant Standards. Any deviation therefrom shall be submitted for approval.

5.2.9 Pipework

It is important that all piping arranged to afford easy access for operation and maintenance. Particular attention shall be given to the arrangement of miscellaneous electrical conduits and piping furnished by the Contractor. The Contractor shall co-operate with the Engineer to ensure a well co-ordinated arrangement.

Steam traps of approved type shall be provided at suitable locations.

All pipes and bends shall be truly cylindrical and uniform in section. For each size of pipe there shall be a standard length, bend and tee, and such standard pieces shall be interchangeable and shall be used wherever possible. Special bends, lengths, etc. shall be used only in approved places.

The joints which are necessary shall be in approved positions and shall be welded butt joints unless otherwise approved. At terminal point the joint shall be of the sea welded or bolted non welded flanged type as provided below.

Except where otherwise approved, joints shall be electric butt welded. All details of fabrication shall be to approval.

Prior to and during the whole of the welding operating of a butt welded joint the ends of the pipes being welded shall be heated in an approved manner.

After welding is completed, all electrical butt welded joints for carbon steel pipes shall be stress relieved by an approved method.

The whole details of construction of seal welded and non welded flanges to the pipes, shall be subject to the approval of the Engineer. All flanges used for bolted joints shall be cutter barred or faced at the back so that...
units, washers and bolts heads may be down satisfactorily.

All blank flanges for pipes included in this Clause shall be steel.

All piping shall be colour coded properly as approved by the Engineer.

1) **High Pressure Piping**

All high pressure steam pipes, bends and fittings shall comply with ISO Standard where applicable.

Where welding is used for the attachment of branch pipes the method shall be subject to approval. In order to compensate for the metal cut away from the main pipes suitable reinforcement shall, where required by the Engineer, be provided around the opening which is formed to receive the branch pipe. The method of welding for the attachment of the reinforcement to the main pipe and to the branch pipe shall be subject to approval.

All steam mains shall be erected with an approved fall in the direction of flow so that condensed steam will flow towards the positions on the mains where the drainage points are situated.

Wherever required expansion bends or loops shall be provided.

2) **Feed Piping**

All high pressure feed pipes shall be designed for a maximum working pressure and temperature and shall comply with relevant ISO standard where applicable.

Where welding is used for the attachment of branch pipes the method shall be subject to approval. In order to compensate for the metal cut away from the main pipes. Suitable reinforcement shall, where required by the Engineer, be provided around the opening which is formed to receive the branch pipe. The method of welding for the attachment of the reinforcement shall be approved by the Engineer.

Sampling valves of arrived design shall be provided in approved positions for taking samples of feedwater.

3) **Drain Piping**

All drain pipes on the inlet side of drain valves shall be designed for the same pressure and temperature as the valves, pipe or vessel which they drain and shall be subject to the specification and tests relevant thereto.

Where hand drains are provided, tow valves in serried shall be provided for operational drains, the up stream valve being of the parallel slide or gate type and the down stream valve being of the glove or other approved type.

The discharge from all drain points shall be arranged with an approved continuos fall towards the drain vessels.

Where drain pipes are led into a drain header the drain pipes shall unless otherwise approved be led at an angle into the header and in direction of flow in the header.

Drain valve hand wheels shall be extended for operation where required by the Engineer.
5.2.10 Valves

All valves shall be of approved design and manufacture and those of similar make size and type shall be interchangeable with one another unless otherwise approved.

All control valves shall have manually operated inlet and outlet isolating valves with a bypass valve arrangement.

All valves shall be fitted with outside screws unless otherwise specified or approved.

All valves shall be closed by rotating the handwheels in clockwise direction when loading at the face farthest away from the body of the valve. The valve spindle shall also be rotated in a clockwise direction the close the valve when viewed from the outer end of the spindle and in cases where the handwheel is not directly attached to the valve spindle, suitable gearing shall be introduced to reconcile the above condition. The face of each handwheel shall be clearly marked with the words 'open' and 'closed' with arrows adjacent to indicate the direction of rotation to which each refers.

Each handwheel shall also be fitted with a circular nameplate indicating the service for which the valve is intended. The nameplates shall be of stainless steel with engraved letters filled with black enamel. Valves for emergency operation shall have the lettering in red enamel. Where required by the Engineer valve spindles shall be lengthened so that the handwheel is at a height of approximately 1 meter above the level of the floor or platform which the valve is to be operated.

Where extension spindles are fitted all thrust when opening or closing the valves shall be taken directly on the valve body and all valve pedestals shall be mounted direct on the floor girders and not on the floor plating. Any floor steel work trimmers necessary for supporting the pedestals shall be provided by the Contractor.

The spindles of all valves for use outside the power station building shall have weatherproof protection covers of approved contraction.

All valves shall be fitted with indicators so that it may readily be seen whether they are open or close and in the case of those valves fitted with extended spindles, indicators shall be fitted both to the extended spindle and the valve spindle.

Valves shall not be fitted in an inverted position unless otherwise approved. Eye-bolts shall be provided where necessary to facilitate handling heavy valves or parts of valves.

(1) Steam Feed and High Pressure Valves

All valves intended for high pressure steam feed or any other services subject to high pressure or temperature shall be approved manufacturer and shall have cast or forged steel bodies with, wherever possible, bolted on covers and glands and the materials of the internal parts shall be subject to approval.

The Tender shall submit alternative offers for the first isolator of all high pressure valves, one of which shall be with gland packing and the other shall be of glandless type.
The design of the high pressure valves shall be given special attention with regard to the selection and thickness of material so that they will be suitable for high pressures and temperatures and full details of the design shall be submitted for approval as early as possible. Approved means shall be provided to prevent and by accumulation of pressure between the discs of any high pressure steam of feed parallel slide valve. Preferable in the case of valves with bypass, the integrate space of the main valve shall be connected to the integrate space of the bypass valve.

The stop which limits the travel of the valve in the "open" and "close" positions shall be arranged exterior to the valve body and no packing under pressure device shall be fitted.

(2) Low pressure Valves

All valves used for low pressure water, exhaust, low pressure steam, air and oil services shall be of approved manufacturer.

(3) Motor Operated Valves

All valves specified to be motor operated shall be fitted both with hand and motor operating gear. They shall be of approved design and complete in all respects including the motor and the necessary controls for automatically stepping the motor when the valve gate has reached the "full open" of "full close" position. The motor shall be placed in such a position relative to the valve that there is no possibilities of steam or water leakage from the valve joints or glands blowing on to the motor or control equipment.

The operation of opening or closing the valve shall be controlled by means of three push buttons labelled respectively "open" "close" and "stop" or by means of an approved type of hand control lever. The control shall be so arranged that the motor can be stopped with the valve in any position and can then be restarted in either direction. The push buttons or hand control lever shall be mounted together in an approved position on or adjacent to the valve, in such a position that valve indicator is readily visible to the operator.

An interlock shall be provided such that when the valve is being operated manually, the electrical supply to the control circuit of the motorising valve is isolated.

An motor operated valves and their associated control equipment shall be suitable for operation by a three phase three wire 415 volt 50 Hz supply.

5.2.11 Instrumentation and Control

The extent of automatic control for the steam generators and auxiliary equipment shall be form start preparations to full load and during normal operation.

Control of the steam generators and associated auxiliary plant will be carried out on a direct wire remote control basis from the central control room.

All controls essential to the normal run up, shut down and operational running of the unit shall be capable of being carried out completely from the control panels in the central control room.

Sensors for temperature, pressure, electrical quantities, switch and valve positions
etc. shall be provided to give indications transducers shall be electrical.

The indications and other relevant information may also be scanned by data logging equipment supplied as part of the central control room equipment which will print out readings and provide alarm indication.

Tenders shall provide a schedule of all the indications of temperature, pressure, pistons, etc. which they recommend shall be displayed in the central control room. A further schedule of all remotely operated motors, valves and controls shall be provided.

All equipment, valves and controls for which provision has been made for remote operation shall be provide with facilities for local operation.

The Contractor shall furnish all motors, limit switches and torque switches necessary for proper operation of the valves which he supplies. Limit switches and torque switches shall be heavy-duty type, independently adjustable for both directions of travel.

It is intended that all designed measurements will be separately displayed and recorded in such a manner that for each measurement, the indicator can operate independently of the recorder and vice versa.

The mounting of transducers amplifiers, indicators, recorders and interconnecting leads shall be such that all components of any interconnecting leads shall be situated in an environment which allows them to operate within their design accuracy under all conditions of local working temperature to be expected under the operating conditions.

All transducers, measuring devices or assembled their connecting leads capable of withstanding their environment. They should be rigidly mounted enclosed or encapsulated to prevent ingress of steam, moisture, oil etc.

All connections between fixed cables and measuring devices should be robust, protected by suitable insulation and electrical screening and placed so as not to be damaged during transit, normal operation or during dismantling of the plant for over hauls.

Electronic measuring systems shall employ all solid state components and be suitable protected against damage from voltage or current surges. The systems shall also possess adequate common and series mode noise rejection characteristics, such that accuracy of indication and recording is not affected by voltage or current surges, or by the general noise level existing at the location of the system.

Each measurement loop shall incorporate an adequate instrument failure indication, such that on failure of the system, the indicator shall move to a position which shows that failure has occurred. Scaling of indicators shall be such that under normal operating conditions the measured variable displayed shall be at least 10% of F.S.D. above the aero line. And be between 50% and 75% of F.S.D. at the recommended alarm setting valve.

Instruments supplied for outdoor units shall be weather proofed and suitable for adverse outdoor conditions.
5.2.12 Stairways, Galleries, Ladders and Handrails

Adequate access shall be provided to all plant and control points requiring access for operation, inspection and maintenance. Stairways and galleries shall be provided to give the necessary access in a convenient way and to form a neat installation.

All flooring and platforms provided under this Contract shall be constructed of open grid flooring of approved pattern and make. The open grid steel flooring and treads shall be generally not less than 24 mm in depth and where required shall be of sufficient strength to carry the maintenance engineers, maintenance equipment and parts of plant which it will be necessary to support temporarily during overhaul and maintenance periods.

All ladders shall be of approved slope and provided with double rungs, the pitch of the rungs being not more than 25 mm internal diameter with neat forged uprights. The rails shall be butt jointed by means of internal ferrules or by nut welds and all joints shall be neatly finished by the removal of all burrs. All standards for stairways shall be of the vertical type, with palms set to suit the slope of the stairways.

Handrails shall be 1100 mm high for platforms and shall vary between 850 mm and 1100 mm for staircase.

All platforms, galleries, stairways and ladders shall be approval of the Engineer. All common passages shall have a headroom of not less than 2000 mm above floor level.

All edges of floor and walkways shall be provided with curbs or kicking strips to project not less than 100 mm above floor level.

5.2.13 Off-load Cleaning Equipment

The Tenderer shall recommend the steam generator plant off-load cleaning method and equipment which has been proved as reliable in service. The Tenderer shall state in his Tenderer where such equipment has been previously used.

It is essential that all deposits on the heating surfaces must be removed down to bare metal throughout by the off load cleaning device. Irrespective of whether dry cleaning or wet methods be employed. Irrespective of whether dry cleaning or wet methods be employed, special care shall be taken to avoid damage and corrosion to the heating surfaces.

5.2.14 Gas Ducts

All gas ducts shall be not less than 6mm thick steel plate, of welded construction. Stiffeners shall be located in such a manner to withstand the pressure encountered. The deflections of the stiffeners shall not exceed 1/360 of the span, and the deflection of the plates shall not exceed 1/180 of the span between reinforcements. Flanges bolted connections shall be used where necessary.

Where required, the Contractor shall provide expansion joints of an approved design. Duct supports and hanger equipment extending to steel, flange gaskets, bolts and nuts shall be furnished.

All necessary dampers in the ducts furnished under this Specification shall be included. Dampers and their operating linkages shall be equipment with ball or tapered roller bearing. Special care shall be exercised in the design of dampers to prevent sticking and leakage. Suitable locking devices shall be provided at all
dampers to facilitate maintenance. Suitable access doors which can be opened form both inside and outside the duct shall be furnished in all ducts. Hot gas ducts shall be properly insulated.

All grease lubrication points for dampers shall be provided with approval lubrication nipples which shall be placed at the end of extension piping and shall be grouped and mounted on a plate situated at convenient locations to the Engineer's approval. The nipples shall be clearly identified with regard to the lubricant used by an approved method.

The Tenderer shall state the cross-sectional area of all gas ducts included in the Tender.

Special consideration shall be given in the design of the gas ducts to ensure freedom from vibration and noise.

5.3 Special Tools and Spare Parts.

5.3.1 Special Tools

Two complete sets of all special spanners and tools necessary for maintaining the whole of the HRSG shall be provided. One set of spanners and tools supplied under this clause shall be provided. One set spanners and tools supplied under this clause will be used during the erection of the plant while the second set will not be used during erection but retained for maintenance purpose. If any item of special tools specified herein is damage prior to the handing over to the Board, the same shall be replaced.

All heavy parts of the plant shall be provided with some convenient arrangement for slinging or handling during erection or overhaul and any special devices, slings or tackle necessary for the complete overhaul shall be available on site before required for erection purpose, and items of plant normally stripped or lifted during periods of maintenance and weighting two tons or over, shall be appropriately marked with their weight.
Section-6

Steam Turbine and Ancillary Equipment
6. **Steam Turbine And Ancillary Equipment**

6.1 Basic equipment Requirement
6.2 Steam Turbine and Auxiliaries
   6.2.1 Steam Turbine Valves
   6.2.2 Supervisory Equipment
   6.2.3 Gland Sealing Equipment
   6.2.4 Turning Gear
   6.2.5 Speed Governing System
   6.2.6 Mechanical Protection Devices
   6.2.7 Turbine Shaft Earthling Devices
   6.2.8 Turbine Blading
   6.2.9 Clearance and Operating Devices
   6.2.10 Rotor
   6.2.11 Turbine Casing
   6.2.12 Bearing
   6.2.13 Nitrogen Sealing
   6.2.14 Drain and Traps

6.3 Condenser and auxiliaries
   6.3.1 Condenser
   6.3.2 Condensate pumps
   6.3.3 Air extraction
   6.3.3.1 Vents & Drains
   6.3.4 Condensate control system
   6.3.5 Deaerator and auxiliaries

6.4 Pipe works and valves
   6.4.1 General
   6.4.2 High pressure piping
   6.4.3 Feed water piping
   6.4.4 Low pressure piping
   6.4.5 Drain piping
   6.4.6 Valves
   6.4.7 Motor Operated Valves
   6.4.8 High pressure valves
   6.4.9 Low pressure valves

6.5 Lagging and Cladding
6. Steam Turbine and Ancillary Equipment

6.1 BASIC EQUIPMENT REQUIREMENT

The Steam turbine unit shall be of well proven design. The extent of supply shall include, but not be limited to the equipment described herein.

6.2 STEAM TURBINE AND AUXILIARY

Steam turbine shall be of proven design and of the single line impulse, impulse reaction or reaction type, throttle or nozzle controlled, designed for high efficiency operation and suitable for coupling to and running in conjunction with the condenser supplied under this Contract. The steam turbine shall be of sliding pressure type with hot and cold start provisions.

Steam will be supplied to the turbine stop valve at steam conditions specified in the heat recovery steam generator section of this Specification.

Condenser vacuum will be maintained by the use of mechanical vacuum pumps or steam jet air ejectors.

The unit shall be designed to operate safely at 47.5 to 52.5 Hz. The Contractor shall state limitations, if any, as to frequency, load, or duration for this mode of operation.

6.2.1 Turbine Steam Valves

The turbine shall be equipped with emergency/stop valves, control valves, with actuators integrated with the turbine control system.

These valves shall be capable of being tripped by hand at the turbine floor level and by remote operation from a push button in the central control room. They shall be automatically closed in the event of failure of the lubrication oil supply.

Provision shall be made on each valve to give remote indication of the valve position over the full range of travel.

The steam chests shall be constructed of approved material and shall be so supported to avoid distortion of the turbine cylinders.

Permanent steam strainers shall be provided to prevent the entry into the machine of any foreign material which could damage blading or control valve seats, it shall be arranged to permit easy inspection and cleaning.

Temporary steam strainers, having passages of a smaller size than those in the permanent strainers shall be supplied and fitted so as to prevent any damage to the turbine blading during the initial commissioning period.

Plugged connection shall be provided on the discharge side of the emergency/stop and governing valves for temperature data logging.

Temporary pressure gauges shall also be provided during the initial period of running so that pressure after the temporary steam strainers can be measured.
Facilities shall be provided for on-load testing the operation of each emergency/stop valves(s), in turn, to partial/full closure while the turbine is on load. The Tenderer shall describe the provisions made and the procedures to be adopted when testing these valves, the test facilities shall be located in such a position that one operator can select, test and observe the operation of the valve.

The Tenderer shall state what provision they have made for on load testing of the governing valves.

The design of all valves and their control gear shall be such that utmost reliability of operation and easy servicing can be achieved.

The Tenderer shall state the precautions taken to avoid seizure of any stop or control valve spindle under all operating conditions. Full details of the materials proposed for the valves, seats, spindles and guides to ensure safe operation shall also be given in the Tender. Full details of the experience with these materials, particularly in respect to maximum operation temperatures shall also be given in the tender.

6.2.2 Supervisory Equipment

Turbine supervisory instruments shall be included to provide a series of measurements from which the mechanical performance of the turbo generator unit may be assessed under start up and loading conditions and during “on-load” operation. Provision shall be made in the design of the rotors, casings, bearing pedestals and valves, etc., for the supervisory measuring devices to be provided under this Contract. The Tender shall include full details of the supervisory instruments offered which shall be subject to the approval of the Engineer.

The Contractor shall provide the following minimum supervisory measurements. The tenderer shall draw attention to any further supervisory measurements they consider necessary for the safe operation of the plant and the Tender include these additional measurement.

a. Bearing pedestal vibration (to be fitted on every bearings)
b. Relative expansion of rotor to casing (differential expansion)
c. Absolute expansion of housing.
d. Eccentricity of rotor
e. Position of thrust bearing
f. Metal temperature
g. Shaft speed with connection for plugging in digital counter.
h. Control valves position
i. Turbine main steam valves position.

All measurements shall include local indication and provision for plugging in portable recorders on the turbine supervisory panel and outputs suitable for remote indication, chart recorders and data logging which are to be provided in the central control room under the Contract.

It is intended that all designated measurements will be separately displayed and recorded in such a manner that for each measurement, the indicator can operate independently of the recorder and vice versa. Also each recorder will be fitted with an event marker operated from the supervisory alarm system.

Operation of the event marker will simultaneously operate a chart speed change mechanism. Such that the chart speed in increased to a value which will allow a
period of not greater than 5 minutes to be resolved on the time scale of the chart. The mounting of transducers, amplifiers, indicators recorders and interconnecting leads shall be such that all components of any measurement circuit are situated in an environment which allows them to operate within their design accuracy under all condition's of local working temperature to be expected under the operation conditions.

Transducers shall be mounted in positions which are readily accessible for purpose of routine maintenance, calibration and replacement with the unit on load. Where the designed measurement precludes ready access, then a second local absolute indication for comparison purpose shall be provided.

All transducers, measuring devices or assemblies and their connecting leads shall be capable of withstanding their environment. They shall be mounted enclosed or encapsulated to prevent ingress of steam, moisture, oil etc.

All connections between fixed cables and measuring devices shall be robust, protected by suitable insulation and electrical screening and placed so as not to be damaged during transit, normal operation or during dismantling of the plant for overhauls.

Each measurement shall have its associated alarm, the level of which shall be capable of being set at any point over the operating range of the measuring instrument.

Operating of the alarm shall not sensible modify or in any way change the accuracy of the measuring system.

Electronic measuring system shall employ all solid state components and be suitable protected against damage from voltage or current surges. The systems shall also possess adequate common and series mode noise rejection characteristics, such that accuracy of indication and recording is not affected by voltage or current surges, or by the general noise level existing at the location of the systems.

The lubricating oil level in the main storage tank shall be supervised by two level switches/transmitter which will be used to initiate alarms when the oil is in order of 100 mm and 150 mm below the normal working level.

The bottom of the tank shall be designed to give a fall to the drainage point which shall be fitted with a drain valve locked in the closed position.

A visual indicator, independent of the alarm float, shall be provided. The indicator shall be marked to show the running and shut down oil levels and variations above and below normal working level shall be indicated in litres and this indicating shall be at operating floor level, or clearly visible from operating floor level.

Special attention is drawn to the provision of vapour extraction equipment for main oil tank and the arrangements proposed shall be stated in the Tender. The Tenderer shall give particulars of the treatment proposal to avoid acid attack on the tank interior, pedestals, oil wells etc.

While oil is being pumped through the coolers, the oil pressure shall exceed the cooler water pressure.

Full flow filters having sufficient fineness of mesh openings to protect the plant
from damage shall be provided in the bearing governor and power oil supply lines. The filters shall be fitted with differential pressure switches. By-passes and other facilities shall be provided to permit the filters to be cleaned in service without interrupting the oil supplies.

The Contractor shall provide information regarding running hours between oil changes, both for the initial commissioning period and for normal operating conditions.

A turbine oil make-up or measuring system shall be provided for initial filling, evacuation and make-up of the main oil tank. The system shall comprise of an adequately sized storage tank, a suitable type of tank for pump, measuring device and pipework and valves.

All steel piping in the lubricating oil system shall be picked and adequately protected for ocean shipment. Piping with hangers for the lubricating system shall be furnished complete, including oil piping to and from oil cooler, and shall be arranged for maximum protection against turbine oil fires. The pipe shall be completely welded throughout, except where flanges are furnished for maintenance. Backing rings are to be used in locations where it is not possible to remove weld slag from pipe bore. As far as possible the piping shall be located below the level of the turbine room operating floor. Piping shall be laid out in straight runs with bends and joints in the piping organised in a neat and orderly manner to give a good appearance.

6.2.3 Gland Sealing Equipment

All glands shall be suitable for starting under high vacuum. The design of the glands shall preferable be such that they can be examined and replaced if necessary without lifting the top halves of the cylinder casings.

Arrangements shall be made for automatic and manual control of the gland steam and to prevent leakage steam blowing from the glands into the turbine house under all loading conditions. The gland steam regulator shall operate satisfactorily under all turbine loads and shall be arranged for automatic control with remote and local facilities.

A full description of the gland sealing arrangements including the gland steam condenser and exhaust fans shall be given in the Tender together with a diagrammatic arrangement of the system.

Individual gland systems shall be fitted with means for periodically measuring the gland flow as check on gland conditions. These facilities may take form of a permanent orifice with appropriate tapping points for measurements.

6.2.4 Turning Gear

The turbine shall be equipped with an AC & DC motor-driven turbine gear to be used for turning the turbine shaft while the unit is being started or taken out of service. When the turning motor driven by AC fails in any case, turning of the rotor shall be continued by DC motor. The turning gear drive shall be designed so as not to interfere with removal of the generator rotor when disassembling a rotor speed of between 5 to 10 rpm. The turbine gear shall be so arranged that the driving gears may be engaged either by remote control from the central control room or manually by means of an external lever while the turbine is at rest. When steam is
admitted to the turbine and its speed is increased beyond that produced by the turning gear, the gear shall automatically disengage and latch in the disengaged position. Limit switches for position indication shall be furnished.

The turning gear shall be equipped with a zero rotor speed indicator for showing the turbine rotor speed as the rotor approaches rest. The speed sensor shall provide a signal to an indicator or alarm to be mounted in the central control room and shall also initiate the automatic engagement of the turning gear when the shaft has dropped below turning gear speed but before coming to rest. An additional indication shall also be given in the control room to indicate the rotor in resting condition.

The turning gear circuit shall be provided with pressure actuated switch to prevent the turning gear motor from staring before adequate bearing and jacking oil pressure have been established by the oil pumps.

Hand turning facilities shall be provided together with the necessary turning tools.

6.2.5 Speed Governing System and Accessory Equipment.

An automatic speed governing system of modern design shall be provide. The governor shall be of the mechanical hydraulic type or electronic hydraulic type operating the control valves by hydraulic means.

The governor shall be equipment with a speed change by means of which the speed power output of the turbine may be changed to suit varying system operating conditions. Means shall be provided for speed changed adjustment made by hand at the turbine as well as by remote control from the central control room.

Provision shall be made to shutdown the turbine under emergency by local and remote control. The speed regulation shall be adjustable between $\pm 5\%$. Speed droop adjustment shall be provided. The governing system shall also be provided with automatic over speed trip devices adjustable up to 110% of normal speed, and a maximum load limiter.

The E-H governor shall include speed control, load control, stress control and variable speed droop facilities.

The speed control system shall govern the turbine from zero speed to rated speed automatically by means of the speed setter which sets the pre-determined speed and the speed rate setter which sets the rate of changing speed.

The governing system shall be suitable for parallel operation with a large power system and also for completely isolated and independent operation.

The load control system shall be control the loading of the turbine by the load setter which sets the target load and the load rate setter which sets the rate of change load. The load control system shall also be able to adjust the power output by response to power system frequency change.

The stress controller system shall monitor and control the thermal stress of the turbine rotor. The system shall determine the loading rate under rolling and loading conditions respectively so the stressed do not exceed the predetermined limits.

The turbine shall be equipment with a load limit device arranged for manual setting at the turbine and remotely from the control room limiting the opening of the governor-controlled valves to any valve within the full range of valve travel, which the
turbine is in operation. Provision for remote indication shall be furnished.

The speed governing system shall be capable for controlling with stability the speed of the turbine at all power outputs between zero and the specified maximum power output inclusive, when the generator is operating isolated, or with energy input to the turbine when the generator is operating in parallel with other generators, via its step-up transformer on the high voltage.

The Tender shall contain a statement of the permissible maximum value of the steady state speed variation, the maximum momentary speed variation, and the time within which a steady speed is at trained, when the maximum guaranteed output is completely thrown on or off.

The Tenderer shall submit complete descriptive information's about the governing system they propose to provide.

6.2.6 Mechanical Protection Devices

(1) Low Pressure Unloading and Trip Gear

The turbine shall be equipped with a device which will limit the steam flow to the machine when the main steam pressure reaches a predetermined low point, and will continue to decrease the steam flow in proportion to further reduction in pressures. A simple means shall be provided for overriding the unloading gear when operating the turbine with low steam pressure during start up. This device shall have provision for remote control and indication.

In addition a separate device shall be included on the main turbine which shall, in the event of a further reduction in pressure, trip close the turbine steam valves.

The Tender clearly indicate the unloading procedure and the related steam flow to steam pressure.

The gear shall be provided with an alarm initiating device, and means for on-load testing both the unloading and the trip functions of the gear.

The gear shall be so arranged that the load is not automatically restored.

(2) Emergency Over speed Governor

The turbine shall be equipment with an undefended safety device in the form of an emergency over speed governor. This shall be mounted on the turbine shaft and shall be arranged to actuate, at a predetermined speed a tripping device which will trip close the turbine steam valves. Means shall be provided for adjusting the speed setting of this governor. The emergency over speed governor shall automatically recover and make possible resetting the valves at approximately one percent above rated speed of 3000 rpm; Means shall be provided for on-load testing the operation of the emergency over speed governor.

(3) Emergency Trip Plunger

A local emergency trip plunger shall be provide on the turbine pedestal. The plunger shall trip close the turbine steam valves in a similar manner to the operation of the over speed tripping device.
(4) **Emergency trip Button**

Provision shall be made for an emergency trip button in the central control room.

(5) **Low Lubrication oil Pressure Trip Device**

A low lubricating oil pressure trip device shall be provided to trip close the turbine steam valves on extreme low pressure in the lubricating oil system. Allow oil pressure switch for alarm purpose shall also be furnished.

(6) **Thrust Bearing Protective Device**

A device (independent of the supervisory instrument) shall be installed on the turbine to warn of excessive movement of the turbine shaft at the thrust bearing and to shut down the unit when the shaft has moved to a point indicting impending failure of the bearing.

(7) **Vacuum Unloading and Trip Gear**

The turbine shall be equipment with device which will limit the steam flow to the machine when the condenser vacuum reaches a predetermined low point, and will continue to decrease the steam flow in proportion to further reduction in vacuum.

In addition an entirely separate device shall be provided on the main turbine which shall, in the event of a further fall in vacuum, trip close the turbine steam valves.

The gear shall be provided with an alarm initiating device, and means for on load testing both the unloading and the trip functions of the devices.

The gear shall be so arranged that the load is not automatically restored.

The tenderer shall clearly indicate the unloading procedure and the related steam flow to condenser vacuum.

(8) **Exhaust Steam Temperature Limiting Device**

A temperature detecting device shall be located in the exhaust of the turbine and be arranged for alarm initiation in the event of high exhaust steam temperature.

6.2.7 **Turbine Shaft Earthing Device**

Adequate provision shall be made to prevent turbine shaft current flowing between shaft and base through bearing and journals. This shall be in the form of one or more earthling devices between the stationary and rotating turbine parts.

6.2.8 **Turbine Blading**

All nozzles, blades and buckets in the steam path shall be of hard corrosion and erosion resisting material suitable for the conditions encountered. All blading shall be readily renewable Clearances shall be such as to avoid danger of rubbing under the operating conditions.

Particulars of the method proposed for protecting the blades at the low pressure end of the machine from erosion by water shall be clearly stated in the tender.
The natural frequency of the last row of the blades shall be such as to avoid resonant vibration at or near the normal separating speeds, including off frequency operations.

6.2.9 Clearance and Operating Limits
The design operating clearance of all stages, together with cold axial clearances positive and negative, and locations where cold axial contacts will occur, shall be stated.

6.2.10 Rotor
The rotor shall be of suitable material accurately machined to size and proportioned so that critical speeds are remote from the operating speed. Vibration severity measured in any direction at the journals of a shaft shall not exceed 10 mm/sec when operated under any load at 3000 rpm.

The turbine rotor shall be forged in one piece. The procedure proposed for inspection of the rotor in order to ensure its soundness and homogeneity shall be stated in the Tender together with particulars of the thermal treatment proposed in order to minimise the possibility of distortion occurring in service.

The rotor, when completed, shall be dynamically balanced and tested to an overspeed of 15 percent for 5 minutes unless otherwise agreed.

The type of thrust block and whether axial adjustment is possible or not shall be stated in the Tender.

The turbine rotor shall be coupled together by rigid forged couplings of approved design.

6.2.11 Turbine Casing
The design and construction of the turbine casing shall be such that growth or distortion of any part such as to affect the efficiency and reliability of the plant shall not occur as a result of operating conditions to which the plant may be subjected.

Those parts of the casings which may be subject to steam at a temperature of more than 1000°C under any conditions of load, shall be constructed of steel and be heat treated before rough machining. The thermal treatment proposed in order to minimise the possibility of distortion occurring in service shall be stated in the Tender.

The turbine casing shall be divided on the horizontal centre line and suitable lifting gear and slings shall be provided for raising and lowering the upper sections of turbine casing and turbine rotor clear of the blending. Guide rod necessary for preventing damage to the blending shall be provided. No studs will be allowed in casings or in pipe connections to casings unless approved.

All cylinder flange bolts or studs or other bolts or studs subject to high temperature shall be of approved design and of creep resisting steel.

To ensure that bolts and studs are tightened up uniformly and correctly when making the flange joints which are subject to high pressure and temperature, arrangements shall be made for stretching the bolts and studs to the required tension either by electric heating or hydraulic means. One set of the necessary apparatus shall be supplied by the Contractor and shall remain the property of the Board.
In no circumstances the casing shall be subjected to high temperature without the protection of adequate lagging either at the manufacturer the protection of adequate lagging either at the manufacturer's works or at the site.

The design of the main turbine shall provide for the inclusion of relief diaphragms in the low pressure casings. The design of the diaphragms shall be such the clamping rings shall effectively support the diaphragm to percent fatigue cracking. Diaphragms shall be easily replaceable preferable without the use of special tools. The diaphragms shall be mounted in with water. Adequate provisions shall be made for convenient and safe access to the diaphragms but the diaphragms shall be so located or protected to prevent inadvertent damage.

Thermocouples in the turbine metal are required to provide measurements from which :-

- The thermal condition may be determined prior to starting up.
- The degree of temperature mismatch between steam and metal temperatures may be determined for appropriate start-up technique.
- The thermal stress at the most vulnerable points of the turbine chests and cylinders may be determined and appropriate limits placed on the rate of acceleration or loading.

The Tender shall comment on the requirements and on the number of thermocouples to be supplied.

6.2.12  Bearings

All bearings shall be of the forced-feed lubricated type. Bearings shall be of split design so that the upper half is readily removable and the lower half can be removed and replaced without lifting the shaft. Means shall be provided to indicated excessive axial movement due to failure of a thrust bearing. Arrangements shall be made for visible indication of the oil flow from each bearing pedestal. A dial thermometer equipped with adjustable contact making device shall be provided at each bearing to monitor the temperature of oil leaving each bearing and to give high temperature alarm.

6.2.13  Nitrogen Sealing :  Deleted

6.2.14  Drain and Traps

All clean drains from steam chests, loop pipes turbine cylinders and any point downstream of the emergency stop valves shall be returned to the atmospheric flash box or drain tank.

Where traps are required they shall be fitted in accessible positions and provided with by-pass arrangement. A valve shall be fitted on the line side of each trap at the junction of the drain pipe and the part of the plant to be drained.

H.P steam and fitting shall be of approved construction.

The Tenderer shall put forward in his proposal a recommended scheme for automatic traps with the appropriate instrumentation.
6.2.15 Oil Purification Plant

Steam turbine generator shall be equipped with one stationary oil purification and water separation plant connected to the main oil tank of the unit, comprises with oil centrifuge machines, filters, oil storage tank and transfer pump.

The oil centrifuge shall preferably be installed in the turbine oil room and shall permit a continuous purification and clarification of at least 5% per hour of the total oil quantity.

The plant shall be complete with integrated inlet and discharge pumps, each with a bypass for flow adjustment, pre-heaters, strainers upstream of each pump, safety valves, flow indicators monitors as well as any other parts required for a complete and fully automatic purification unit. A common alarm shall be given to control room in case of any fault.

6.3 CONDENSER AND AUXILIARIES

6.3.1 Condenser

A surface type condenser set shall be provided for operation with steam turbo generator. The condenser shall consist of single shell having water box and hotwell.

The condenser shall be equipped with backwashing facility.

The source of condenser circulating water shall be from Cooling tower basin only.

The plant in operation shall be able to meet the following specific performance requirements.

(1) The condenser temperature at all loads shall be equal to the corresponding back pressure in the condenser at that load.

(2) The absolute pressure at turbine exhaust, as stated by the Contractor in "TENDERER'S DATA SHEET" shall be obtainable with a condenser cleanliness factor of 0.8 with circulation water inlet temperature of 38°C and with heat duty as established for the turbo generator at guaranteed gross output in accordance with specified parameters as stated in "TENDERER'S DATA SHEET". The condenser shall be constructed in all details for a design gauge pressure of 2.2 bar in the water boxes and for a design gauge pressure of 0.5 bar to full vacuum in the steam space. The velocity of water in condenser tubes shall not exceed 1.8 m/sec.

The condenser shall be complete with all gauges, switches, and other necessary fittings.

Supports shall be capable of taking resultant loads with flooded shells.

Cathodic protecting provided shall be of the impressed voltage type.

The condenser tube shall be material suitable for the specified river water. The tubes shall be adequately stayed by supporting plates to prevent vibration and to permit self draining of the tubes, the contractor shall provide means to cater for differential expansion between the tubes and the shell.
Water boxes shall be bolted to the tube sheet to permit removal of the water boxed without disturbing the shell to tube sheet joints. Condenser inlet and outlet valves shall motorised butterfly valves.

The hotwell outlet to the condensate pump suction shall be arranged to avoid dead strange in the hotwell.

Design of the water box shall ensure an even distribution of flow to all tubes.

The condenser end covers shall be provided with an ample number of side hinged manhole doors to enable access to be gained to the whole surface of the tube plates without removal of the end covers. The manhole doors shall be secured by the guide release or captive nut and bolt arrangements.

6.3.2 Condensate Pumps

The Contractor shall supply 2 x 100% or 3 x 50% capacity multistage, free suction centrifugal condensate pump, each complete with mounting flange, inner assemble, driving motor coupling and standard accessories for each turbine unit. The pumps shall be identical and all parts interchangeable.

The pumps shall have continuously rising head capacity characteristics. The discharge pressure shall be selected so that the pumps will meet the pump the design flow pressure drop requirements.

The pumps shall be constructed of materials specially chosen to resist deterioration by pitting, or corrosion.

All parts subject to wear shall be fitted with renewable liners, and all bearings shall be automatically lubricated.

The pump gland and suction valve shall be suitable sealed to avoid the ingress of oxygen into the condensate. An emptying connection complete with drain piping shall be provided on the feed piping between the extraction pump discharge valve and the ejectors if supplied. A suitable strainer shall be provide to prevent any foreign matter being discharged from the extraction pumps to the feed system during the initial commissioning period.

6.3.3 Air Extraction

Air extraction system shall be one of the following two types or combination those:

(1) Vacuum Pumps

Two duplicate condenser steam side mechanical vacuum pumps including motor and auxiliaries shall be provided for normal operation of the plant to remove air leakage into the condenser to maintain condenser vacuum. Pumps will be applied singly to maintain vacuum in both condenser shells under normal operation conditions. Vacuum pumps will be applied in parallel to evacuate are from the condenser shells for start-up. The time allowed for raising vacuum shall be determined by the hot start up time specified by the Tender.

Vacuum pumps shall be rotary, positive displacement liquid sealed type. Pump shall be complete integrated units with motor-drives, couplings, interconnecting piping, control valves, gas evacuation measuring devices and all necessary in-
instrumentation and controls for complete automatic on of operation which also provides for remote manual actuation of the unit.

(2) **Steam Jet Air Ejector**

The Contractor shall provide one full capacity steam jet air ejectors complete with condensing unit for air extraction. These ejectors shall be combined with inter and/or after coolers designed to operate a pressure sufficiently below the normal pressure at the steam generator pressure. All necessary fittings and local instruments shall be included. In addition the time allowed for raising vacuum shall be determined by the hot start up time specified by the Tenderer.

6.3.3.1 **Vents & Drains**

(1) **Automatic Venting System**

An automatic venting system of proper design shall be provided for the condenser system.

(2) **Drain Tank**

A suitable drain tank shall be provided for receiving drain water from the ejectors if provided, and other equipment. The tank shall be fitted with a protected gauge glass, a thermometer pocket, and a float-operated valve, the float being so arranged that when the accumulating of water in the tank reaches a predetermined limit the excess water is passed through the valve to the condenser. A section of the tank cover shall be hinged for cleaning purposes.

6.3.4 **Condensate Control System**

The Contractor shall provide a manual/automatic condensate control system suitable for all operating conditions from start-up to full load. Details of the system shall be submitted with the Tender and a full description given of the method of operation.

Particular attention shall be given to minimising fluctuation in water levels and pipework vibrations. Careful consideration shall be given to full load operating conditions and the system shall be capable of permitting blow-down and soot-blowing operations to be carried out when the turbo-generator unit is at full load.

6.3.5 **Deaerator and Auxiliaries**

The Contractor shall furnish a high head, horizontal tray, pressure type de-aerator, if required, with internal direct contact vent condenser and a separate horizontal storage tank section for turbine unit. The unit shall be complete with, but not limited to, trays, baffles, spray valves, internal distribution piping for introducing of steam drains and condensate. The de-aerating section shall be supported on the storage tank section.

The feedwater delivered at all loads up to and including the maximum effluent flow shall no exceed an oxygen content of 0.01 ppm measured at the deaerator outlet. However, during the first hour of start up, a higher oxygen content can be tolerated, but in any case, a maximum value of 0.1 ppm shall not be exceeded.

The Tenderer shall state in his proposals to minimise dissolved oxygen at start-up. The drain pump shall be of approved type and manufacturer. It shall preferable be
mounted horizontally on a common bed-plate with its motor, and with the pump
casing split on the horizontal centre line.

The pump shall be contracted of materials specially chosen to resist deterioration
by pitting or corrosion. All parts subject to wear shall be fitted with renewable lin-
ers.

The pump glands and suction valves shall be suitable sealed to avoid ingress of
oxygen into the condensate.

The Tenderer may propose an alternative means to the deaerator.

6.4 PIPEWORK AND VALVES

6.4.1 General

All piping shall be arranged to afford easy access for operation and maintenance.
Particular attention shall be given to the arrangement of miscellaneous electric al
conduits and piping furnished by the Contractor, such as bearing oil, gland steam,
drains, etc. The Contractor shall co-operate with the Engineer to ensure a well co-
ordinated arrangement.

All pipes and bends shall be truly cylindrical and uniform in section. For each size
of pipe there shall be a standard length, bend and tee, and such standard pieces
shall be interchangeable and shall be used wherever possible, Special bends,
lengths, etc. shall be used only in approved places.

The joints which are necessary shall be in approved positions and shall be welded
butt joints unless otherwise approved. At terminal points the joints shall be of the
seal welded or bolted non-welded flanged type as provided below.

Exceed where otherwise approved, joints shall be electric with welded.

The whole details of constructing of seal welded and non-welded flanges to the
pipes, shall be subject to the approval of the Engineer.

All flanges used for bolted joint shall be cutter barred or faced at the back so that
nut, washers and bolt heads may be down satisfactorily.

All blank flanged for pipes included in this clause shall be of steel.

All piping shall be colour coded properly as approved by the Engineer.

6.4.2 High Pressure Piping

All high pressure steam pipes, bends and fittings shall be designed for the max-
imum steam generator super heater safety valve blow off pressure and tempera-
ture.

To enable regular creep measurements to be made under service conditions the
Contractor shall provide non-corrosible gauging points at suitable positions on the
high temperature steam pipework together with gauging apparatus. Arrangement
shall be made with the Engineer for the initial measurements to be taken prior to
the pipework going into service.

Where welding is used for the attachment of branch pipes the method shall be
subject to approval. In order to compensate for the metal cut away from the main
pipes suitable reinforcement shall, where required by the Engineer, be provided
around the opening which is formed to receive the branch pipe. The method of welding for the attachment of the reinforcement to the main pipe and to the branch pipe shall be subject to approval.

All steam mains shall be erected with an approved fall in the direction of flow so that condensed steam will flow towards the positions on the main where the drainage points situated.

Where necessary drain pockets of ample size and of approved construction shall be fitted.

Wherever required expansion bends of loops shall be provided.

6.4.3 Feed water Piping

All high pressure feed pipes shall be designed for maximum working pressure and temperature of the feed system and shall comply will ISO standards were applicable.

Where welding is used for the attachment of branch pipes the method shall be subject to approval. In order to compensate for the metal cut away from the main pipes, suitable reinforcement shall, where required by the Engineer, be provided around the opening which is formed to receive the branch pipe. The method of welding for the attachment of the reinforcement to the main pipe and to the branch pipe shall be approved by the Engineer.

All release valves shall be provided and arranged in suitable positions for operation.

6.4.4 Low Pressure Piping

All medium and low pressure piping for condensate drain, bleed steam, vent, vapour and other services shall be provided. It shall be of hot-finished seamless steel tubes manufactured and tested in accordance with the current issue of ISO standards.

Flanging shall be in accordance with the appropriate table given in ISO and flanges shall be cutter-barred or faced at the back so that nuts, washers and bolt heads bed down satisfactorily.

All nuts and bolts shall be of best quality bright steel, and shall be machined on the shank and under the head and nut.

6.4.5 Drain Piping

All drain pipes on the inlet side of drain valves shall be designed for the same pressure and temperature as the valve, pipe or vessel which they drain and shall be subject to the specification and tests relevant thereto.

Drains shall be provided at suitable points on the steam ranges where water may collect during the period of warming up of the plant. Automatic drain traps shall be provided on the water range where appropriate.

The discharge from all drain points shall be arranged with an approved continuous fall towards the drain vessels.

Where drain pipes are led into a drain header the drain pipes shall unless other-
wise approved be led at an angle into the main header and in the direction of flow in the header.

Drain valve hand wheels shall be extended for operation where required by the Engineer.

Motorised/ Pneumatic drain valves essential for automatic start-up and control purpose shall be provided to Engineer's approval.

6.4.6 Valves

All valves shall be of approved design and manufacturer and those of similar make, size and type shall be interchangeable with one another unless otherwise approved.

All control valves shall have manually operated inlet and outlet isolating valves with a bypass arrangement unless otherwise stated.

All valves shall be fitted with outside screw unless otherwise specified or approved.

All valves shall be closed by rotating the handwheels in clockwise direction when looking at the face of the handwheel. The face of the handwheel shall regarded as the face farthest away from the body to the valve. The valve spindle shall also be rotated in a clockwise direction to close the valve when be viewed from the outer end of the spindle and in cases where the handwheel is not directly attached the valve spindle, suitable gearing shall be introduced to reconcile the above condition. The face of each handwheel shall be clearly marked with the words "open and close" with arrows adjacent to indicate the direction of rotation to which each refers.

Each handwheel shall also be fitted with a circular name-plate indicating the service for which the valve is intended. The name-plates shall be of stainless steel with engraved letters filled with black enamel. Valves for emergency operation shall have the lettering filled in with red enamel where required by the Engineer, valve spindles shall be lengthened so that the handwheel is at a height of approximately 1 meter above is to be operated.

Where extension spineless are fitted thrust when opening or closing the valves shall be taken directly on the valve body and all valve pedestal shall be mounted direct on the floor girders and not on the floor plating. Any floor steelwork trimmers necessary for supporting the pedestals shall be provided by the Contractor.

All valves shall be fitted with indictors so that it may readily be seen whether they are open or close and in the case of those valves fitted with extended spindles, indicators shall be fitted.

The valves in the circulating water system and in other water services connected thereto shall be subject to the corrosive action of river water and care shall be taken in the choice of materials to be used in the construction of those parts of the valves which shall be in contact with this water, the valve bodies being constructed of special cast iron or rubber lined to resist corrosion.
6.4.7 Motor Operated Valves

All valves specified to be motor operated shall be fitted both with hand and motor operating gear. They shall be of approved design and complete in all respects including the motor and the necessary controls for automatically stopping the motor when the valve gate has reached the "full open" or "full close" position. The motor shall be placed in such a position relative to the valve that there is no possibility of leaked or water from the valve joints or glands blowing on to the motor or control equipment.

The operation of opening or closing the valve shall be controlled by means of three push buttons labelled respectively "open", "close" and "stop" or by means of an approved type of hand control lever. The control shall be so arranged that the motor can be stopped with the valve in any position and can then be restarted in either direction. The push buttons or hand control lever shall be mounted together in an approved position on or adjacent to the valve, in such a position that the valve indicator is readily visible to the operator.

An interlock shall be provided such that when the valve is being operated manually, the electrical apply to the control circuit of the motorised valves is isolated supply and indications for the status of control shall be shown in the central control room.

The Tenderer shall give a full list in "TENDERER'S DATA" valves fitted with extended spindles, indicators shall be fitted both to the extended spindle.

Valves shall not fitted in an inverted position unless otherwise approved. Eyebolts shall be provided where necessary to facilitate handling heavy valves or parts of valves.

6.4.8 High Pressure Valves

All valves intended for high pressure steam, feed water, or any other services subject to high pressure or temperature shall be of approved manufacturer and shall have cast or forged steel bodies with, wherever possible bolted on covers and glands and the materials of the internal parts shall be subject to approval.

The design of the high pressure valves shall be given special attention with regard to the selection and thickness of material so that they will be suitable for high pressure and temperatures and full details of the design shall be submitted for approval as early as possible. Approved means shall be provided to prevent any accumulation of pressure between the discs of any high pressure steam or feed parallel slide valve. Preferable in the case of valves with by-passed, the integrate space to the by-pass valve.

6.4.9 Low Pressure Valves

All valves used for low pressure water, exhaust, low pressure steam, air and oil services shall provided by the approved manufacturer SHEET of all motor operated valves they considers necessary for the remote control/operation of the plant.

6.5 Lagging and Cladding

The Contractor shall provide all lagging and cladding for the turbo-generator unit and heat recovery steam generators.
All exposed portions of the plant which operate at temperature above 80 °C shall be provided with heat insulation suitable for the temperature conditions. The exterior temperature of the lagging not exceed 70 °C. All lagging materials interior temperature of the lagging shall not exceeded 70°C. All lagging material shall be asbestos-free.

All lagging on deaerator, if furnished, shall be neatly finished off by the provision of removable planished steel sheeting with stainless beading and secured in an approved manner.

The turbo-generator unit shall be provided with a rigidly reinforced steel housing, so arranged that it can be readily removed for access to flange bolts, control valves and other parts that required periodic inspection.

All unlagged surfaces shall have smooth finish. Any surplus welded seams shall be removed by grinding.
Section 7

Generator and Ancillary Equipment
7. Generator and Ancillary Equipment

7.1 Generator
7.1.1 General Requirement
7.1.2 Generator(s) Rating
7.1.3 Voltage and Short Circuit Ratio
7.1.4 Temperature Rise
7.1.5 Insulation
7.1.6 Stator
7.1.7 Generator Leads
7.1.8 Bearings
7.1.9 Rotor
7.1.10 Temperature detectors
7.1.11 Insulation against shaft current
7.1.12 Accessories

7.2 Exciter and automatic voltage regulator
7.2.1 Exciter
7.2.2 Automatic voltage regulator

7.3 Generator switchgear
7.3.1 General
7.3.2 Type and rating
7.3.3 Construction and fitting
7.3.4 Circuit breaker
7.3.5 Current transformer
7.3.6 Voltage transformer
7.3.7 Surge absorbing equipment
7.3.8 Neutral Earthing Equipment
7.3.9 Composition of Cubicles

7.4 6.6 KV Common Switchgear
7.4.1 General
7.4.2 Type and rating
7.4.3 Construction and fitting
7.4.4 Circuit breaker
7.4.5 Composition of Cubicles
7. Generator and Ancillary Equipment

7.1 Generator

7.1.1 General Requirements

The generator shall be designed and manufactured in accordance with International Electro-technical Commission Publication IEC34.

The generator cooling shall be air cooled or H₂ cooled. If H₂ cooled Generator is proposed, Contractor has to supply, install 2x 100% capacity H₂ Generator, 02 nos. of H₂ compressor (for H₂ storage bottles), H₂ storage bottles, on line H₂ analyzer, H₂ dryer, Co₂ system etc.

The MVAR leading capability shall not be less than 30 % of the MVA rating of the generator at 0.8 leading power factor. The generator in conjunction with its exciters shall be designed to operate stably at all loads up to the maximum continuous rating.

The generator shall be capable of operating continuously under unbalance loading conditions when the negative phase sequence current component is less than 8% of the rated current.

The generator shall be so designed as to minimise the effect of torsional rotor oscillation due to system disturbances and rapid load change. The generator shall withstand continuous over-speed of 1.2 times of the rated speed without damage. The generator shall withstand 150% of rated current for more than 15 seconds.

7.1.2 Generator(s) Rating

a. Capacity : To match Combined Cycle Power output at any ambient temperature.

b. Power factor : 0.80 (lagging)

c. Frequency : 50 Hz ±4% Continuous.

d. Rated rotating speed : 3000 rpm

e. Rated voltage : 21 kV (or as per manufacturer voltage level)

(If Generator voltage rating is different, associated equipment voltage rating will be changed accordingly)

In compliance with Bangladesh Grid code, the Generator shall be capable of generating its rated real power output within the frequency range of 48 to 52 Hz at -10% to +10% of nominal voltage and at power factor range 0.80 lagging and 0.95 leading. The generator shall be configured to appropriately react to frequency and voltage changes in the transmission system. At emergency conditions, the generator shall be able to operate within the frequency range of 47 to 52 Hz and must run the unit as per Bangladesh Grid Code. The Plant protection relays shall be configured to protect the plant from frequency excursion beyond the said range.
7.1.3 Voltage and Short Circuit Ratio

The generator shall be capable of supplying the rated output at rated speed and at rated power factor with a voltage variation between 90% and 110% of the rated voltage.

The generator shall be designed to guarantee that a nominal short circuit ratio is not less than 0.55 or as per IEC 34.1

The generator shall withstand the electro-magnetic and thermal stresses causing from short circuit fault at generator terminal without damage.

7.1.4 Temperature Rise

The temperature rise of the generator under the base and peak rating operations at any ambient condition shall not exceed the values given below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Base/MCR (°C)</th>
<th>Peak (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Stator winding by resistance temperature detectors method</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>b. Field winding by resistance method</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>c. Cores and mechanical parts in contact with or adjacent to insulated winding by thermometer</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>d. Bearing when measured on the surface</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

7.1.5 Insulation

The insulation of the armature and field windings of the generator shall satisfactorily withstand high voltage tests as specified in IEC standard. Insulation of the armature windings, field windings, and collectors shall be class F.

7.1.6 Stator

The cores shall be made up of high permeability, low loss, stampings, tightly clamped together to reduce noise and vibration to a minimum. All burrs of laminations shall be removed after punching. Sufficient ventilation ducts to ensure uniform cooling shall be provided. Clamping of the laminations and securing to the stator frame shall be done by approved methods. Attention shall be given to prevent vibration being transmitted to the generator foundations or associated equipment.

Protective covers and air shields shall be made of steel plates, welded, stiffened with suitable angles and channels, and formed in segments for case of handling. The segments shall be bolted together and to the stator frame.

The windings, terminals, and leads shall be fully insulated throughout and
braced, blocked and supported against the single and three-phase short circuits fault at the generator terminals under any operating conditions.

The general construction of the stator and bracing of the winding overhand shall provide adequate cooling surface and the avoid the hot stops. The stator coils shall be either semi or completely pre-formed and shall be made up before insertion to the slots.

7.1.7 Generator Leads

The neutral and output ends of each phase windings shall be brought out to the generator terminal cubicle.

The generator neutral shall be grounded through suitable transformer with secondary resistor.

The connection between generator terminal and 21 kV (or generating voltage) generator switchgear & Unit transformers shall be of copper 21 kV or generating voltage) Isolated (insulated) phase bus duct.

7.1.8 Bearing

Bearings shall be pressure lubricated by pressured oil from the gas turbine lubricating oil system, and oil drain pipes shall be equipped with pockets for thermometer and suitable sight flow opening for observing bearing oil flow. Separate lubricating oil system for condenser operation shall also be provided, if required.

7.1.9 Rotor

The packing blocks used especially in the rotor winding shall be of approved material and entirely suitable for the high temperatures and mechanical forces which may cause on rotors.

The rotor slot insulation shall be mainly of epoxy resin or other approved material and particular attention shall be given to the insulating and securing of coil to coil and slip ring connections, if any, and to avoid vibration and the possible failure to either the connector or its insulation.

Adequate precautions shall be taken against local overheating of the rotor surface when neutral short circuits and single phase loading and the Contractor shall submit data showing permissible single phase and unbalanced three phase loading. The rotor shall be capable of withstanding an over-speed test of 1.2 times rated speed for two minutes.

If slip-rings are provided, a grinder for slip-ring maintenance shall be supplied by the Contractor.

7.1.10 Temperature Detectors

More than nine (9) resistance type detectors shall be provided for monitoring of generator stator winding temperatures. The detectors shall be built into the generator, fully protected from the cooling air, suitable distributed around the circumstances, and embedded in the slots in positions normally having the highest temperature in accordance with
requirements of IEC standards. All detectors shall be wired out to a terminal box.

7.1.11 Insulation against Shaft Current

One of the bearings shall be suitable insulated to prevent flow of shaft current.

7.1.12 Accessories

a. Temperature detector (Refer to Clause 7.1.10)
   - normal use : more than 6 (six)
   - spare : more than three (3)

b. Thermometers and thermocouples at bearing drain of generator and exciter bearings, and at any other location required for operation monitor.

c. Pressure gauge at bearing oil feed and at any other location required for operation.

d. Alarm contacts

e. Space heater

   The stator shall be equipped with space heater. During the generator stop, the space heater shall be in service automatically.

f. Other instrument, terminal box, hardware buried into the generator foundation and all other necessary accessories for generator.

7.2 Exciter and Automatic Voltage Regulator

7.2.1 Exciter

A complete voltage regulating and excitation system shall be provided. A complete and details description of the proposed system meet the requirements of these specification shall be submitted with the Tender.

Brush less type exciter system can be provided.

The excitation system shall match the generator rating and shall maintain the voltage of the unit within a tolerance of plus and minus 0.5% of rated voltage regulation. The exciter shall have capacity to supply not less than 110% of the field current required by the generator at rated output, power factor, frequency and voltage.

The rated voltage of the exciter shall be 110% of the machine excitation voltage at the rated output of the machine.

The ceiling voltage of the exciter shall not be less than 140% of the matching excitation voltage. Insulation of stator and rotor winding of the exciter shall be class F. A field breaker and discharge resistance shall be provided or alternatively special provisions must be taken to either
discharge or suppress excitation following generator fault.

The excitation system shall have ample capacity to permit operation throughout its capability up to over-excitation and under-excitation limit as shown in the manufacturer's capability curves.

Over excitation limiter and under excitation limiter shall be provided.

If external static excitation system is proposed, excitation transformer with related switchgear and equipment shall be included in the offer.

7.2.2 Automatic Voltage Regulator (AVR)

A quick response continuously acting regulator having a negligible dead-band and characteristics enhancing the transient stability of the generator shall be provided.

The regulator shall be responsive to the generator line-to-line voltage and shall restore the exciter output voltage to range of plus / minus 2% of the nominal pre-set level in a response time of less than 50 milliseconds. The accuracy of controlling the AVR shall maintain the generator terminal voltage within plus I minus 0.5 % of the pre-set value for gradual change of output within the specified load range of the machine. It shall have the capability to adjust the generator voltage between a minimum of 80% of rated voltage (open circuit) and a maximum of 110%of rated voltage (full load).

The regulator shall be equipped with devices which will provide compensating or overriding signals to the regulator in response to the following conditions.

a. Excessive exciter output current in the event of fault in the field circuit.

b. Pole slip due to reverse induced field voltages.

c. Under excited reactive current in excess of generator capability limits

d. Voltage drop due to generator reactance.

e. Dynamic variation of generator output.

Manual control shall be provided to set the generator terminal voltage between 80% and 110% of the rated voltage.

Automatic change-over from Auto to Manual system shall be provided in case of abnormal/faulty PT Voltage.

Manual control shall also allow setting of generator terminal voltage between zero to 110% of nominal voltage.
7.3 Generator Switchgear

7.3.1 General
The generator circuit breaker, LA, isolators, earthing switches, CT, PT, surge capacitors, surge absorber shall be provided, and these shall be accommodated in metal clad switchgear cubicle arranged for local and remote control. Secondary wiring including cable termination facilities shall be provided.

7.3.2 Type And Rating
1) The switchgear shall be of the metal clad type and shall comply with the standards given below and with the relevant requirements stated in this specification.

<table>
<thead>
<tr>
<th>IEC</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>298</td>
<td>AC metal-enclosed switchgear</td>
</tr>
<tr>
<td>85</td>
<td>Insulating materials</td>
</tr>
<tr>
<td>51</td>
<td>Electrical indicating instruments</td>
</tr>
</tbody>
</table>

2) The switchgear busbar and associated connections shall have the insulation levels as given below:

- System highest voltage: As per IEC
- Withstand voltage
  - Lighting (impulse): As per IEC (11.2/50micro sec.)
  - Power Frequency (rms.): As per IEC (For 1 mm.)

3) The rated service voltage shall be of Generation Voltage.

4) The current rating of the main bus bars shall not be less than rated current of the related generator and rating of the associated connections shall be determined by the Contractor.

5) The short time three phase fault level rating for one second of the switchgear shall be of 100 kA (rms). The Contractor shall check the system fault current level. If fault level is higher, switchgear with higher fault level shall have to be provided.

7.3.3 Construction and Fittings

1) The switchgear shall consist of rigid welded steel cubicles and shall house generator circuit breaker, bus bars, current transformers, voltage transformers, neutral grounding transformer, surge absorbing equipment etc. The generator circuit breaker and the voltage transformers shall be withdrawable type. All doors shall be padlockable and readily removable when necessary.

2) The bus bar and its connections shall be of copper and all joint surfaces shall be silver plated.

3) All bus bar connections shall be by bolted type. Flexible joints shall be
provided wherever for thermal expansion will occur.

(4) Safety shutters actuated by inserting or withdrawing of the circuit breaker shall be provided in the circuit breaker compartment.

(5) Control circuit isolating connector shall also be provided.

(6) Clearly labelled mechanical interlocks shall be provided in each circuit breaker compartment to prevent:

- a close circuit breaker from being withdrawn from or inserted into the isolating contacts;
- A circuit breaker from being moved into any location unless it is fully withdrawn;
- a circuit breaker from being inserted into the fixed position unless the secondary isolating contacts are fitted.
- a circuit breaker from being closed except when fully inserted or fully withdrawn:
- a circuit breaker from being inserted into the fixed position unless the secondary isolation contacts are fitted.
- a circuit breaker from being closed except when fully inserted or fully withdrawn:
- a circuit breaker from being inserted against a locked safety shutter.

7) A common earth bus bar shall be provided in the switchgear. The bus bar shall consist of one copper

8) All secondary wiring shall be terminated on terminal blocks in an enclosure separate from the high voltage compartment.

7.3.4 Circuit Breaker

Generator unit Circuit Breaker shall be of SF$_6$ gas and other Circuit Breaker(s) shall be of SF$_6$ gas or vacuum type.

The circuit breaker shall comply with the requirements of IEC 56 and the relevant requirements of these Specifications.

- Rated Voltage : Generation voltage
- Rated Current : As per IEC Standard and Generator rated current.

- Interrupting Current : 100 KA (rms)

All circuit breakers of same rating & shall be identical in arrangement and shall be interchangeable and floor mounted.

Only fully type tested circuit breakers complying with IEC 56 will be considered, and a statement as to the availability of certificates of all such
type tests including impulse tests on identical or similar circuit breakers shall be submitted with Tender.

7.3.5 Current Transformer

The current transformers in the generator switchgear shall be of the epoxy resin insulated and of the bar `or wound primary type. The ratio, rating, polarity and accuracy classes (Metering: 0.2s, Protection: X/5P30) of current transformers shall conform to IEC185 or IEC 60044-1.

7.3.6 Voltage Transformer

The voltage transformers shall be of the horizontally with draw-out type and shall be located on top parts of each unit switchgear. Padlocking facilities shall be provided for both the services and isolated positions. The fixed isolating contacts shall be covered by a positively driven pad-lockable shutter when the voltage transformer is withdrawn.

The ratio, rating, polarity and accuracy classes of voltage transformers shall conform to IEC 186 or IEC 60044-2. The current limiting fuses shall be provided on high tension circuit of the voltage transformer.

7.3.7 Surge Absorbing Equipment

The surge arresters and capacitors for surge protection of the generator shall be provided.

7.3.8 Neutral Earthing Equipment

(1) Neutral Earthing Transformer

A single-phase, 50 Hz, dry or oil immerse type, naturally cooled neutral earthing transformer conforming to IEC 76 shall be provided for generating unit.

The voltage ratio of transformer shall be 21000 (or generating voltage)/ 240 V. The continuous rating in KVA appropriate to an earth fault duration of 30 seconds and a maximum primary earth fault current of 10 A shall be determined by the Contractor.

Insulation level of primary winding shall be of as per IEC.

(2) Earthing Resistor

The resistance of secondary resistor on neutral earthing transformer shall be equal to one third of the zero sequence capacitance per phase of the generator plus the bus bar capacitors if provided. The current rating shall be suitable for a single phase to earth fault on the generator circuit for 30 seconds and a maximum primary earth fault current of 10 A.

The terminals of the resistor shall be corrosion resistance.
7.3.9 Composition of Cubicles

(1) Generator Circuit Breaker Cubicle (For single-shaft arrangement, 01 for both GTG and STG)

- Circuit breaker : One (1)
- Current transformer/ PT : As per design
- End terminal : One (1) lot
- Ammeter : One (1) set
- Voltmeter with selector switch : One (1) set
- Protective relays : One (1) set

7.4 6.6 KV Switchgear

7.4.1 General

The switchgear shall be fully metal clad arrangement for local and remote operation, and shall comprise the following cubicles:

- Incoming circuit breaker cubicle for the Unit auxiliary and Reserve auxiliary transformer.
- Outgoing circuit breaker cubicle to station transformers.
- Voltage transformer cubicle.
- Outgoing circuit breaker cubicles to starting motor/ SFC transformer, Excitation transformer, GBC, other 6.6 kV loads etc.

The circuit breaker shall be of SF6 gas or vacuum type. The circuit breaker shall comply with the requirements of IEC 56 and the relevant requirements of this Specifications.

All circuit breakers shall be of same rating and identical in arrangement and shall be interchangeable.

7.4.2 Type and Rating

1) The switchgear shall be of the metal clad type and shall comply with the standard given below and with the relevant requirement stated in the Specification.

   IEC 298    AC metal enclosed switchgear
   IEC 85    Insulation material
   IEC 51    Electrical Indicating Instruments

2) System highest voltage : 7.2
   Withstand voltage
   Lighting (impulse) : 60 KV (peak)
   (11.2/50 micro sec.)
   Power Frequency (rms.) : 22 KV
   (For 1 mm.)

3) The rated service voltage shall be of 6.9 KV.

4) The current rating of the main bus bars shall not less than the rating of the
unit auxiliary transformer and rating of the associated connections shall be determined by the Contractor.

(5) The short time three phase fault level rating for one second of the switch gear shall be of 40KA (rms).

7.4.3 Construction And Fittings

The 6.6 KV switchgear shall be designed and constructed as same as those for Generator switchgear specified in Section 7.3.

7.4.4 Circuit Breaker

The circuit breaker shall be of SF6 gas or vacuum type.

The circuit breaker shall comply with the requirements of IEC 56 and with the relevant requirements of this specification.

All circuit breakers shall be identical in arrangement and shall be interchangeable.

- Rated Voltage : 6.6 KV
- System highest voltage : 7.2
- Rated Current : As per requirement and IEC
- Interrupting Current : 40 KA (rms)

Only fully type tested circuit breakers complying with IEC 56 will be considered, and a statement as to the availability of certificates of all such type tests including impulse tests on identical or similar circuit breakers shall be submitted with Tender.

7.4.5 Composition of Cubicles

- Circuit breaker : One (1) for each feeder
- Current transformer/ PT : As per design
- End terminal : One (1) lot
- Ammeter : One (1) set
- Voltmeter with selector switch : One (1) set
- Protective relays : One (1) set
Section 8

Transformers
8. TRANSFORMERS

8.1 General
  8.1.1 Requirements for Characteristics
  8.1.2 Requirements for Construction

8.2 Generator Step-up Transformer
  8.2.1 Type and Ratio
  8.2.2 Output and Required Numbers
  8.2.3 Impedance Voltage
  8.2.4 Winding and Insulation
  8.2.5 On Load Tap Changer
  8.2.6 Cable Box/Isolated & Insulated Phase Bus Duct
  8.2.7 Phase & Neutral Circuit Current Transformer

8.3 Auxiliary Transformer
  8.3.1 Type and ratio
  8.3.2 Output
  8.3.3 Impedance Voltage.
  8.3.4 Winding and Insulation
  8.3.5 Off Load Tap Changer
  8.3.6 Cable Box

8.4 Station Transformer
  8.4.1 Type and Ratio
  8.4.2 Output
  8.4.3 Impedance Voltage
  8.4.4 Winding and Insulation
  8.4.5 Off Circuit Tap Changer
  8.4.6 Cable Box

8.5 Start-up/Reserve Auxiliary Transformer

8.6 Accessories
8. TRANSFORMERS

8.1 GENERAL

The transformers shall be designed and tested in accordance with IEC 76

(1) Generator Step-up Transformers

1 set of (3+1) Single phase, oil immersed, self-cooled / forced air cooled (ONAN / ONAF), outdoor use type for stepping up the voltage from 21 kV or generating voltage to 230 kV with on load tap changer having uniform insulation.

The maximum continuous rating of the transformer (Three single phase and Vector Group = Ynd1) shall meet at any taps with the output (at any ambient temperature) of the Generator, which is connected with the transformer in series. The maximum continuous rating of the step-up transformer shall be at least 120% (one hundred and twenty per cent) of the corresponding MVA (pf=0.8) of the Generator terminal output at Site condition of 35° C, 1.013 bar and 98% RH.

The self-cooled capacity shall not be less than 75 % of forced air cooled capacity

(2) Unit Auxiliary Transformer

Two (2) set of three phase, oil immersed type, self-cooled / forced air cooled (ONAN / ONAF) transformer for stepping down the voltage from 21 kV or generating voltage to 6.6 kV with off circuit tap changer. The capacity of each auxiliary transformer shall be 120% of total aux. power requirement for both GT & ST and common station service including all residential and non-residential load but not less than 25 MVA. Low voltage rating to be considered as 6.9 kV.

The self-cooled capacity shall not be less than 75 % of forced air cooled capacity

(3) Station Transformers

Required nos. of three phase, oil immersed type, self-air cooled (ONAN) transformers for stepping down the voltage from 6.6 kV to 415 V with off load tap changer. In each location there will be 02 nos. of 0.4 kV buses, loads in that location will be divided into these 02 buses, each 0.4 kV bus will be feed through one 6.6/ 0.4 kV transformer, each 6.6/ 0.4 kV transformer capacity shall be 120% of total loads of these 02 buses. So that one of these two 6.6/ 0.4 kV transformers can be isolated without disturbing 0.4 kV loads. High voltage rating to be considered as 6.9 kV.

For fire protection, Transformer deluge system shall be provided for Generator Step up Transformer, Unit Auxiliary Transformer.
8.1.1  REQUIREMENT FOR CHARACTERISTICS

(1)  Efficiency
The transformers shall be of highest efficiency that the Contractor can attain.

(2)  Temperature Rise
The temperature rise of the windings shall not exceed 55°C when measured by the resistance method, after circulating the rated current at rated frequency in the windings under test.

The temperature rise of top insulation oil shall not exceed 55°C when measured by a thermometer in an oil filled thermometer pocket on the cover or in the outlet pipe to the cooler, and the method of the test of temperature rise will be decided in accordance with IEC 76-2.

(3)  Dielectric Test Voltage
The transformers shall withstand the following test voltages in accordance with IEC 76-3.

a.  230 KV CIRCUIT
   -  lightning impulse withstand test voltage : 1050KV (peak)
     (1.2/ 50 micro sec.)
   -  Power frequency test voltage : 460 kV for one minute.

b.  Generation Voltage circuit
   -  lightning impulse withstand test voltage : As per IEC
     (1.2/ 50 micro sec.)
   -  Power frequency test voltage : As per IEC

c.  6.6 KV circuit
   -  lightning impulse withstand test voltage : 60 kV(Peak)
     (1.2 / 50 micro sec.)
   -  Power frequency test voltage : 22 kV for one minute

d.  415 V circuit
   -  lightning impulse withstand test voltage : As per IEC
     (1.2 / 50 micro sec.)
   -  Power frequency test voltage : 4KV

4)  No Load Excitation Current
The no load excitation current under the rated voltage and frequency shall be as small as possible.

5)  Mechanical and Thermal Strength for Short Circuit
Tile transformers shall be designed and constructed to withstand for three seconds without damage the thermal and dynamic effects of external short circuits under the most severe conditions.
(6) Tolerances
The tolerances on the guarantee values shall be in accordance with IEC 76-1.

(7) Noise
Vibration and noise levels of transformers shall be in accordance with the best commercial practice.

8.1.2 REQUIREMENTS FOR CONSTRUCTION

(1) Tank and Interior Structure
a. The power transformer shall be of such structure to permit installation at the Site to be simple.
   Assembling work at the Site such as staking of core and insertion of coil shall not be allowed.

b. The tank shall be of the welded steel plate structure and shall withstand and hold continuously a vacuum of 760 mm Hg.

e. The sealed joint part of the tank shall be designed to prevent oil and gas leakage and shall be water tight even after long term use, and careful attention shall be paid to fastening methods of packing of bushing, bursting tube, cooling radiator, connecting pipes and other accessories.

d. Looseness of core, yoke, coil and other parts shall not happen during transportation and long term use.

e. The transformer shall be provided with a pressure relief device (PRD) or bursting tube to discharge the pressure in case of abnormal rise of the inner pressure. The PRD or tube shall be equipped with trip contact. The tube shall be extended up to the oil pit which will be constructed around the transformer.

f. No corona shall be discharged inside and outside of the tank under the imposed primary voltage of $230\sqrt{3}$ KV x 130%.

g. All generated gas and oil flow under fault conditions shall be concentrated to the Buchholz or similar type relay so as to ensure the relay action.

h. The transformer shall be provided with skid type base.

i. Anti-vibration rubber or the equivalent, shall be provided under the base so as to prevent propagation of transformer's vibration to the other Equipment, if installed in the power house.

j. Winding of coils shall be designed so as to make the initial potential distribution caused by impulsive travelling waves as uniform as possible, to avoid potential oscillation and to withstand abnormal voltage due to switching.

k. The ground terminals of the transformer shall be copper faced steel ground pad, and shall be welded on the tank wall near the base.
The ground terminal shall be of the bolt fastened type, suitable for 100-200 sq.mm hard or annealed copper stranded conductors.

l. In designing the transformers, the Contractor shall refer to the general arrangement of the transformer as shown in the attached Drawings, and shall consider the location of the lightning arrester.

(2) Bushing and Connection

a. 230 KV line and neutral bushings of the generator step-up transformer shall be oil filled nitrogen sealed draw lead type with an oil level gauge, and 13/ 15/ 19/ 21 kV bushings shall be of the solid type. The glazing colour shall be of brown.

b. The lightning impulse (1.2/ 50 micro see.) insulation level of bushings shall be as follows.

- 230 KV line bushings : \(1050 \text{ kV}_{\text{peak}}\)
- 230 KV line neutral bushing : \(1050 \text{ kV}_{\text{peak}}\)
- 13/ 15/ 19/ 21 k bushings : As per IEC

c. The creepage distance of bushings of outdoor use transformer except neutral bushing shall not be less than 25 mm / KV of rated phase to phase voltage.

(3) Oil Preservation System:
Oil immersed transformers shall be provided with an oil preservation system in which the insulating oil shall be isolated from atmospheric air. The oil preservation system shall be of the diaphragm seal or air seal cell type conservator with silica-gel breather. Oil level gauge with low level alarm contact shall be mounted on the conservator.

(4) Cooling system:
An adequate number of unit coolers shall be fixed to the tank of oil immersed transformers, and the cooling capacity shall be sufficient to operate the transformer under the rated power. The coolers shall be of such structure that will not be affected by the vibration of transformer. A valve shall be provided with each pipe connecting a unit cooler to the tank. Fixing bolts and terminals shall be such that will never get loosened after being fastened. The power source of the cooling fans shall be 415V, 3 phase or 230 V, single phase. The fans shall normally be controlled by its own winding temperature relaying device.

(5) Temperature Detector:
One (1) temperature detector shall be installed at the point where the highest temperature is anticipated.

(6) Protective Device:
The following protection system shall be provided:
- Buchholz relay and Pressure Relieve Device (PRD) similar type for alarm and trip
- High temperature alarm and trip (winding and oil)
A Buchholz relay or oil pressure relay shall be fitted on between the conservator and the tank. A dial type thermometer with hand resetting
maximum indicator shall be provided. A Pressure Relief Device (PRD) with operation indicator shall be provided.
The gas relay should be provided with double float (one operated by volume of gas flow and other operated by mass gas flow). It should have following provision:

a. Gas release valve  
b. Mechanical test button  
c. Provision for testing both the floats by injecting air from outside.  
d. Drain cock  
e. Transport graduated window  
f. The relay should be mounted at such a place that can be visible From the ground without climbing on the transformer.

(7)  
Wiring:  
All wiring mounted on the transformer shall be drawn through conduit pipes or adequate protective tubes to the control cabinet which shall be properly located on the transformer.

The wiring shall be connected at the terminal blocks terminating the outgoing control cable. The flexible tube of the vapour tension thermometer shall be covered by a protective tube.

(8)  
Insulating oil:  
The insulating oil shall have a sufficient insulation strength, and shall be excellent in heat conductivity, low in viscosity and pour point, and high in flash point. The oil shall not cause any corrosion to insulating materials and structured materials of electrical equipment and shall be chemically stable for long years of use.

Delivery shall be made to Site partly contained in the transformers and partly in steel drums, according to the method of packing employed. An excess of 10% of the quantity of oil required for filling transformers shall also be supplied and its cost shall be included in the price of each transformer.

(9)  
Skid Base:  
The transformer shall be provided with a skid base with four (4) steel wheels and necessary jacks for setting and appropriate devices for locking in position of its foundation.

8.2  
GENERATOR STEP-UP TRANSFORMER  

8.2.1  
TYPE AND RATIO  
The transformer shall be of 1 set of (3+1) single phase, oil immersed, self-cooled / forced air cooled (ONAN/ONAF) by cooling fans, outdoor use type. Ratio of delta star connection shall be Generation Voltage to 230 KV on full load condition. High voltage rating of Transformers to be considered 242 kV.

The connection shall be arranged in vector symbol Ynd₁ (HV/LV) according to IEC 76-4 and neutral of star connected high tension winding shall be solidly grounded.
The on load tap changer (MR, Germany/ABB, Sweden) shall be provided on the high tension winding, and their ratio shall be as follows:
230 kV (+ 8 x 1.25% to – 12 x 1.25%)

8.2.2 OUTPUT AND REQUIRED NUMBERS
1 set of (3+1) single phase, oil immersed, self-cooled / forced air cooled (ONAN/ONAF) by cooling fans, outdoor use type Generator step up Transformer.

The maximum continuous rating of the transformer (Three phase and Vector Group = Ynd₁ᵢ) shall meet at any taps with the output (at any ambient temperature) of the Generator, which is connected with the transformer in series. The maximum continuous rating of the step-up transformer shall be at least 120% (one hundred and twenty per cent) of the corresponding MVA (pf=0.8) of the Generator terminal output at Site condition of 35⁰ C, 1.013 bar and 98% RH.

The self-cooled capacity shall not be less than 75 % of forced air cooled capacity.

8.2.3 IMPEDANCE VOLTAGE
Impedance voltage (+ve Seq.) shall be within the range of 15% to 18% on the forced air cooled rating on the rated tapping (Generation voltage/230 KV) and shall be guaranteed by the Contractor.

8.2.4 WINDING AND INSULATION
The full uniform insulation shall be applied on both 230 KV (phase & neutral) and LT windings and neutral point of 230 KV windings shall be solidly grounded.

The winding conductors shall be of high conductivity copper.

The insulation shall be designed not merely by normal voltage per turn, but also by variation of line voltage and the operating conditions including impulse surge caused by lightning strokes on the transmission line and switching surges.

8.2.5 ON LOAD TAP CHANGER
The on load tap changer with motor drive unit (MDU) made by “MR, Germany/ABB, Sweden” shall be provided on 230 KV side of winding and shall be designed to meet the requirement of IEC 76. Provisions shall be made for padlocking in any tap position.

8.2.6 Isolated & Insulated Phase Bus Duct
Isolated and Insulated Phase copper Bus Duct shall be provided from Generator terminal to Generator circuit breaker and Generator circuit breaker to LV side of Generator step up Transformer and Unit auxiliary Transformer.
8.2.7 PHASE & NEUTRAL CIRCUIT CURRENT TRANSFORMER

Current transformers shall be provided on the high tension neutral circuit for Restricted Earth Fault & Stand by Earth Fault relays and ratio should match with phases (LV & HV) Differential protection circuit. If necessary interposing current transformers may be used.

1) Use : Protection
2) Ratings
   Rated primary current : As per design
   Rated secondary current : 5 A
   Accuracy class : 5 P30
   Rated burden : 15 VA

3) Requirements for characteristics and Construction

   The current transformer shall be designed to meet the requirements of latest IEC standard.

8.3 STATION TRANSFORMERS

8.3.1 TYPE AND RATIO

   The transformers shall be of three (3) phase, oil immersed, self-air cooled (ONAN) type. Nominal no load ratio of delta star connection shall be 6.6 KV to 0.415 KV.

   The connection shall be arrangement in vector symbol Dyn_{11} according to IEC 76-4 and neutral of star connected low tension winding shall be earthed solidly.

   The off load tap changer shall be provided on the high tension winding, ± 2 X 2.5%.

8.3.2 OUTPUT

   As mentioned in clause 8.1 (3).

8.3.3 IMPEDENCE VOLTAGE

   The impedance voltage shall not less than 5 %, but not more than 7.5 % on the rated tapping (6.6KV/ 415V) and shall be guaranteed by the Contractor.

8.3.4 WINDING AND INSULATION

   The requirements shall be in accordance with section 8.2.4 for LV side.

8.3.5 OFF LOAD TAP CHANGER

   The off load tap changer shall be provided on 6.6 kV winding and shall be designed to meet the requirements of IEC 76. as follows.
   - Central tap : 6.6kV
   - Step voltage : 2.5%

   All the mechanical operating parts of the gear shall be self-lubricated with
transformer oil, no special lubrication being necessary. The tap changer shall be operated electrically by means of manual push buttons mounted on the central control panel. The tap changer compartment oil shall be isolated from main transformer tank oil, and the compartment shall be provided with proper protection facilities and accessories.

8.3.6 CABLE BOX

The cable boxes shall be provided on both high tension and low tension terminals to terminate high and low voltage power cables. Proper cable supports and cable cleats shall also be provided.

Non segregated bus duct between low tension terminals of auxiliary transformer and power centre terminals instead of cables may be acceptable.

8.4 UNIT AUXILIARY TRANSFORMER

8.4.1 TYPE AND RATIO

The unit auxiliary transformer shall be of three (3) phase, oil immersed self-cooled / forced air cooled (ONAN / ONAF) type. Nominal no load ratio of delta star connection shall be 21 kV or generating voltage / 6.6 KV. The self-cooled capacity shall not be less than 75 % of forced air cooled capacity. Low voltage rating to be considered as 6.9 kV.

The connection shall be arrangement according to IEC 76-4 and neutral of star connected winding shall be earthed solidly.

The off circuit tap changer shall be provided on the high tension winding ± 2 X 2.5%.

8.4.2 Output

As mentioned in clause 8.1 (2).

8.4.3 IMPEDENCE VOLTAGE

The impedance voltage shall not less than 5%, but not more than 7.5% on the rated tapping (21 / 6.6 KV) and shall be guaranteed by the Contractor.

8.4.4 WINDING AND INSULATION

The requirements shall be in accordance with section 8.2.4, except voltage rating.

8.4.5 OFF CIRCUIT TAP CHANGER

The requirements shall be in accordance with Section 8.3.5 except on 21 kV or HV side winding.
8.4.6 **IPB duct (Copper)/ CABLE BOX**

**IPB duct (Copper)** cable boxes shall be provided on high tension and cable boxes shall be provided on low tension terminals to terminate low voltage power cables. Proper cable supports and cable cleats shall also be provided.

Non segregated bus duct between low tension terminals of auxiliary transformer and power centre terminals instead of cables may be acceptable.

8.5 **Deleted**

8.6 **ACCESSORIES**

The following accessories shall be furnished for each transformer:

a. Name plate  
b. Valves for oil filtering and sampling  
c. Air vent valve  
d. Manhole and hand-hole including blind covers  
e. Ladder fixed to the transformer tank for inspection of the upper part of the transformer.  
f. Hanging hook  
g. Grounding terminals  
h. Anchor device  
i. Oil preservation system including oil conservator  
j. Oil level gauge  
k. Dial type thermometer with hand resetting maximum indicator  
l. Breather with silica-gel  
m. Other necessary accessories  
n. Rail track in the transformer yard.
Section-9

230 kV Switchgear, Equipment
9. 230 kV Outdoor Switchgear, Equipment

9.1 General
9.1.1 Design Requirement

9.2 230 kV Switchgear, Equipment
9.2.1 230 kV Circuit Breakers
9.2.2 230 kV Disconnecting Switches
9.2.3 230 kV Voltage Transformer
9.2.4 230 kV Current Transformer
9.2.5 230 kV Lightning Arresters Steel Structure

9.3 Steel Structure
9.3.1 Type
9.3.2 Design Criteria
9.3.3 Requirement for Design and Construction
9.3.4 Design Items
9.3.5 Accessories

9.4 Insulators and Wiring Materials
9.4.1 Insulators
9.4.2 Fitting
9.4.3 Standard Conductor for Over Head Line

9.4.4 Miscellaneous Material
9. 230 kV Outdoor Switchgear, Equipment

9.1 GENERAL

The contractor shall furnish the 230 kV outdoor switchyard equipment which shall comply with relevant IEC as listed below and the 230 kV equipment shall be arranged in the outdoor as per PGCB guideline.

9.1.1 DESIGN EQUIPMENT

(1) System Voltage

The system shall be as follows:
- Nominal system voltage: 230 kV
- Highest system voltage: 245 kV

(2) Outdoor Conductor Clearance

<table>
<thead>
<tr>
<th>Description</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum clearance between live metal and earth</td>
<td>3500 mm</td>
</tr>
<tr>
<td>Minimum clearance between live metal</td>
<td>4000 mm</td>
</tr>
<tr>
<td>Minimum safety clearance between ground and the nearest point not at earth</td>
<td>2500 mm</td>
</tr>
<tr>
<td>Minimum safety clearance between ground and the nearest live unscreened</td>
<td>6400 mm</td>
</tr>
<tr>
<td>conductor (BS 7354 ‘Safety Working Clearance’)</td>
<td></td>
</tr>
<tr>
<td>Minimum insulator creepage distance (at rated voltage between phases)</td>
<td>25 mm/kV</td>
</tr>
</tbody>
</table>

(3) Design Conditions

Switchgear equipment shall be designed to avoid local corona formation and discharge likely to cause radio interface, and to endure short circuit current without thermal and mechanical failure for one (1) second. All cubicles and enclosures shall be vermin proof, dust resistance and weatherproof.

9.2 230 kV SWITCHGEAR, EQUIPMENT

9.2.1 230 kV CIRCUIT BREAKERS

(1) Type

Three (3) pole, porcelain type, high speed, outdoor, trip free in any position, hydraulic & spring operated SF₆ gas puffer, single flow type complete with hydraulic pump, tank, piping, conduit, wiring, and all other necessary accessories.

(2) Ratings

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Rated voltage</td>
<td>230 kV</td>
</tr>
<tr>
<td>Standard</td>
<td>IEC 62271-100</td>
</tr>
<tr>
<td>Rated short duration power frequency withstand voltage (1 min.)</td>
<td>345 kV rms</td>
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<tr>
<td>- Between line terminal and ground</td>
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</tbody>
</table>
- Between terminals with CB open & 440 kV rms

<table>
<thead>
<tr>
<th>Rated switching impulse withstand voltage</th>
<th>1050 kV peak</th>
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</thead>
<tbody>
<tr>
<td>- Between line terminal and ground</td>
<td>900 (+345) kV peak</td>
</tr>
<tr>
<td>- Between terminals with CB open</td>
<td>1050 kV peak</td>
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<tr>
<td>Rated lightning impulse withstand voltage</td>
<td>1050 (+240) kV peak</td>
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<tr>
<td>- Between line terminal and ground</td>
<td>1050 (+240) kV peak</td>
</tr>
<tr>
<td>- Between terminals with CB open</td>
<td>1050 (+240) kV peak</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First pole to clear factor</th>
<th>1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated current</td>
<td>As per requirement</td>
</tr>
<tr>
<td>Rated short circuit breaking current</td>
<td>40 kA rms</td>
</tr>
<tr>
<td>Rated short circuit making current</td>
<td>100 kA peak</td>
</tr>
<tr>
<td>Short time withstand current for 1 sec.</td>
<td>40 kA rms</td>
</tr>
<tr>
<td>Corona extinction voltage with CB open or close</td>
<td>320 kV rms</td>
</tr>
<tr>
<td>Max. radio interference voltage for frequency between 0.5MHz and 2MHz in all positions</td>
<td>1000 micro V (at 266 kV rms)</td>
</tr>
<tr>
<td>Total closing time</td>
<td>Not more than 150 ms</td>
</tr>
<tr>
<td>Total breaking time</td>
<td>40 ms</td>
</tr>
<tr>
<td>Operating mechanism</td>
<td>Spring or Spring-hydraulic Combination</td>
</tr>
<tr>
<td>Rated duty cycle</td>
<td>O-0.3S-CO-3min-CO</td>
</tr>
<tr>
<td>Creepage distance</td>
<td>25 mm/kV</td>
</tr>
<tr>
<td>Number of closing coils</td>
<td>1</td>
</tr>
<tr>
<td>Number of tripping coils</td>
<td>2</td>
</tr>
<tr>
<td>Number of auxiliary contacts for:</td>
<td></td>
</tr>
<tr>
<td>- Making</td>
<td>Min. 12</td>
</tr>
<tr>
<td>- Breaking</td>
<td>Min. 12</td>
</tr>
<tr>
<td>- Middle position</td>
<td>0</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP55</td>
</tr>
</tbody>
</table>

3) Control System

The rated supply voltages of closing and opening devices shall be 110 V DC, and the operation of circuit breaker shall be performed safely under the following conditions:

For tripping operation (-30% to +10%)

For closing operation (-15% to +10%)

The rated hydraulic pressure shall be recommended by the Contractor.

5) Requirements for Design and Construction

a. The circuit breakers shall have automatic trip free mechanism.

b. Time difference between contacts of three (3) poles shall not be more than 0.006 sec.

c. In case of phase open trouble, all phases of the circuit breaker shall be opened by a protection circuit.

d. The arcing contact shall be of an arc proof metal and the main contact shall be covered with silver electroplated.
e. Five (5) pairs of “a-b” spare contacts shall be equipped with the auxiliary switches.

f. The tripping current of the trip coil shall not be more than 2 A per phase.

g. The porcelain insulator or bushings shall have sufficient strength to withstand stressed due to breaker operation. The glazing colour shall be of brown. The creepage distance shall not be less than 25 mm / kV of phase to phase voltage.

h. Integrating time register for hydraulic pump shall be driven by a self starting synchronous motor through mechanical gears to record operating hours of hydraulic pump and shall be able to perform four operations without AC power.

i. Gas circuit breaker shall be provided with gas density detector responding to gas density and pressure. This gas density detector shall have two (2) different functions according to the gas condition: The first step gives alarm and the second step locks the operating mechanism. Operating mechanism which employs compressed air or hydraulic for driving the circuit breaker shall be provided with pressure detector which have two (2) different functions according to compressed air or hydraulic condition: The first step gives alarm and the 2nd step locks the operating mechanism.

j. The weather and dust proof type control box shall be furnished with the circuit breakers. The control box shall be equipped with all necessary parts to operate the circuit breaker, such as control solenoids, operating switch of remote and local control, auxiliary switch, terminal blocks, protective devices, indicating lamp sockets, and other accessories. An anti condensation electric heater with thermostatic switch shall be provided inside the control box.

k. The circuit breakers shall be provided with an emergency push button switch with cover to prevent inadvertent switching.

l. The circuit breakers shall be provided with an electrical anti pumping relay.

m. The supporting structure shall be free from mechanical vibration and loosening under long term use.

n. The circuit breakers shall be designed to facilitate inspection, especially for those parts which need inspection frequently.

o. The circuit breakers shall be filled with sufficient SF$_6$ gas.

p. SF$_6$ gas leak detector shall be furnished.

q. The circuit breakers shall be driven by hydraulic and spring charged. Hydraulic supplying system shall be furnished with the circuit breakers, and shall be installed in weather dust proof type housing. The operating mechanism shall be designed to meet the requirements of IEC 56.
r. Temperature limitation shall be in accordance with IEC 56.

s. The Contractor shall furnish all control cables, pipes or ducts and fittings between each phase and control box.

t. The indicating lamp signals which display "on (red)" and "off (green)" of the main contacts shall be furnished on the each control box of circuit breaker.

(6) Tools and Accessories
The following tools and accessories shall be supplied for each circuit breakers.

a. Name plate
b. Position indicating lamps (red and green) or flags.
c. Operation counter.
d. Grounding terminals
e. Gas, and hydraulic pressure gauge
f. Safety valves, if any
g. Pressure drop protecting device
h. Manual operation device.
i. Auxiliary switch
j. Control box with locking device
k. Steel supporting structure with anchor bolts and nuts
l. Operating mechanism.
m. Special tools for checking and testing
n. Power outlet, single phase, 230 V, 10 A in control box
o. Conduit pipes (Steel/GI)
p. Communication facilities between switchgear and control room
q. Other necessary accessories, if any

9.2.2 230 kV DISCONNECTING SWITCHES

(1) Type
Outdoor, three (3) pole, single throw, group operated, horizontal break, rotating insulator, remote controlled motor operated type.

(2) Ratings

a. Rated voltage : 230 kV

b. Rated insulation level
lighting impulse withstand test voltage : 1050 kV (peak)
(1.2 /50 micro see.)
- Power frequency withstand voltage ( for 1 mm.) : 460 kV

c. Rated frequency : 50Hz
d. Rated nominal current : 2000A
e. Rated duration of short circuit current : 3 sec
f. Rated short circuit withstand current : 40 kA
g. Rated peak withstand current : 63 kA  

h. Rated short circuit making current : 100 kA

(3) Requirements for Design and Construction

a) The disconnecting switches shall be so designed and constructed in accordance with IEC 62271-102.

b) The contact part of the blade shall be silver electroplated.

c) The porcelain insulator shall be an outdoor and post type, and shall have creepage distance not less than 25 mm/ kV of phase to phase voltage age. The glazing colour shall be of brown.

d) An electrical or mechanical interlocking device shall be equipped between its related circuit breaker.

e) Revolving parts shall be so designed that operation will be sure and smooth under long term use without necessity of inspection, oiling.

f) Auxiliary switches with three (3) spare parts “ a-b “ contacts, terminal blocks, indicator lamp sockets, etc. shall be accommodate in a control box shall be of the weather and dust proof type with locking device.

(4) Accessories

Nameplate.  
Control box with locking device.  
Grounding terminal.  
Auxiliary switches.  
Steel supporting structure with anchor bolts and nuts.  
Manual operation handle.  
Motor operating mechanism with manual operation inter-lock.  
Conduit pipes(Steel/ GI).  
Other necessary accessories, if any

9.2.3 230 kV VOLTAGE TRANSFORMER

(1) Type

Outdoor, single phase, oil immersed with level indicator or gauge, N₂ gas sealed Electromagnetic type voltage transformer.

(2) Use

For metering and protection

(3) Ratings

a. Rated voltages

- Primary  : 230/√3 kV  
- Secondary  : 110/√3 V  
- Tertiary  : 110/ 3 V
Rated insulation level

a. Lighting impulse withstand voltage : 1050 kV\textsubscript{peak}
   Full wave (1.2 / 50 micro sec.)

b. Power frequency withstand voltage : 460 kV
   for one minute

c. Rated frequency : 50 Hz

d. Rated burden

- Secondary : 200 VA
- Tertiary : 25 VA

e. Accuracy class
   - Secondary : 0.2s
   - Tertiary : P

f. Rated short circuit withstand current : 40 kA

(4) Requirements for Design and Construction

a. The voltage transformers shall be of hermetically sealed and
   accessories shall be of weatherproof type. The glazing colour shall
   be of brown.

b. Creepage distance of bushing shall not be less than 25 mm / kV of
   phase to phase voltage.

c. A protection device shall be provided against short circuit of the
   secondary circuits of the voltage transformers.

d. Unless otherwise specified, the characteristic and others shall
   comply with the requirements of IEC 186.

(5) Dielectric Test Voltages

a. Power frequency withstand voltage
   on primary windings. : 275 kV for one minute

b. Lighting impulse withstand voltage : 460 kV peak

c. Power frequency withstand voltage
   on secondary windings. : 2 kV for one minute

(6) Accessories

The following accessories shall be provided for each voltage transformer.

Nameplates.
Grounding terminals.
Lifting lugs.
Steel supporting structure with anchor bolts and nuts.
Junction boxes.
Conduit pipes (Steel/ GI).
Other necessary accessories, if any

9.2.4 230 kV CURRENT TRANSFORMERS

(1) Type

Outdoor, single phase, oil immersed with level indicator or gauge, \( N_2 \) gas sealed porcelain clad type, quadruplicate cores.

(2) Use

For metering and protection

(3) Ratings

a. Rated current
   - Primary : As per design
   - Secondary : 5-5-5-5 A

b. Rated insulation level
   - Lighting impulse withstand voltage : 1050 kV<sub>PEAK</sub>
   - Power frequency withstand voltage : 460 KV for one min.

c. Rated frequency : 50 Hz

d. Rated burden : 60 VA for protection and 30 VA for measuring.

e. Rated continuous thermal current : 120%

f. Short time current ratings
   - Thermal rating (r.m.s. for one sec.) : 40 KA
   - Dynamic rating (peak) : 2.5 times the thermal ratings

g. Accuracy classes
   - For metering : 0.2s
   - For protection : 5P30

(4) Requirements for Design and Construction

g. The current transformer shall be of oil immersed hermetically sealed structure type.

g. Internal conductor shall be adequately reinforced taking into account over current intensity.

g. The junction box with terminals shall be provided for the secondary circuit connections.

g. Each current transformer shall be equipped with terminal block of short circuiting type.

g. Creepage distance of bushing shall not less than 25 mm / kV of phase to phase voltage. The glazing colour shall be of brown.

g. Unless otherwise specified, the characteristics and others shall comply with IEC 185.
(5) Dielectric Test Voltages

a. Power frequency withstand voltage on primary windings: 460 kV for one minute.

b. Lighting impulse withstand voltage: 1050 kV\(_{PEAK}\)

c. Power frequency withstand voltage on secondary windings: 2.0 kV for one minute.

(6) Accessories

The following accessories shall be provided for each current transformer.

- Nameplates.
- Grounding terminals.
- Lifting lugs.
- Steel supporting structure with anchor bolts and nuts.
- Junction boxes.
- Conduit pipes (Steel/GI).
- Other necessary accessories, if any

9.2.5 230 kV LIGHTNING ARRESTERS

(1) Type

Outdoor, single phase, self standing, Zinc Oxide, gapless type with surge counter & Leakage current detector.

(2) Use

For protection of 230 kV outdoor switchyard equipment and transformer windings.

(3) Electric system to be protected

Three (3) phase, three (3) wire, neutral point solidly grounded system.

(4) Ratings and Performances

a. Rated voltage: 186 kV

b. Rated frequency: 50 Hz

c. Nominal discharge current: 10 KA

d. Type of duty: Heavy, Long duration discharge

e. Discharge class: Heavy duty 3

f. Lighting impulse insulation level: 1050 KV\(_{peak}\)

g. Maximum residual voltage: 400 KV

h. Power frequency spark-over voltage: 170 KV

(5) Operating duty

The arrester shall successfully interrupt the dynamic current repeatedly conducted by impulse wave.

(6) Requirements for Design and Construction

a. The series gaps shall be so designed that for practical purposes the various characteristics will not alter under the change of weather conditions.

b. The various parts of the lightning arrester shall be of complete moisture proof construction so that the characteristics shall not be impaired under
long term use. Sealed parts shall be so designed to prevent to ingress of moisture or water under long term use.

c. The operation counter shall be equipped on the lightning arrester in each phase and consist of a sure current recording and measuring device, such as a magnetic link surge crest ammeter, and counter for the number of discharges of the lightning arrester. It shall be located at the position convenient for inspection.

d. Creepage distance of bushing shall not be less than 25 mm/ kV of phase to phase voltage. The glazing colour shall be of brown.

e. Unless otherwise specified, tile characteristics and others shall comply with IEC 60099-4.

(7) Dielectric Test Voltage

a. Power frequency withstand voltage : 460 kV for one minute

b. Lighting impulse withstand voltage (1.2/50 micro sec.) : 1050 kV (peak)

(8) Accessories

The following accessories shall be provided for each lightning arrester.

a. Nameplates.
b. Grounding conductor to grounding terminal.
c. Operating counter.
d. Grounding terminal.
e. Steel supporting structure with anchor bolts and nuts.
f. Other necessary accessories, if any.

9.3 STEEL STRUCTURE

One (1) lot of 230 KV Bay equipment (for extension of 2 nos. bay) such as but not limited to Circuit Breaker, isolator, earth switch, CT, PT, LA, bus coupler etc. as per requirement and guideline of PGC (Power Grid Company of Bangladesh).

9.3.1 TYPE

The steel structure shall be lattice truss construction made of galvanised formed steel and assembled by bolts and nuts.

The component members of steel structure shall have inter-changeability with other identical members. The basis framing of the steel structure shall be identical on all four (4) faces below the bend line.

9.3.2 DESIGN CRITERIA

The steel structure shall be designed in accordance with the following criteria.

(1) Load due to the tension of conductor and wire.

- 230 kV bus and outgoing conductor : 1200 kg per conductor
- Overhead grounding wire : 700 kg per wire
(2) Vertical loads
The weight of the conductors, grounding wires, insulator strings and steel structures shall be taken into consideration.

(3) Human Loads
105 kg at the centre of the beam.

(4) Wind loads
Wind loads shall be calculated with wind speed as per latest wind map, but the wind loads on unit projected area shall not be less than the followings:
- On conductors and grounding wires : 125 Kg/sq.m
- On insulators and other circular section : 130 Kg/sq.m
- On lattice structures or beam structure : 230 Kg/sq.m

(5) Seismic Coefficient (Horizontal)
As per Seismic Map of approved Latest BNBC

(6) Working Conditions
The normal working condition for various loads shall be deemed to work simultaneously. The wind direction shall be classified into transverse, longitudinal and oblique components to the line route and the largest load acting on the line shall be taken as the design stress of the component material.

(7) Combination loads
The Contractor shall calculate the maximum and minimum stresses at any combination of loading conditions. The design of each type of steel structure shall be made by the same manner of analysis. The design stresses of individual components shall be largest value of maximum stresses in the respective loading conditions.

(8) Safety Factors
The safety factors shall not be less than two (2) under the normal working conditions.

(9) Minimum Thickness and Size of Steel Members
Minimum thickness and size of steel members shall be as follows:
- Formed steel : not less than 45 x 45 x 4 mm
- Plate : not less than 4 mm thick.

(10) Slenderness Ratio
The slenderness ratio shall not exceed 120 for main members, 200 for bracing and 250 for other members.
Design methodology (combination of Load) shall be followed as per BNBC (Bangladesh national building code).

9.3.3 REQUIREMENTS FOR DESIGN AND CONSTRUCTION

(1) Workmanship
Workmanship shall be first class throughout. All pieces shall be straight, true to detailed drawings and free from lamination, flaws and other defects. All clipplings, back nuts, grindings, bends, holes, etc. shall be true to detailed drawings and free of burrs.

(2) Galvanising
The steel structure shall be completely galvanised (Hot-Deep), except for part which shall be embedded in concrete foundation. All ferrous materials shall be galvanised to meet the requirements of IEC.

(3) Materials of Steel Structure
All materials shall be hot rolled structural steel and/or high strength structural steel.

(4) Marking
All products shall be marked with systematic numbers and/or colours for convenience of assembly.

(5) Future Extension of Structure
In designing the steel structure, consideration shall be given in the design criteria to permit easy extension of steel structure in the future and same loading conditions shall be taken into account in accordance with the Specifications.

(6) Bolts and Nuts
All the members shall be connected by bolts and nuts. The diameter of the connection bolts and step bolts shall not be less than 16 mm.

9.3.4 DESIGN ITEMS

The Contractor shall submit to the Engineer for approval design sheets and drawings including calculation of Loads, selection of constitution and members, selection of connecting bolts and calculation of reaction load against base concrete.

9.3.5 ACCESSORIES

The following accessories shall be provided, but not be limited.

a. Anchor bolts and nuts : One (1) lot
b. Gauge plate for anchor bolt : For (4) of each kind
c. U-hook bolts and nuts : one (1) lot
d. Grounding terminals : one (1) lot
e. Step-bolts : one (1) lot
f. “Roval” paint for repair : Five (5) Kg
g. Phase identification plates : one (1) lot
h. Other necessary accessories, if any : one (1) lot
9.4 INSULATORS, BUSHINGS, BUSES AND HARDWARE

Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-60233. The support insulators shall be manufactured and tested as per IEC-60168, IEC-60273. The insulators shall also conform to IEC-60815 as applicable. All bushings shall be one piece only and no joints shall be accepted.

9.4.1 BUSHINGS AND SUPPORT INSULATORS

The parameters shall be determined by the Contractor, however the minimum performance parameters for the 230 kV insulator shall as mentioned below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>230 kV</td>
</tr>
<tr>
<td>Lightning impulse withstand positive and negative (kVp) (Dry and wet)</td>
<td>1425</td>
</tr>
<tr>
<td>Switching impulse withstand voltage (kVp)</td>
<td>1050</td>
</tr>
<tr>
<td>One min. power freq. withstand voltage (kVrms) (Wet and Dry)</td>
<td>520</td>
</tr>
<tr>
<td>Total creepage distance (mm) pedestal</td>
<td>10500</td>
</tr>
<tr>
<td>Total min. cantilever strength (kg)</td>
<td>800</td>
</tr>
<tr>
<td>Corona extinction voltage (kVrms)</td>
<td>320</td>
</tr>
<tr>
<td>Total min. height of insulator (mm)</td>
<td>3500</td>
</tr>
</tbody>
</table>

STRING INSULATORS & HARDWARE

The insulators for suspension and tension strings shall conform to relevant IEC/Standard. Insulator hardware shall conform to relevant IEC/Standard. The insulation levels shall be determined by the Contractor but the minimum performance characteristics shall be as specified below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>230kV</td>
</tr>
<tr>
<td>Type</td>
<td>Anti FOG</td>
</tr>
<tr>
<td>Size of insulators units (mm)</td>
<td>255 x 145</td>
</tr>
<tr>
<td>Creepage distance of individual insulator unit (Minimum or as required to obtain total creepage distance, mm)</td>
<td>430</td>
</tr>
<tr>
<td>Electromechanical strength (kN)</td>
<td>120</td>
</tr>
<tr>
<td>Power frequency withstand voltage of the complete string (kVrms)</td>
<td>520</td>
</tr>
<tr>
<td>Lightning impulse withstand voltage of the complete string with C.C. ring (Dry and wet, kVp)</td>
<td>1425</td>
</tr>
<tr>
<td>Switching surge withstand voltage of the complete string with C.C. rings (Dry &amp; wet, kVp)</td>
<td>1050</td>
</tr>
<tr>
<td>Power frequency puncture withstand voltage for a string insulator unit</td>
<td>1.3 times the actual wet flashover voltage of the unit.</td>
</tr>
<tr>
<td>Minimum corona extinction voltage level of the complete string with C.C. ring (Dry, kVrms)</td>
<td>320</td>
</tr>
<tr>
<td>R.I.V. Level of the complete string with C.C. ring (micro V)</td>
<td>1000</td>
</tr>
<tr>
<td>Total creepage distance of complete insulator string (mm)</td>
<td>10500</td>
</tr>
</tbody>
</table>
9.4.2 FITTING

The suspension and tension clamps for bus works and outgoing feeders, tension clamps for overhead grounding wires, U-bolts, ball eyes, anchor shackles, etc. for wiring of switchyard shall be furnished by the contractor. Unless otherwise specified, all hardware fittings shall be made by malleable iron or forged steel hot dip galvanised or aluminium alloy.

All metal shall be free from rust, burrs, sharp edges, lumps and dross and shall be smooth so that interconnecting parts will fit properly and the parts may be assembled and disassembled easily. Hardware shall have ultimate strengths exceeding three (3) times tension load of bus work and overhead ground wire.

The cramps shall not be occurred in excessive heating by magnetising or other causes.

9.4.3 BUSBARS, CONDUCTORS AND CONNECTIONS

Busbars and electrical connections in outdoor substations shall be in accordance with BS 215, 159 and 2898 and relevant IEC standards in respect of current rating and material analysis.

Overhead conductors carried by the switchyard structures shall be erected with such sags and tensions that when the conductors are subjected to the load combinations in Section 11, the factor of safety will not be less than 3.5. The switchyard structures shall be designed considering the sag limit at minimum ambient temperature (50°C) in still air not exceeding one (1) percent of the horizontal span length. Conductor sag chart and clearance data shall be subject to approval of Engineer.

Materials used for bus bars and connections shall be stressed to not more than two-fifths of their elastic limit. Provision shall be made for expansion and contraction with variation in conductor temperature and busbars shall be arranged so they may be readily extended in length with a minimum of disturbance to existing equipment. Tubular bus conductor shall be used for 230 kV busbar and supported by station post insulator.

TUBULAR BUS CONDUCTORS

Aluminum used shall be of grade 63401 WP conforming to relevant IEC/BS Standard.

Constructional Features
a) For outside diameter (OD) & thickness of the tube there shall be no minus tolerance. The other requirements shall be as per IEC 114.

b) Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be small drain hole at the end of each corona bell.

c) The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be furnished for approval of the Employer. Material for welding sleeve shall be same as the Aluminium tube.
Parameters
The size and other parameters of tubular bus conductors suitable for the busbar arrangement and Power plant capacity shall be determined by the Contractor.

9.4.4 MISCELLANEOUS MATERIALS

All miscellaneous materials such as phase mark plates, angle steel, C-shaped steels, conduit pipes, cable cleats, bolts, nuts, and other materials for completion of the switchyard shall be provided by the Contractor.
Section 10

6.6 KV Switchgear and Low Tension Switchgear
10. 6.6 kV SWITCHGEAR AND LOW VOLTAGE SWITCHGEAR

10.1 6.6 kV SWITCHGEAR

10.1.1 CONSTRUCTION

10.2 415 V SWITCHGEAR AND MOTOR CONTROL CENTRES

10.2.1 SWITCHGEAR (POWER CENTRE)

10.2.2 MOTOR CONTROL CENTER
10. **6.6 kV SWITCHGEAR AND LOW TENSION SWITCHGEAR**

The auxiliary Power system shall consist of the following equipment, but not be limited to:

- 6.6 kV Switchgear
- 415 V Switchgear and Motor Control Centres

In addition of the requirement, 02 nos. of spare 6.6 kV circuit breaker are to be installed for future use.

**System Voltage**

The system shall be as follows:
- Nominal system voltage : 6.6 kV
- Highest system voltage : 6.9 kV

**Note:** High speed Bus Transfer (HSBT) system to be incorporated with 6.6 kV bus incomer breakers. With the failure of 6.6 kV bus incomer breaker, bus interconnector is to be closed without making any disturbance to 6.6 kV loads.

10.1 **6.6 kV SWITCHGEAR**

10.1.1 **CONSTRUCTION**

(1) **Type and Rating**

- **Type**
  Indoor, steel sheet formed cubicle, single bus draw-out type
- **Rating**
  - Rated voltage : 6.6 kV
  - Rated insulation level
    - Lighting impulse withstand voltage : 60 KV
    - Power frequency withstand voltage : 22 KV (1 min)
  - Rated frequency : 50Hz
  - Rated normal current
    - Incoming and bus tie circuit : 600 A
    - Feeder circuit : 600 A
    - Rated short circuit current : 40 kA (rms.)
    - Rated short circuit making current : 100 kA (rms)
  - Number of circuit : Determined by the Contractor but two

(2) **Draw-out System**

Circuit breakers shall be floor mounted drawn out horizontally by hand, and primary and control circuits shall be disconnected from the buses
automatically.

(3) Compartment
Circuit breaker chamber and bus chamber shall be isolated by grounded steel plates, and bus conductors shall be installed.

(4) Front Door
Each compartment shall have hinged door mounted with instruments switches, indicating lamps and test terminals.

(5) Rear Panel
Each compartment shall have removable covers.

(6) Leading of Cable
Control cables shall be led from terminal blocks through front bottom of front bottom of cubicle.

(7) Bus bar
3-phase, 3-wire system. Copper bar, totally insulated. Buses shall be suitable for capacity continuous duty.

a. Main bus, more than 1000 A
b. Branch bus, more than 600 A

(8) Control Power Bus
2-wires DC 110 volt insulated wire.
Branched circuit shall consist of two circuits of closing and tripping for every circuit breaker.

(9) Neutral Grounding Resistor
Low tension winding of the station transformer shall be grounded through neutral grounding resistor which is accommodate in the compartment of 6.6 kV switchgear. The current rating shall be suitable for a single phase to earth fault on 6.6 kV circuit for 30 seconds and a maximum neutral current shall not be exceeded 10 A.

10.2 415 V SWITCHGEAR AND MOTOR CONTROL CENTRES

400 V switchgears and motor control centres shall be supplied to control all electric motor driven auxiliaries and supply power to the other electric load of the plant. If control centres or distribution panels not described in this Specification be needed, they shall be supplied with each facility. In addition of the requirement, 10 nos of spare 415V circuit breaker are to be installed for future use.

The switchgears and motor control centres are classified into the following:

- One Lot of 415 V common switchgear
- One lot of 415 V unit switchgears
One lot of 415 V motor control Centres

Note: High speed Bus Transfer (HSBT) system to be incorporated with 0.415 kV bus incomer breakers. With the failure of 0.4 kV bus incomer breaker, bus interconnector is to be closed without making any disturbance to 0.415 kV loads.

10.2.1 SWITCHGEAR (POWER CENTER)

a. Type and Rating

- Type
  Indoor, steel sheet formed cubicle, single bus draw-out type.

- Rating
  Rated voltage: 400 V
  Rated frequency: 50 Hz
  Rated normal current: 2,500 A or as per requirement
  Feeder circuit: 600 A
  Rated short circuit current: 50 kA (rms)

- Number of circuit: To be Determined by the Contractor but one (1) Spare feeders shall be included

(b) Kind of Unit

The switchgear shall be of 3 phase, 4 wire, neutral solidly grounded, 415V power center type with circuit breakers 50 kA interrupting capacity. The switchgear shall contain the following kind of circuits as general.

- Incoming and bus tie circuit
  2,500 A or as per requirement, 50 kA (rms) ACB

- Motor feeder circuit
  600 A, 50 kA (rms) ACB

- Feeder for motor control center
  600 A, 50 kA (rms) ACB

- Voltage transformer unit
  All circuit breaker shall be able to draw out horizontally.

C. Compartment

Grounded metal plate shall be provided to separate between the units and circuit breaker section and bus bar section. Conductor shall be insulated.

d. Bus-Bars
  Bus bars shall be copper bars with insulating cover.

e. Cable Connection
  Power cables and control cables will be led from the terminals through rear bottom of cubicle.

f. Control Power
  The switchgear
10.2.2 Motor Control Centre

a. Type and Rating

- Type
  Indoor, steel sheet formed, self-standing dual face type motor control centre.

- Rating
  
<table>
<thead>
<tr>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Rated normal current</td>
<td></td>
</tr>
<tr>
<td>Incoming</td>
<td>2,500 A or as per requirement</td>
</tr>
<tr>
<td>Feeder circuit</td>
<td>450,200 or 100 A</td>
</tr>
<tr>
<td>Rated short circuit current</td>
<td>50 KA(rms)</td>
</tr>
<tr>
<td>Number of circuit</td>
<td>as required</td>
</tr>
<tr>
<td></td>
<td>including three(3) spare feeders on each motor control centre.</td>
</tr>
</tbody>
</table>

b. Kind of Unit

The motor control centre shall be of 3 phase, 4 wire, neutral solidly grounded, 415 V motor control centre type and shall contain the following circuits as required.

- **Incoming**
  2,500 A or as per requirement, 50 kA (rms), moulded circuit breaker.

- **Motor feeder circuit**
  400, 200 or 100 A, 50 kA (rms) moulded circuit breaker, contactor, and reserve units if required.

- **Non-motor feeder circuit**
  400, 200 or 100 A, 50 kA (rms) moulded circuit breaker.

c. Compartment

Grounded metal plate shall be provided to separate between the unit and C B. section and bus bar section conductors shall be insulated.

d. Draw-out system

Control centre unit and incoming circuit breaker shall be drawn out horizontally by hand and main circuits shall be disconnected from bus bar.

e. Motor Feeder Unit

Each unit shall have hinged door on which circuit breaker operating handles, indicating lamps, operating push button and miscellaneous attachment shall be mounted.
f. **Non-motor Feeder Unit**  
Each unit shall have hinged door on which circuit breaker operating handles and miscellaneous attachment shall be mounted.

g. **Cable connection**  
Power cables and control cables will be led from the terminals through front bottom of cubicle.

h. **Busbars**  
Bus bars shall be copper bars with insulating cover.
Section 11

Control and Protection
11. Control and Protection Equipment

11.1 General requirements
11.1.1 Control Functions of Gas Turbine Generating Unit Local Control
11.2 Gas Turbine Generating Unit Protection
11.3 Gas Turbine Generating Remote Unit Control
11.4.1 Gas Turbine Generating Unit Remote Control Switch
11.4.2 Gas Turbine Generating Unit Remote Indication
11.4.3 Gas Turbine Generating Unit Remote Metering
11.5.1 Local Control and Instrument Panel for GT Generating Unit
11.6 230 kV Switchgear Control and Protection
11.6.1 230 kV switchgear, equipment panel
11.6.2 Step up Transformer Panel
11.6.3 Synchronising Panel
11.6.4 Modification of existing Protection Panels
11.7 Desk Board 21 kV or other voltage Switchgear
11.8 Desk Board for Auxiliary Power Supply
11.9 Instrumentation and Controls
11.9.1 Design Requirements
11.9.2 Control
11.9.3 Control Equipment
11.10 Panel Construction
11.11 DCS system
11.12 Standard Weather Station
11.13 Continuous Emission Monitor Module
11. Control and Protection Equipment

11.1 GENERAL REQUIREMENTS

The Contractor shall supply and install all control, protection and instrument panels with measuring instruments, relays, control switches, automatic controllers, annunciator, etc. necessary for proper operation and monitoring of the Gas/Steam Turbine generating units, switchyard equipment and their associated facilities. All Control & Protection System must be Micro-Processor based and Protective Relays shall be as follows:

a) Generator Unit Protection : ABB, Switzerland or Sweden/ Siemens, Germany/ GE, USA or EU/ Mitsubishi, Japan

b) Step-Up Transformer Protection : ABB, Switzerland or Sweden/ Siemens, Germany.

c) 230/15.75 or 21 (Generating Voltage)/ 6.6/0.415 KV AUX. transformer, 15.75 or 21 (Generating Voltage) & 6.6 KV Protection: Siemens, Germany/ Areva, UK or France/ABB, Finland/ ABB, Switzerland or Sweden.

11.2 Local Control

11.2.1 CONTROL FUNCTIONS OF GAS / STEAM TURBINE GENERATING UNIT [HMI, Computers]

The unit shall be furnished with a state of the art automatic control system suitable for unattended operation in base load or peak load operation. The automatic control system shall have a sequence the unit for normal start-up, emergency start-up, synchronisation, operation, spinning reserve, voltage control, load control, station performance monitoring, normal shutdown, emergency shutdown, and return to standby status.

Upon actuating the normal start command, the unit shall be started, come up to the rated speed, synchronised, closed the main circuit breaker and when parallel operation, picked up a pre-set base load which can be adjusted from approximately zero to the full capability of the unit. A" Base-Peak" selection shall be provided in the control system which shall permit the operator to select the loading of the unit at base or peak rating.

During either parallel or isolated operation, loading shall be manually controllable in addition to the automatic controls provided during either parallel or isolated operation; voltage shall be manually controlled in addition to the automatic controls provided.

Upon actuating the stop command the unit's load shall be reduced gradually by pre-set programming, the generator circuit breaker shall be opened, speed shall be reduced to turning gear rotational speed, the turning gear shall be engaged automatically and the unit shall be returned to standby status. An emergency stop control shall be provided.

The units shall be automatically prevented from starting, or if operating, shall be automatically shut down upon the occurrence of abnormal conditions or malfunctions, which would be injurious to the unit.

All auxiliary sequence, timing voltage, synchronising, load sensing and protective relays required for complete automatic control and protection of the unit shall be provided.
1.2.2 GAS TURBINE GENERATING UNIT LOCAL CONTROL [HMI, Computers]

The unit shall have its own local unit control room which is completely independent of the control room for the other unit.

Equipment, materials, accessories furnished, mounted, and connected on the local unit control panel shall include, but not limited to, the following functions.

- Normal start-stop
- Emergency stop switch
- Base- peak load selection
- Manual load control
- Manual voltage control
- Synchroscope switch
- Synchroscope, synchronising lights, and incoming and running voltmeters
- Status lights to indicate: Standby, starting, on-line, Emergency shutdown, etc.
- Speed indicators
- Frequency meters
- Fired time indicator in both base load operation and peak load operation
- Three start counters:
  - No. of start signals
  - No. of fired starts
  - No. of breaker closing
- Generator ammeter
- Generator voltmeter
- Bus voltmeter
- Generator watt meter
- Generator voltmeter
- Bus voltmeter
- Generator watt meter
- Generator var meter (zero centre)
- Generator watthour meter with indicating lamp for voltmeter
- Generator varhour meter
- Watt and Var
- Test switch
- Recording of following parameters:
  - Air temperature
  - Lube oil temperature
  - Bearing temperature
  - Critical Turbine gas temperatures
  - Bearing vibration
- Integrator for fuel gas flow
- Annunciator with test, acknowledge and reset push buttons and horns to indicate malfunction of the unit.
- Synchronising auto/ manual
- Automatic synchronising equipment for synchronising to energised or de-energised the system.
- Voltage regulator
- Vibration monitor
- Temperature meter (generator, etc.)
- Excitation voltmeter
- Excitation ammeter
- Field breaker control switch and lights
- Control switches and lights for generator breaker

The automatic synchronising equipment shall include, but not be limited to the following.

- Automatic synchroniser
- Speed matching
- Voltage matching
- Voltage acceptance
- Synchronising check or synchro-acceptor

The contractor shall furnish all control equipment, meters, relays or similar devices not specifically listed but those are required for the sound operation of the unit.

The above shall be realised and available in the screen of monitoring computers.

11.3 GAS/STEAM TURBINE GENERATING UNIT PROTECTION

Automatic protection devices complete with annunciation system shall be provided to protect the Gas Turbine generating unit at all items, regardless of weather locally or remotely controlled, against any malfunction of the unit or control system and shall, at least, include the following:

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Alarm &amp; Gen</th>
<th>Alarm &amp; GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB Trip</td>
<td>shutdown</td>
<td></td>
</tr>
</tbody>
</table>

a. Unit DC Supply under-voltage and ground fault x
b. Auxiliary motor overload x
c. Inlet air filter differential pressure high x
d. Cooling liquid level low x
e. Fuel oil inlet pressure low x
f. Fuel gas inlet pressure low x

g. Rotor vibration high:  
   1st stage x  
   2nd stage x x
h. Turbine over-speed x x
i. Generator under frequency x x x
j. Incomplete start sequence x

k. Bearing temperature high:  
   1st stage x  
   2nd stage x x
1. **Exhaust temperature high:**
   - 1st stage: x
   - 2nd stage: x

m. **Exhaust temperature unbalance:** x

n. **Generator stator temperature:**
   - 1st stage: x
   - 2nd stage: x

0. **Lube oil pressure low:**
   - 1st stage: x
   - 2nd stage: x

p. **Lube oil temperature high:**
   - 1st stage: x
   - 2nd stage: x

q. **Lube oil tank level abnormal:** x

r. **Generator differential:** x

S. **Generator over-current:** x

t. **Generator reverse power:** x

u. **Loss of excitation:** x

v. **Negative phase sequence current:**
   - 1st stage: x
   - 2nd stage: x

w. **Generator over voltage:** x

x. **Generator ground:**
   - 1st stage: x
   - 2nd stage: x

aa. **Generator field ground:** x

bb. **Generator breaker ground:** x

cc. **Field breaker trip:** x

dd. **Exciter trouble:** x

ee. **AVR failure:** x

ff. **Emergency Trip (Manual):** x

gg. **Fire:** x

The above alarms shall be indicated and available in the screen of monitoring computers.
11.4 GAS TURBINE/ HRSG/ STEAM TURBINE GENERATING REMOTE UNIT CONTROL [HMI, Computers]

State of the art Distributed Control System shall be provided so as to allow the following minimum features of remote operation, indications and alarms.

(1) Start the unit
The operation shall bring the unit automatically through all the stages of start up and synchronise the generator to the system, and taking the load.

(2) Stop the unit
The generator shall be automatically unloaded, tripped off the circuit breaker and the Turbine shutdown.

(3) Active load control
Active load raise or lower control shall be connected to the governor speed control circuit.

(4) Reactive load and voltage control
Reactive load and voltage raise or lower control shall be connected to the generator AVR system.

(5) Base load / peak load selection

(7) Emergency stop
The above shall be available in the screen of computers.

11.4.1 GAS TURBINE/ STEAM TURBINE GENERATING UNIT REMOTE CONTROL

Tile following control shall be provided, but not be limited to, on the remote unit control.

a. Unit start / stop
b. Active load raise / lower
c. Voltage raise / lower (Reactive load control)
d. Mode changeover base / peak
e. Synchroniser: manual / off / auto

The above shall be indicated and available in the screen of computers.

11.4.2 GAS TURBINE/HRSG/ STEAM TURBINE GENERATING UNIT REMOTE INDICATION

The following remote indications shall be provided, but not be limited to, on the remote unit control:

a. Ready to start
b. Auxiliaries running
c. Normal start sequence in progress

11.4.3 REMOTE METERING

The following parameters shall be provided, but not be limited to, on the remote unit control.

a. Generator active power output
b. Generator reactive power output (MVar)
c. Generator bus voltage
d. Speed indicator
e. Generator coolant and stator temperature (deg. C)
f. Generator frequency
g. Generator stator current
h. Filed current and voltage (A and V)
i. Average exhaust temperature (deg. C)

11.5 DELETED

11.6 230 KV SWITCHGEAR CONTROL AND PROTECTION

11.6.1 230 KV SWITCHGEAR EQUIPMENT PANEL

The DCS shall include 230 KV system switchgear equipment for controlling, indication and protection but not to be limited to, in the central control room.

11.6.2 STEP UP TRANSFORMER PANEL [for each GTG/STG]

(1) The DCS shall include the following but not be limited to:

One (1) 230 KV circuit breaker control faceplates.
One (1) 230 KV disconnecting switch control faceplates. (optional)
One (1) Ammeter 3 Nos.
One (1) Synchronising key switch, removal types.
One (1) Ammeter (230 KV side) (0-600 A), Voltmeter, pf meter, wattmeter
Two (2) uni-directional watt hour meter (230 KV side) with provision of reserve stop for export and import of energy and with indicating lamps for voltage failure.
One (1) Mimic bus
One (1) lot Annunciation system

(2) CONTROL PANEL

The control panel shall be equipped with the following items of protection, but not be limited to:
Three (3) Overall differential relay
Three (3) Step-up transformer primary over-current relay
One (1) Step-up transformer neutral over-current relay

One necessary auxiliary relays, test terminal blocks, lockout relays, etc. shall also be provided.

The quantities shown above are for reference only. Actual figures shall be based on the bidder's study and proposed CCPP configuration.

11.6.3 SYNCHRONIZING PANEL

Synchronising of the Generating units shall be performed within the DCS with following indication:

One (1) Synchroscope
Two (2) Voltmeter
Two (2) Frequency meter

11.7 21 KV or Generating Voltage COMMON SWITCHGEAR

The 21 KV instruments, and other necessary things:

One (1) Control switch for 21 KV or Generating Voltage circuit breaker
One (1) 21 KV or Generating Voltage voltmeter selector switch
One (1) 21 KV or Generating Voltage ammeter
One (1) 21 KV or Generating Voltage voltmeter (0-21 KV)
One (1) Mimic bus
One (1) lot Annunciation
One (1) lot Test terminal blocks
One (1) Spare breaker for watt meter
One (1) Spare breaker for Var meter
One (1) Spare breaker for watt-hour meter with indicating lamp for voltage failure

In the case of 6.6 KV starting motor(s) control switch for starting motor(s) and one (1) ammeter with selector switch for each motor shall also be provided on this panel.

The 21 KV or generating voltage, 6.6 KV, 0.4 KV systems shall be available & indicated in the DCS. The quantities shown above are for reference only. Actual figures shall be based on the bidder's study and proposed CCPP configuration.

11.8 DESK BOARD FOR AUXILIARY POWER SUPPLY

- Required no. of 6.6 KV and 415 V incoming circuit breaker control switch
- Required no. of 6.6 KV and 415 V bus tie circuit breaker control switch
- Required no. of 6.6 KV and 415V feeder circuit breaker control switch
- Required no. of 6.6 KV and 415 V voltmeter selector switch
- Required no. of 6.6 KV and 440 V incoming circuit ammeter selector switch
- Required no. of 6.6 KV and 415 V bus voltmeter
- Required no. of 6.6 KV and 415 V incoming circuit ammeter
- Required no. of 6.6 KV and 415 V incoming circuit watt-hour meter (for Auxiliary transformer and one common auxiliary transformer) with indicating lamps for voltage failure
- One (1) lot Annunciators
- One (1) Mimic bus
- One (1) Test terminal blocks

11.9 INSTRUMENTATION AND CONTROLS

11.9.1 DESIGN REQUIREMENTS

Control signals and instrumentation signals shall not be affected by stray AC voltage or other interface of any type normally found in a power station. The Contractor shall supply shielded cables and surge arresters where necessary.

Shock absorbing mountings shall be supplied for instrumentation equipment where required.

Each component shall be identified and tagged with a designation number. Instrument scale ranges shall be expressed in SI units metric units.

11.9.2 MEASUREMENTS

Measurements shall be taken for plant operation and control, and for heat balance and equipment's performance & efficiency calculations including supply of software on on-line plant monitoring and optimisation to interface with DCS system. Offered transmitter should be HART SMART type as minimum.

(1) Pressure Measurement

Pressure shall be measured near the pump discharges, pump suctions where NPSH availability is critical, at either side of equipment where pressure drop is significant, pressure regulated process, remote end of service lines, and near flow and level measurements affected by compressibility or density changes.

Normal operating point shall be approximately 60% of the range, over-range protection of at least 1.3 times the maximum scale reading shall be furnished on all pressure instruments. Accuracy shall be plus / minus 0.5% of calibrated span for bellows or bourdon tube transmitters at the minimum.
(2) Temperature Measurement

Temperature at appropriate locations at compressor discharge, Turbine wheel space, exhaust gas, rotor shaft bearings, stator windings, critical Turbine metal points, lube oil, radiators, etc. shall be measured.

In general, temperature element shall be thermocouples, resistance temperature detectors may be used as sensors for control loops. Thermocouples shall be cooper-constantin for temperatures upto 200°C iron constantin upto 750°C, and chromel alumel up to 950 °C. Cold junction compensation shall be achieved in the control room. All extension wires from thermocouples and resistance temperature detectors shall be shielded. Thermocouples shall be accurate to plus / minus 0.75 % maximum measured temperature.

Resistance temperature detectors shall have platinum resistance windings and shall be connected by the three-wire method. Resistance temperature detectors shall have an accuracy of plus / minus 2°C. Local temperature gauge shall be bimetal thermometers and shall have 80 mm round dial at minimum with black and white markings.

Welded wells for temperature element shall be the same material as the associated piping systems. All screwing wells shall be stainless steel.

(3) Level measurement

Level shall be measured in all tanks and vessels. Measurement of level in large or pressurised vessels shall be by differential pressure. Local level indication of small be by gauge glass for clear liquids, and by a top mounted float or bubbler for viscous liquids. Level controllers shall be of the differential pressure, or external cage displacement type.

(4) Flow measurement

Flowmeters shall, with the exception of the area meter, operate on the relationship which exists between differential pressure and fluid velocity. Flowmeters shall have liner outputs. Accuracy for fuel gas flow meter shall be within 2.0% at rate of flow higher than 80%.

Flow metering of gas shall be temperature and / or pressure compensated.

For flow metering of oil, positive displacement meters or area meters shall be used.

11.9.3 CONTROL EQUIPMENT

(1) Transmitters

Indicating transmitters shall be provided for control loops as required. Transmitters shall be substantially unaffected by changes in temperature and in process static pressure over a range from zero to twice the normal operating pressure. Transmitter shall feature accessible zero, and span adjustment. Offered transmitter should be HART SMART type as minimum.

(2) Final Control Elements

Control valves and damper actuators shall be pneumatic, where necessary, provided with electric- to-pneumatic converters. The response of final
control elements shall have minimum time lag.

a. Control Valves

Control valves rated at 2,00 kN/ sq.m (300 lbs ASA) and below shall be flanged and higher rating shall be welded. Valves shall withstand shock loads imposed by the processor. Control valve actuators shall be sized to overcome packing friction and dynamic stem forces. Unbalanced force shall be kept to a minimum level consistent with efficient operation in service.

b. Damper Actuators

Damper actuators shall be fully enclosed and supplied with all accessories including special mounting brackets as required. A solenoid operated, four way pneumatic valve plus open and close limit switches shall be included.

(3) Positioners and E/P Converters

Positioners shall be furnished with final control elements where:

- small change in pneumatic signal are to be amplified
- Split range control is required
- valve pressure drop is greater than 280 kN/sq.m

Positioners shall have a feedback cam to characterise relationship between input signal and final element position.

E / P converters shall be provided to convert electronic control signals to pneumatic output signals. Converter accuracy shall be plus / minus 0.5% of output span.

(4) Solenoid Valves

All solenoids shall have class F insulation or higher class and solenoid enclosure shall be of weatherproof construction.

Solenoid for operation on AC shall give satisfactory operation over the range of 75 % to 105% AC supply voltage.

Solenoid for operation on DC shall give satisfactory operation over the range of 85 % to 115 % DC supply voltage.

11.11 DELETED.

11.12 Distributed Control System (DCS)

11.11.1 General

A fully integrated unitary DCS has to be supplied for monitoring, control, display, alarm and recording of selected physical and electrical parameters associated with all relevant plant areas. All monitoring and control interactions shall be done via VDU, keyboard and Mouse/Track ball. No conventional control desk equipment shall be required in the central control room (CCR).
One (1) latest version DCS system as per requirement of the offered Plant from ABB, Germany, USA or Singapore/ Foxboro or Schneider, USA or Singapore/ Siemens, Germany/ Alstom, France/ GE, USA or EU/ Mitsubishi, Japan. All the Hardware & software i.e. Controller Processors, I/O Module, terminal assembles, work stations, Cabinets, terminal box, Cables etc. shall be supplied from the mentioned countries.

The structure of the DCS shall be clearly separated in sequence (binary) control (unit control, function group control, drive control and analog control, master controllers, analog drive controllers) . The control system shall be also structured hierarchically, according to process areas, into clearly defined groups. The controls must be completely shared in Hardware and Software. Interconnections between the controllers shall be done via a redundant data bus. All signals shall be available on redundant data bus.

The DCS must be reliable and unique, covering all automation functions of the power plant, which are:

- HRSG control and protection
- Turbine control and protection including Turbine supervisory instruments
- Hydraulic operated Diverter Damper control (GT Exhaust System)
- Generator protection, excitation, voltage regulation and synchronisation systems
- Auxiliary system control
- Balance of plant control

In co-ordinating the design of the control systems for this contract, the contractor shall account for the following requirement. The operational functions of control, and supervision of the combined cycle power plant, its auxiliaries, the 230 KV substation, 21 KV or Generating Voltage, 6.6 KV and 415 V station and unit switchboards, and diesel generator shall be carried out remotely from the Central Control Room (CCR).

The scope shall include provision of control and supervisory facilities for the systems; 230 KV substation, 21 KV or Generating Voltage, 6.6 KV and 415 V station and unit switchboards, and Emergency Diesel Generator.

The co-ordination necessary to achieve this objective shall be achieved by the provision of a single integrated control system, encompassing the entire contract scope. It shall be microprocessor based and use state of the art Distributed Control System (DCS) technology.

The Contractor shall perform all the engineering necessary to provide the operators in the CCR with a consistent standardised man-machine interface solely by means of the single approved DCS for all the plant in this contract.

In certain cases the Contractor may propose that a plant supplier is also the provider of its associated control system because it forms an integral part of the proprietary package. Where this approach is approved, it is referred to as a Proprietary Package Control System (PPCS). The Contractor shall provide the necessary means of communication/interfacing between the PPCS and the DCS to facilitate the proper and efficient control of the whole Combined Cycle Power Plant.
It is to be noted that, heterogeneous solution for the proposed control system of the Steam Turbine and HRSG shall not be accepted.

The PPCS and the choice of DCS shall be subject to the approval of the Employer.

The following criteria shall be met in the proposed control system:

- Operational availability
- Configuration flexibility
- Ease of maintenance
- System design shall be adapted to the power generation application
- Vendor support for the projected plant lifetime

The specifications shall apply to all systems and components for protection, safety, permissive, interlocks, auto-sequencing, regulating control, supervisory control, data acquisition, maintenance, configuration, and interfacing to others.

11.11.2 System Description

General

One unified Distributed Control System (DCS) based on free configurable microprocessor and of approved design for power plant application shall be used. The protection system of HRSG and Steam Turbine must be an integral part of the plant control. Human interfacing with process shall be done via Process Operation Station (POS). The boiler protection system must be type tested and approved by the respective authorities. It is the contractor's responsibility to provide a control system, which fulfils all requirements of power plant operation and maintenance having at least the following features:

- Function groups, analogue control loops, drives control loops shall be controlled by fully redundant POS from the main control desk.
- No electronic module shall be installed locally. All analogue and binary signals shall be cabled to the electronic rooms. Where the conversion into BUS signals takes place.
- The design of the control system shall be distributed and decentralised such avoiding that one failure leads to a tripping of more than the directly related apparatus.
- The transmission capacity of the BUS system must permit to handle the maximum amount of data arising during major process disturbances. Data buffers between the control stations and the BUS transmission system are not allowed.
- Any failure within the electronic digital control system shall not affect the operation of the plant or any major part of it.
- Redundancies in the process (e.g. feed water pumps, condensate pumps, etc) shall be followed in the design of the controls. That means, that the processing has to be realised in separate modules.
- The documentation shall be based on function descriptions (control logic, interlocking diagrams) principle DIN-or equivalent symbols and shall be revised after commissioning. Paperless documentation shall be provided.
- The electronic control system shall be resistant to radio frequency interference and shall be protected against external and internal over voltage according to IEC 801.
Adequate measures shall be taken to ensure a high security in data transmission of the BUS system. The minimum hamming distance on actual transmission shall be not less than 5.

Interfaces to other control systems (e.g. aux. Plants) shall be made in RS232C and MODBUS-Protocols.

The system shall include all test and programming devices necessary for maintenance, trouble shooting and programming.

The scanning rate acquisition and transmission shall allow a resolution of ms for all digital and analogue signals. An accumulation of alarms, e.g. 400 alarms in one second, must not cause any loss of alarms.

Design and method of grounding and the treatment of the common reference and the cable screens shall be unified for all control systems and DC supply systems throughout the plant.

The heat dissipation of the control cubicles (fully equipped but with 10% spare space) shall be given in the offer.

Availability of the power plant requires the installation of redundant sensors/transmitter for important values, mainly for protection purposes. The sensors shall be in double with mean value information and supervision, or in triple with 2 out of 3 selection. These input signals shall be processed on different modules. Each module has to be provided with separate power supplies. Special measures shall be taken to avoid damages, power drops or loss of power in case of a failure of one measurement.

11.11.3 Acceptability of Control Systems

It is a requirement that the DCS proposed for this project meet the following requirements.

(a) The manufacturer shall be of international repute.
(b) The control system shall have been developed for power generation plant control, incorporating proven hardware and firmware for such applications.
(c) The control system shall have a demonstrable development history.
(d) The manufacturer shall operate a design policy incorporating compatibility between versions/generations of equipment.
(e) The version of system proposed shall be the manufacturer’s latest current design (State of the art) and shall be identified.
(f) Engineering support facilities for Bangladesh are in place.
(g) The control system must have a satisfactory reference list illustrating power generation applications.
(h) The manufacturer is required to give his undertaking to provide support, in terms of spares provision / compatible solution, maintenance and engineering for a period of 15 years from the taking over date for the station. The manufacturer shall explain the history of his customer support policy by outlining the duration of support provided for previous generations of control system.

The Tenderer shall submit sufficient information in response to each of the above items to enable the Engineer to complete his assessment.

If the Tenderer proposes a choice of control system that fails to meet the stipulated requirements, then the Tender may be rejected unless the proposal is amended to the Engineer’s approval.
11.11.4 Acceptability of the Control System Design Group

The timely completion of the Contract and the satisfactory operation of the plant will depend upon the successful engineering and implementation of the integrated control system whose duty is to co-ordinate all the normal plant operations.

The Contractor shall therefore meet the following requirements.

(a) The engineering of the DCS shall be the responsibility of a single management unit. It is recognised that the identity of this unit will be dependent upon the composition of the consortium undertaking this project. It is accepted that this management unit may be, for example, in the DCS Vendor's company, or in the turnkey managing company.

(b) The DCS design unit must have demonstrable know-how and experience in the particular field of power generation project engineering.

The Tenderer shall submit sufficient information in response to each of the above items to enable the Client to complete his assessment. The proposed "DCS design management unit " shall be clearly identified in the Tender.

If the Tenderer proposes a choice of design entity which fails to meet the stipulated requirements then the Tender may be rejected unless the proposal is amended to the Engineer's approval.

11.11.5 Contractor's Control Room Design Review

The Contractor shall prepare, for drawing approval, a document entitled "Control & Operation Review of Proposed CCR Facilities". This report shall be accompanied by the first issue of CCR general arrangement drawings.

The above review shall cover the following aspects and their impact on control room facilities design.

(a) Layout of proposed DCS equipment and peripherals

(b) Work flow and movement of personnel

(c) Degree of automation

(d) Lighting, ventilation, noise levels

(e) Application of Ergonomic principles throughout system design.

The CCR facilities shall incorporate a consistent design throughout for VDU and keyboard/ Mouse positioning, Monitors, Mimic copiers / Colour Printers.

The human-machine interface (HMI) in the CCR shall be based mainly upon operator workstations each comprising a VDU, functional keyboard and mouse. These shall all be sourced from the same vendor and operate by means of a common firmware system (namely that, of the approved DCS) yielding a common format for display, graphics and operator interaction. Furthermore the application software shall be developed to yield commonality in the appearance and operation of the MMI plant wide. CCR shall have Large Video Screens for appearance and operation of the plant.
An operator’s station shall comprise an ergonomically profiled desk on which are mounted several VDUs and keyboards / Mouse grouped together in a manner which accounts for the above-mentioned requirements. The design shall take note of the fact that, although a high degree of automation is to be achieved, operators in the CCR will on a periodic basis be instructed to perform plant start up and shut down procedures without the assistance of auto-sequence control. Hence the presence of additional operator(s) at the station is to be allowed for.

The Contractor shall explain the impact of VDU failure upon the control and supervisory facilities provided by each console.

In order to demonstrate avoidance of high luminance images in VDU screens, the Contractor shall submit for approval his design proposals (and calculations). These shall show how the design of the luminaries (luminance limit angle), tilt angle of screen, screen height, radius of curvature of screen and other factors are integrated to prevent the appearance of reflections of luminaries in the screens.

The Computers, Monitors and other facilities in the CCR and adjacent areas shall be laid out to meet the needs of shift management, control room operators and maintenance staff. The requirement for storage of documentation shall be accounted including O&M manuals, printouts, reports and magnetic media.

The Contractor shall develop his proposal, tailored for the requirements of this project and for the design characteristics of his equipment. The Contractor shall be required to justify his control room layout, which shall be subject to approval.

11.11.6 Central Control Room Operator Interlace

11.11.6.1 Operational Management

All normal operations, relating to the combined cycle power plant shall be carried out remotely by staff situated in the CCR. This room will be continuously manned.

In designing the CCR and its operational facilities, the Contractor shall take into account of the following points.

(a) The CCR shall be the communications focal point enabling all operations to be supervised from here, including normal operations, abnormal operations, emergency operations and also electrical controls.

(b) It is a requirement that all normal plant operations, including shutdown and any start up not preceded by maintenance outage, are achieved remotely and solely by operators in the CCR. During such operations there shall be no need for plant attendants to intervene locally at the plant itself.

(c) Ease of communication between the CCR engineers and the unit operators is a requirement.

(d) By means of DCS visual display unit (VDU) facilities, the engineer (supervisor) and manager shall be able to monitor the status of the plant and be able to exercise historical data retrieval, analysis, review and report production.

11.11.6.2 Equipment and Facilities Associated with the Central Control Room

The CCR shall be equipped with the following:
(g) Combined cycle power plant control

(h) Supervisor's control

(i) Four printers

(j) Document storage system in a room besides the control room.

Associated with the above, situated in the Control Building, or as appropriate shall be provided:

(a) Printers (3)

(b) Engineer's control

(c) Manager's control

(d) Employer's commissioning control

11.11.6.3 Combined cycle power plant control

**This is to be referred to as the Unit Control.** The scope of supervision, control and operation performed from the Unit Control shall include the Gas Turbines, the HRSG, the Steam Turbines, Generators, and all associated auxiliaries.

The control shall comprise:

(a) Suitably profiled curved or segmented desk unit.

(b) Operators' chairs (5)

(c) Operators' workstation (5) each including high resolution colour VDUs (2)
  - Associated functional keyboard and Mouse
  - Workstation computer

(d) Sub-panels integrated into the control on which are mounted (hardwired)
  - Emergency trip push buttons (key re-settable)
  - Indicators and controls for manual synchronisation of Generators as back-up.
  - Alarm annunciation system

(e) Drum level indicators (Hydra step)

(f) Working space with telephones

The following functions must be realised within the DCS:

- Plant isolations and supervision of permits-to-test and permits-to-work
- Responding to alarms and incidents and taking the appropriate corrective actions
- Station load control and responding to load dispatch requests
- Voltage control and management of reactive power
- GT start up, synchronisation, loading, and shutdown
- Exhaust gas diverter damper control
- HRSG start up
- Pipeline drains and warming
- Steam bypass operation
- Steam Turbine auto-run up, auto-synchronisation
- Steam Turbine loading ramp
- Emergency stop/ shutdown of the GT and its auxiliaries

11.11.7.1 Permissive Interlocks

Permissive interlocks shall be provided to ensure that plant cannot be endangered by incorrect operation of inter-related items such as pumps and valves; this shall apply whether the command was initiated by the CCR operator or by the auto-sequence system.

11.11.7.2

(a) Emergency trip push buttons (fitted with lift up cover flap to prevent inadvertent operation) for Gas Turbine trip, HRSG trip, steam Turbine trip, and generator trip.

(b) Emergency stop pushbuttons (key lock re-settable) shall be provided locally for each major plant drive (uni-directional).

11.11.7.3 Regimes of Automation to be implemented

It is a requirement that the plant can be operated, at the manager's discretion, under the various regimes of automation set out below. The necessary controls, instrumentation and sensors must be provided to achieve all the regimes described, i.e., automation levels. **This automation shall be co-ordinated and implemented by the DCS**, utilising where appropriate subsidiary automation (to the same standard) of Proprietary Package Control Systems.

Automation Level I

The auto sequencing of the drive level items associated with a subgroup applies at this level of automation. Also activated is the auto sequencing together of all the subgroups forming a group. Under this level of automation, the necessary interactive operator guidance shall be provided by the DCS. This is to include displays of actual progress through a group sequence, criteria not satisfied (and 2 advice on action to obviate the resultant hold), and advice on any operator action needed to sustain progress. When the group sequence is completed, operator guidance shall be displayed regarding the next group to be started (or stopped).
Automation Level 2

This is the highest level of automation, and in terms of plant start up and shutdown, it corresponds to "Block co-ordination" control/Unit control described later.

Accordingly families of group controls, which have a functional relationship between them, shall have their operations co-ordinated by additional auto-sequencing logic. This shall incorporate operator guidance interactive displays, including advice on the next step the operator should take when each "Level 2 sequence" has been successfully completed.

The operational objectives that shall be met by the implementation of level 2 Automation are as follows:

(a) To ensure that the Block start-up and shut-down manoeuvres are of predictable duration to facilitate load dispatching and grid system operations;

(b) To achieve minimum run-up and loading times for the Units and Block, compatible with the plant constraints;

(c) To maximise the life span of the plant;

(d) To reduce the number of decisions that need to be taken routinely by unit operators.

The following sections include a description of the controls, which comprise the various automation levels:

11.11.7.4 Drive Controls

All drives which need to be put into operation in order to proceed through a unit cold or warm, hot start-up shall be remotely controllable by the unit operator in the Central Control Room, i.e. stop/start of motors (pumps, fans), open/shut/inching of isolating valves, dampers and open/shut of solenoid valves. It is not acceptable to resort to intervention by roving attendants local to plant items and local to motor control centres as a means of achieving start-up. Plant items trips, start permissive and run permissive, shall also be implemented for drive level controls.

11.11.7.5 Sub-Group Controls

This includes the auto-sequencing of, for example, valves or dampers associated with the discharge or suction of each individual pump or fan. Also in this category are auto-start of standby or make-up drives, and closed loop modulating control functions. Such sub-group controls shall be implemented for every plant system whose operational status needs to be changed during unit start-up or shutdown.

11.11.7.5 Group Controls

The auto-sequencing of start and stop initiation of all sub-groups shall be implemented. This is represented, for example, by the boiler feed group, covering the co-ordination of three boiler feed-pumps, main and start-up feed regulation valves, the suction valves and discharge valves.
11.11.7.4 Block Co-ordination of Start-up and Shutdown

This is defined as the on-line co-ordination of all the plant groups associated with the start-up and shut-down of each of the Gas Turbine, HRSG units in conjunction with the Steam Turbine Generator. In establishing the design requirements, it shall be noted that the following manoeuvres have to be achieved by the block co-ordination scheme:

(a) Block start-up cold but not preceded by maintenance;
(b) Block start-up following various duration of shut-down; this shall take into account of the initial conditions of the Gas Turbines, HRSG's, and Steam Turbine
(c) Re-start of block, Gas Turbine, HRSG, or Steam Turbine following a trip;
(d) Block normal shutdown (heat retention to facilitate subsequent warm start)
(e) Block shutdown (to facilitate earliest possible maintenance access to either boiler or Turbine).
(f) Block emergency shutdown.

The extent of automation required for block co-ordination of auto-start is as follows:

(a) Preparation of all drive, auxiliaries, motor operated valves, control settings and auto-control status's required to satisfy the Gas Turbine "ready list"
(b) Start up of the Gas Turbines in the pre-selected order
(c) Auto synchronisation of each Gas Turbine generator and load ramp to pre-set load
(d) Preparation of all drives, auxiliaries, motor operated valves, Hydraulic operated diverter dampers, drain valves, control settings and auto-control status's required to satisfy the HRSG "ready list"
(e) Start up of the HRSG in the pre-selected order
(f) Preparation of all drives, auxiliaries, motor operated valves, drain valves, control settings and auto-control status's required to satisfy the Steam Turbine "ready list"
(g) Start of steam Turbine run up
(h) Auto synchronisation of Steam Turbine generator and load ramp to pre-set load

(1) Block load automatic control.

j) Initiation of any other auto-sequences required, in accordance with plant design, to complete the start up procedure to full load generation;

k) Dedicated indication of failures during Start-up, Operation & Shut-down must be indicated in details to the operator in the POS.

The ready list, in each case, comprises the particular set of permissive criteria that must be satisfied prior to start initiation of the plant concerned.
The Contractor's design shall take away from the operator much of the routine work-load but require his attention and decision-making at the key stages of start-up. Extensive operator guidance shall be included. Each of the above automatic sequences shall incorporate displays to show the operator the succession of the steps and the criteria to be met for each step. This shall be a dynamically updated display indicating actual progress, the meeting of criteria and achievement of steps within the sequence. In the event that a criterion is not met, this shall be indicated and guidance on obviating the problem shall be displayed.

It is a requirement of the design that the Power Station's Operational Management is able to take the decision to enforce the limitation of automation to, say, Level Zero. This is to ensure that all operators benefit from continued experience of the details of plant supervision and control and do not become unfamiliar with the requirements.

The system shall be designed such that, whether automation is being utilised or whether the operator is making his own decisions at drive level or sub-group level, the plant is always secured against mal-operation by means of the permissive protection (interlock) system.

- HRSG LP/HP drum level control
- HRSG HP steam temperature control
- HRSG LP steam temperature control
- Turbine HP steam pressure control
- Turbine LP steam pressure control
- HP steam bypass pressure control & LP steam bypass pressure control
- HP steam bypass temperature control
- LP steam bypass temperature control
- Feed-water temperature control
- De-aerator pressure control
- De-aerator level control
- Feed-water tank level control
- Condenser level control
- Auxiliary steam pressure control
- Auxiliary steam temperature control

Other controls as deemed necessary by the contractor to produce a complete working system

The HP and LP steam pressure controls shall be designed to achieve the necessary transition between bypass controls and steam Turbine admission controls, from starting to full load operation.

The Steam Turbine governor valves and bypass steam valves will follow the sequence of operation depending on the command initiated by the operator. The DCS in conjunction
with Electro-hydraulic Converter (EHC) controls steam valves admitting steam into Steam Turbine.

When the governor valves are fully open they no longer act as pressure regulators; when this has occurred, the steam pressure is solely the result of the steam generation rate of the HRSG's in operation.

The steam Turbine's stress controller is to intervene and initiate governor valve action in the event that an operational gradient limit is exceeded.

The steam Turbine operates with the governor control valves in the fully open positions for the upper 50% of the load range.

When pressure control is not performed by the bypass valves, the bypass system tracks the actual pressure with an offset to inhibit bypass opening for small pressure fluctuations.

11.11.7.5 Co-ordination of Block Power Generation

A block load control (BLC)/ Unit control system shall be provided for the control and supervision of MW generation. This shall incorporate a target load set point that can be accessed by the CCR operator.

The following modes of control shall be included, as a minimum.

(i) Block combined cycle: full block load control

Operating Gas Turbine is in combined cycle and included in BLC.

(ii) Gas Turbines in open cycle: full block load control

All operating Gas Turbines are included in the BLC. The required block load is shared equally, which make use of normal plant measurements to compute data, enabling trends in performance to be assessed. This is not intended to provide absolute efficiency figures; the objective shall be to provide information to the operations staff to allow deterioration of plant to be identified. Separate performance assessments shall be provided online for the following but not be limited to:

- Gas Turbine generator
- HRSG
- Steam Turbine
- Condensers

These assessment figures shall be normalised as necessary before presentation to the operator to permit easy comparison of data derived under varying ambient conditions.

Plant Life Monitoring

Algorithms shall be included in the DCS which make use of normal plant measurements to enable the cumulative effects of operation upon remaining plant life to be determined, as an online function.

This facility shall be provided for:

- all high temperature components subject to creep or fatigue
• all major uni-directional drives

11.11.7.6 Modulating Controls

In order to meet the needs of automation, the modulating controls shall incorporate extensive logic control functions including the automatic initiation of:

• switching between selected set-points
• switching between ramp rates
• switching between auto and manual
• freezing of set-points
• ramping of set-points

Also the following techniques shall be implemented where appropriate;

• algorithms for the computation of set-points
• self-optimisation routines utilising weighted variables
• load dependent adjustment of control parameters
• application of feed forward techniques
• application of multi-variable control techniques
• application of fuzzy logic control techniques
• application of predictive control techniques
• application of artificial intelligence techniques.

The modulating controls fall into two categories and shall be itemised in the Tender; these are:

(a) those whose set-points follow the power generation required from the block.

(b) those which have a constant set-point and whose duty is to maintain this value in the face of disturbances arising in normal operations (for example steam temperature control).

11.11.7.7 Operator Command and Supervisory Functions

(i) Description

The operator shall gain access to the command and supervisory facilities by means of the VDUs and keyboards, Mouse forming part of the DCS, and which provide the interface to all plant systems. The CCR shall include in its design the facilities needed to enable the operators and supervisors to carry out their duties under the various operational regimes described in the earlier sections of this specification.
The DCS shall include the following supervisory functions:

- Process status and analogue value reporting
- Active mimic displays
- Alarm annunciation and reporting
- Sequential event reporting and post incident recording
- Data logging (periodic and on demand)
- Performance calculations
- Totalisation of plant running times
- Trend displays and reporting
- Information dump and screen copying.

The DCS and its incorporated VDUs shall provide the sole means by which the CCR operator commands and supervises power station and switchyard plant.

The displays shall be selected by use of the functional keyboard and cursor or else by track-ball or mouse. Additionally the operator must be able to quickly step from one display to another related display by means of soft-keys or equivalent facility depending upon the proprietary range of equipment.

When the operator needs to carry out a command operation, the procedure shall typically be as follows. By use of the keyboard/ Mouse he is to call up a mimic graphical display. He shall then identify the particular valve and call up a display showing its "auto-manual fascia"; this is to correspond to an actual array of auto/manual, raise/lower keys on the keyboard by which the operator commands a change in the valve’s status. These shall preferably be performed by Faceplates.

A similar procedure shall apply for the commanding of motor stop/start, switchgear open/close and auto-sequence start/stop.

For the proposed DCS, the Tenderer shall provide a description of the particular operator actions necessary for the above commands.

(ii) Scope

The Tender shall include for the configuration of sufficient numbers of displays to meet the requirements of the Contract. This shall include at least the following designated numbers of active mimic displays.

(iii) Block: mechanical plant and electrical systems:

The Tender shall state the numbers of other displays proposed to be configured, identifying them and subdividing them into categories of displays (trends, alarms, reports etc.)
11.11.7.8 Signalling to Load Dispatch Centres

Interface equipment shall be provided to facilitate communications with the Load Dispatch Centre (LDC).

Interface equipment shall be provided to facilitate communications with the Load Dispatch Centre (LDC). Communication Facility at Power Plant for telephone communication with NLDC through existing PGCB Grid substation telecommunication system (OPGW) must be provided.

The station's block operator shall, by use of the BCC, have means of authorising the remote control centre to raise/lower the demanded or target power generation on selected operating units or blocks. The limitations to power generation and rates of change (pre-set by the unit operator) shall apply, and this data shall be transmitted to the remote control centre. In turn the remote centre's load dispatcher shall be equipped to transmit the unit or block power generation target for the completion of the next time interval to the UCC, enabling the station's electrical control supervisors and unit operators to make the appropriate preparations.

In a similar manner, the remote grid control centre shall have access to the control of unit voltage and power factor.

11.11.7.9 Local Operation and Testing

Means shall be provided for the local operation of modulating control valves, motorised isolation valves and for the testing of motor drive switchgear from their respective motor control centres. It is not the intention to facilitate the local control of plant as a "normal operation" basis. The arrangement described is intended to allow testing only, because the action of selecting "local" status on the contractor panel (or breaker panel or control valve or motorised valve) will bypass incoming control signals including permissive interlocks.

The Contractor shall provide in his Operation and Maintenance Instructions clear reference to the need for management safeguards (in the case of local operations) requiring a permit-to-test procedure.

The local/remote status of each plant item, for example motorised isolation valve, shall be transmitted to the BCC, thus advising the unit operator of the condition (availability) of the plant item concerned.

11.11.8 Control System Technology and Design

11.11.8.1 Principle of Integrated Controls

It is an essential requirement of this Contract that the design and engineering responsibility for all the plant control systems be vested by the Contractor with a single entity (i.e. management group). The Contractor shall demonstrate his recognition of the fundamental role that is to be played by this particular entity in co-ordinating the control and operational design of the entire plant.

The Tenderer shall demonstrate in his proposal how he will meet this requirement. In the design of the DCS, the following needs shall be met:

(a) Commonality of equipment, facilitating spares management, documentation and training.
- (b) Standardisation in the design of interfaces between the DCS and every category of plant item. This shall lead to:

• Standard interface schematic diagrams
• Standard interface macros
• Standard operator's display macros
• Standard documentation for test and maintenance purposes.

(c) Standardisation in the design of interfaces to foreign bus serial highway links. This shall lead to a subset of design standards corresponding to (b1) to (b4) above.

(d) Adoption of a single standard for both the appearance and the functioning of all the operators' interfaces in the Central Control Room. This principle shall apply to the management of operations and the management of information.

(e) Control systems shall be engineered to avoid the use of obsolete or obsolescent equipment. The Contractor shall undertake to make the Engineer aware without delay of any pertinent information from original equipment manufacturers regarding design changes (or prospective design changes) in equipment, or changes in its availability.

(f) Spare input measurement capacity of 10% shall be provided.

11.11.8.2 Distributed Control System Technology

The control system proposed as the means of achieving total integration of the control functions, shall be a state of the art micro-processor based Distributed Control System (DCS). The DCS vendor shall be selected and the system shall be supplied and configured to comply with the following requirements.

(a) All the functions of - operational control, plant supervision, data acquisition, sequence of event recording, accumulation of historical data and archiving, presentation of processed and formatted information to the operator, and supervision of the DCS itself - shall be implemented by one system.

(b) The above functions shall be implemented by means of solely one DCS system which shall encompass these plant areas; combined cycle power plant and auxiliaries, station common services plant and auxiliaries,

(c) Open system architecture shall be employed. The Contractor shall identify the extent to which his proposed DCS achieves multi-vendor inter-operability. The Contractor shall list which internationally recognised standards the proposed system complies with, under the categories of; communications, software, displays. The system shall incorporate Windows System (latest version). Compliance with industrial certification standards shall be identified.

(d) The proposed DCS shall inter-operate with industrial standard software packages including report-making, database, spreadsheet, statistical analysis and graphical functions.

(e) The DCS system's design basis shall incorporate a stated migration policy, by which newer technologies can be inter-operated transparently with existing technologies.
(f) The DCS shall be self-documenting. This includes the requirement that, subsequent to any design changes, the revised configuration is readily available on-screen and in the form of documentation suitable for retaining for "as-built" records in hard copy form, incorporating diagrammatic information supported by text annotation.

(g) The data management shall be object based and relational. Any data to be put into the system shall only need to be entered once. Any user of the system, subject to authorisation, must have access to all current data wherever it resides in the system.

(h) Tools and facilities shall be supplied as part of the Contract to enable design and configuration work to be carried out on the contract system by the use of a Personal Computer. The scope shall include the provision to the Engineer of such a facility early in the Contract to enable the Engineer to review the design submissions as they are submitted.

(i) An engineering workstation shall be provided for the use of the Engineer during construction and commissioning. This facility shall, via the DCS communications link, enable the Engineer to monitor progress with construction and commissioning of the control systems. This facility shall be limited to monitoring only.

(j) The proposed DCS shall in all respects exhibit well developed characteristics of being user-friendly, easy to maintain and readily re-configurable.

11.11.8.3 System Design: Redundancy of Control Equipment

Operational availability of the entire control system is of prime importance. Each of the various links and modules of which the system is comprised especially Safety related equipment, Boiler protections, Turbine protections, Feed pump protections shall be engineered in Triple redundant forms. The Contractor shall issue for approval a formal document entitled "System Reliability and Availability Report", in which

(a) The system design philosophy is explained and

(b) The impact of failure of each link or module of the system is tabulated.

This report shall systematically embrace all controls; it is not merely to be limited to the DCS. It shall therefore take into account the PPCSs and the arrangement of Communications between them and the DCS.

Recording & Reporting

Trend display and analog value history

Analog value storage of the Process operator station for process control shall be extendable to an 8 day history preferably. Both associated cyclic buffers shall operate with the following time references and storage times

- 24 h for values with storage cycle time 1s
- 8 days for values with storage cycle time 16s

The values shall be condensed as average/min/max. values
Access to the two buffers shall automatically depend on the selected representation/times.

- The fixed (pre-configured) trend displays and trend displays shall be freely defined by the operator (as part of the existing values of the fixed set of curves).

**Bar Charts (Profile display)**

The bar charts (profile displays) shall display a group of process values with the same scale and engineering units. The display shall be used for stress monitoring of the boiler or turbine.

**Alarm Display**

Both the standard and the user configurable displays (e.g. mimic displays), plus all process, control system and machine disturbances, shall be signalled to the operating staff on the process operator station. For the standard display, an alarm hierarchy shall be built up becoming progressively finer when proceeding from signalling in the plant overview down to the group display. The loop display should provide a further degree of detail for disturbances in the control system. The plant overview shall provide the operating staff with generalised knowledge for each area and for different alarm priorities as:

- Priority 1 (alarm)
- Priority 2 (warnings)
- Priority S (control system faults).

An extensive range of standard tools shall be provided for alarm function in the user-configurable displays:

- Status dependent text change
- Colour change in the colour code for message priority
- Flashing light
- New valve/old value message
- Comes/goes message for alarm
- Sequence of Events

**Sequence of Events**

A characteristic feature of this display shall be the indication of alarm and other messages for total or partial sequence of event messages in correct chronological order. It shall be a partial function of the Sequence of event function complex, as described here (over and above the actual display) in a summarized form. Sequence of event functions should include the acquisition, storage, archiving, display and reporting of the following message types:

- Process alarm messages priorities:
  - Prio 1, Prio 2, Prio 3, Prio S (S=DCS System alarm)
- Maintenance information messages
  (Difference: changeover to manual/sequence control timeout/missing of control criteria.
- Status messaged (messages without priority)
- System alarm messages
Control actions

Storage should take place as a history within the Process Operator Station, at the storage rate of \( n \times 50,000 \) messages in cyclic FIFO buffers (\( n \) depends on configuration of the system). The history messages are to be combined into units capable of being archived. These shall also be transferred to an external archive (manual and automatic initiation). Process control and evaluation tasks should take place according to different criteria. Different presets capable of defining in relevant task specific message selection defined, exist both for displays and reports, The sequence of event display shall fully be integrated into the Process Operator Station selection philosophy, i.e. cross selections from one message line to other relevant display types. Acknowledgement shall also be effective for all display types, plant segment wide The system should be of fully colour compatible with all other displays for all types of display selection, the most recent messages should be initially displayed. In this condition (display of the most recent messages), new incoming messages shall always be added at the bottom end of the almost entire monitor page. If the monitor page is already full on the arrival of an new message, the messages on the monitor shall automatically be moved upwards by message, the messages on the monitor shall automatically moves upwards by ten messages. In addition to the usual paging options jumping to the beginning or end of the list shall also possible. Reporting should be possible consecutively or on call according to current selection. In principle, the report layout shall correspond to that of the display.

Reports: The operational reports primarily shall contain calculation values that refer to certain periods of time.

Available operational reports should be:

- Shift report (8 hours), resolution 1 hour, commencement, hour selectable.
- Daily report, resolution 1 hour, commencement, hour selectable.
- Weekly report, resolution 1 day commencement, day/hour selectable.
- Yearly report, resolution 1 month, commencement, 1 January, 0:00 hours.

Initiation shall take place automatically at the end of the report or also manually as required.

- Shift/daily report data, over 2 to 3 shifts/day.
- Weekly report data, 1 month
- Monthly report data, 1 month
- Yearly report data, 1 year

Archiving shall be initiated manually on an external storage medium.

11.12 Standard Weather Station

Standard weather stations with all required facilities have to build so that ambient condition can be monitored and recorded for the purpose of capacity test.

11.13 Continuous Emission Monitor Module

Continuous emission monitor sensors have set at different exhaust position so that emission level can be monitored continuously for environmental legislation.
Section 12

Cabling and Grounding
12. CABLING AND GROUNDING

12.1 General
12.2 Cable Types
   12.2.1 21 KV or Generating Voltage IPB duct
   12.2.2 6.6 KV KLPE Power Cable
   12.2.3 600 V Power Cable
   12.2.4 Control and Instrument Cable
   12.2.5 230 kV XLPE POWER CABLE

12.3 Raceway
   12.3.1 Raceway
   12.3.2 Raceway Fittings and Supports

12.4 Cable Erection
12.5 Grounding
12. Cabling and Grounding

12.1 GENERAL

(1) Scope
The Contractor shall design, supply, install, terminate and commission all the cables for the plant.

(2) Voltage Drop
The maximum permissible voltage drop shall be such that in no case shall the drop exceed 2.5% under normal running condition and 10% under motor starting.

(3) Armouring
All cables, control and instrument cables shall be provided with galvanised steel wire or steel tape armour and PVC cover sheath.

12.2 CABLE TYPES

12.2.1 21 KV or Generating Voltage ISOLATED PHASE SOLID COPPER BUS DUCT

ISOLATED PHASE BUS (IPB) DUCT shall be of SOLID COPPER.

12.2.2 6.6 kV XLPE POWER CABLES

The single or triplex core 6.6 kV XLPE copper conductor power cable and other necessary items for the completion of the cable system.

The power cables and accessories shall be designed and constructed in accordance with the most up-to-date experience for a system of this voltage level and shall incorporate the latest improvements of design and manufacture for the type of cables and accessories required.

(1) The cable shall be stranded annealed copper conductor. The construction of the conductor shall be the compacted circular single or triplex core type. The size of the conductor shall be capable to carry the rated capacity of each feeder and at specified site conditions without exceeding its maximum temperature i.e. 90°C. The minimum size of 6.6 kV cable shall not be less than 60 sq. mm.

(2) Insulation
The insulation material shall be extruded cross-linked polyethylene of low dielectric loss, high dielectric strength, low thermal resistivity and long term stability. It shall be free from contamination by oil, chemical, and moisture. The extrusion process shall ensure that the insulation is homogeneous and free from voids and impurities, and it shall be dry method.

(3) Terminations
The end terminating materials shall be supplied for the termination of 6.6 kV cables.
12.2.3 600 V Power Cables

The cables shall be rated 600 volts for installation in cable trays, conduits and cable ducts. All auxiliary power cable with a nominal conductor area of 60 sq. mm and above shall be stranded annealed copper conductor, XLPE insulated with galvanised steel wire or steel tape armour and PVC sheathed. All other auxiliary power cables shall be stranded annealed copper conductor, PVC insulated with galvanised steel wire or steel tape armour and PVC sheathed. All auxiliary power cables shall be designed, fabricated and tested in accordance with the latest IEC Standard.

The cables shall have copper conductor and shall be selected with due consideration to load requirements of each feeder and short circuit current capacity of the cable in order to prevent premature insulation failure. The conductor insulation shall be numbered or colour coded.

For motor circuit, the cables shall have a current carrying capacity of at least equal to 115% of the full load current rating of the motor after application of the appropriate de-rating factors.

Cable supports shall be provided for the cables and shall be at least one cable support bracket per vertical section for interconnection between adjacent sections. The minimum size of power cable shall be of 10 sq.mm.

12.2.4 CONTROL AND INSTRUMENT CABLES

In general, control and instrument cables shall be rated 600 volt and shall have copper conductor with either PVC overall jacket, unless specified otherwise. All control and instrument cables shall be designed, fabricated, and tested in accordance with the latest JIS or IEC Standards.

All cables shall be of oil-resisting, heat-resisting and flame-retardant type (armoured) and shall be stranded copper conductor. The minimum size of control cables shall be as follows:

- For CT circuit - 6.0 sq. mm
- For PT circuit - 2.5 sq. mm
- Other circuit - 2.5 sq. mm

Wiring for circuits such as the circuits to be connected to electronic circuit, telephone circuit, etc. adversely influenced by stray electric field shall be provided with suitable shielding.

-PVC Insulated and Jacket Cables
PVC insulated control cables shall be used in the area of installation where the ambient temperature is normally lower than 40°C.

-Cross linked polyethylene Insulated Cables.
Cross linked Polyethylene insulated control cables shall be used in the area of installation where the ambient temperature is normally between 40°C and 55°C.

-Mineral Insulated (MI) Cables.
Mineral insulated control cables shall be used in the area of installation
where ambient temperature is normally above 55°C. Where instrument junction boxes such as for limit switches, pressure switches, transmitters, resistance temperature detectors etc. are at high ambient temperature, they shall be wired with MI cables up to a junction box.

(1) Insulation requirements

All control cables, with the exception of equipment internal wiring and panel wiring, shall be installed in conduits, cable ducts or cable trays.

Cables contained in cable trays, conduit or cable ducts shall be continuous with no splices permitted between loads and supply location. Methods for installation of cables shall be such that there will be no cuts or abrasions in the insulation or sheath or break in the conductor. Conductors used for AC and DC circuits shall not be mixed in the same multi-conductor cable.

In general, conductors and cables shall be supported and terminated so that no strain is imposed on the terminations. Insulated clamped jugs shall be used for all control cable terminals.

12.2.5 230 kV XLPE POWER CABLE

(1) The cable shall be stranded annealed copper conductor.

The construction of the conductor shall be the compacted circular single core type. The size of the conductor shall be capable to carry the rated capacity of each feeder and at specified site conditions without exceeding its maximum temperature i.e. 90°C. The minimum size of 230 kV cable shall not be less than 2000 sq. mm. for Generator Step Up Transformer. The copper conductor shall comply with latest IEC Standard.

(2) Insulation

The insulation material shall be extruded cross linked polyethylene of low dielectric loss, high dielectric strength, low thermal resistivity and long term stability. It shall be free from contamination by oil, chemical and moisture. The extrusion process shall ensure that the insulation is homogenous and free from voids and impurities. The process shall be dry method. The average thickness of insulation measured at section shall not be less than the value specified in the standard.

(3) Terminations

The end terminating materials shall be supplied for the termination of 230 kV cables.
(4) Laying

Laying Under-Ground Cable from 230 KV side of Unit Transformer to 230 KV Sub-Station Bay shall be provided with RCC slab on three sides.

12.3 RACEWAY

12.3.1 RACEWAY

Raceway shall be provided for all cables, and these shall be rigid conduit metal through type cable trays.

12.3.2 RACEWAY FITTINGS AND SUPPORTS

Raceway shall include all fittings, junction boxes, flexible attachments, raceway support hardware, etc.

12.4 CABLE ERECTION

Concrete lined cable trenches shall be provided within the power station. All such trenches shall be provided with covers to form a flush finish with the finished floor level. Cables shall be secured by non-corrodable cleats supporting steelwork, or on trays. Wooden cleats shall not be used. Cables shall not be clipped or cleated directly to masonry. All cable supporting steelwork racks cleats trays and fixings in trenches or elsewhere shall be supplied under this contract.

Where the cables are to be installed on racks, these racks shall be of galvanised steel angles or aluminium and designed such that the spacing and type of supporting cleat ensure that no undue pressure is exerted on the sheath or armour of any cable.

Cables tray shall be of the first grade perforated galvanised steel with folded side members and supported on steel work or masonry is required. Segregation of the various services shall be achieved by use of separate trays for each voltage grade of cable used. The design of the cable tray system shall make due allowance for the future installation of at least 10 percent spare cables and also for the installation of cables supplied by others.

All cables in vertical runs shall be supported to ensure that no strain due to the weight of the cable is taken by any terminating box. Each cable when erected shall have permanently attached to it at each end, non-corrodable metal markers showing the cable identification number, voltage, rating, size and make up.

Single core cables shall be laid up in close trefoil 3-phase groups and erected in separate non-magnetic clamps to the approval of the Engineer.

Where cables are erected on outdoor steelwork supporters, sun shades of approved design and materials shall be included and erected as necessary to protect the cables.
12.5 GROUNDING

The Contractor shall provide all grounding cable, equipment, and materials required for a complete installation including the direct buried ground mat for the power station. This shall include, but not be limited to, all facilities for grounding of panel boards, control panels, transformers, switches, lighting poles, lighting standards, and all electrical equipment enclosures. Two point grounding for each equipment, panel board and steel structure shall be provided.

(1) Grounding wire for ground grid

Hard drawn copper stranded wire in accordance with latest IEC Hard Drawn Copper wire for electrical purposes”. Nominal cross sectional area: 200-sq. mm.

(2) Grounding wire of the equipment to be connected with grounding grid.
Annealed copper standard wire in accordance with latest IEC Annealed copper stranded wire for electrical purposes"
Nominal cross sectional area: 120 sq. mm.
Ground grid shall be laid so that the completed earthing system shall have a maximum earth resistance value of less than 0.5 ohms, at any point on the system. The contact voltage at any point inside the power station at the incidence of an earth fault shall not exceed 50 volts. The power station grounding shall be embedded to a minimum depth of 800 cm. The grounding rods (copper) addition to the above grid shall be provided, if required. The minimum outer diameter of grounding rod shall not be less than 15 mm.
Section 13

DC Power Supply System
13. DC Power Supply System & UPS

13.1 Battery Charger Performance

13.2 UPS Performance

13.3 Batteries Performance
13.0 DC and UPS Systems

The DC and UPS system shall consist of:

- 220V /110/125 V DC battery and charger
- 24V DC (220/24 DC/DC converter or 110/24 V DC/DC converter)
- 230V AC UPS (inverter with back-up AC supply)
- 48V DC battery and charger for communication equipment. (as required)

The main DC voltage shall either be 220V or 110V or 125 V. The main DC loads shall be as follows:

- Generator circuit breaker closing and tripping
- DC lubricating oil pumps for GTG and STG rotating plant
- Protection relay systems
- HV switchyard equipment controls
- MV/LV Switchboard and motor control centre closing and tripping.

DC (Battery, Charger and others) and UPS system for the combined cycle plant shall be dedicated system with 2X100% redundant facility and it will be separate from rest of the plant DC system. DC system shall be designed based on the combined cycle requirement and pre-engineered packages designed in accordance with internationally recognized standards. Battery, Chargers and UPD shall be supplied in accordance with internationally recognized standards and as per combined cycle plant Original Equipment Manufacturer (OEM).

The main 220V/110/ 125 V DC system shall consist of 2X100% battery and chargers each connected via individual fuses to dedicated 100% battery banks. Each battery shall supply its respective distribution board. There shall be a tie feeder breaker between the two distribution boards.

The 24V DC systems are powered via 2x100% redundant DC/DC converters. Their mains are taken from the 220V /110 V DC battery system. Main consumers of 24V DC are the main ICMS cabinets. Each I&C cabinet shall receive two in-feeds from the redundant DC/DC converters via decoupling diodes.

The 2x100% UPS system (230V AC) shall provide power to essential AC consumers which are sensitive to short power failures, e.g. main ICMS computers. This system is fed from the 220V DC system via an inverter, which provides a regulated single-phase 230V AC supply. The inverters shall also be provided with static bypass switch to the normal bus and emergency bus. The two UPS shall supply its dedicated distribution board. There shall be a tie breaker between the two distribution boards.

There shall be 48V DC batteries redundant chargers. The system shall be independent from the 220V DC system. The 48V DC system shall provide power to communication systems.

Batteries shall consist of single cells connected to provide the appropriate voltage. Cells shall be valve-regulated type nickel-cadmium. The rated life of the batteries under normal operating conditions with constant current and constant voltage charge shall not be less than 18 years. The battery capacity shall be rated for safe plant shutdown (including emergency oil pumps and barring gear) plus operation of UPS for a minimum of five (05) hours without AC power.

Two unit battery chargers scheme shall be implemented and connected in parallel with the DC standing load and float charge current being shared equally by the chargers. Either
charger may be taken out of service leaving the other to carry the full duty.

Each battery charger shall be continuously rated to supply 100% of the design load, in addition to battery charge requirements, under the most severe variation of AC supply input.

A dedicated battery room shall be provided which should be well ventilated. Battery chargers shall be located external to the battery room. The battery room shall be equipped with facilities for the safe handling of battery acid, and with an emergency eye washing station and a safety shower.

13.1 Battery Charger Performance

Battery charger performance shall conform to the battery manufacturer’s recommendation. Chargers shall be identical in design and rating. One charger shall be in service whilst the other shall be in standby mode. Switching between service and standby mode combinations shall be done manually by the operator.

Each charger shall be capable of recharging the battery from fully discharged condition to 100% of the fully charged capacity in not more than 12 hours while supplying the design loads.

The chargers shall be of the automatic with I/U characteristics.

The charger output voltage regulation range shall be less than 1% for:

- Frequency variation of ± 5 percent of 50 Hz
- Rated input AC voltage variation of ± 10 percent
- Output between 0 and 100 percent of rating.
- The charger shall be short circuit proof.

Each charger shall include at least the following instrumentation and indicating facilities:

- AC and DC voltage and current
- Programmable settings of float and equalizing voltage
- Alarm indication for AC/DC failure
- Polarity of current

Charger status and fault conditions shall be signaled at the operator interface.

Input voltage 415 volts, three phase
Input voltage stability ±10%
Input frequency 50 Hz
Output Voltage To suit battery and load voltage limits
Output current To suit load and battery requirements
Control Constant voltage with current limit
Output ripple Less than 5% of the nominal dc voltage
Indications Output voltage
AC/DC Currents
Alarms Over-voltage trip (switch rectifier off)
Over-voltage alarm
Charger failed alarm
13.2 UPS Performance

Static uninterruptible power supply (UPS) systems shall be sized to feed the plant critical loads related to ICMS, work station computers, communications/telemetry, fire protection/detection and turbine/generator control panel. Each system shall consist of an inverter section, bumpless static transfer switch, maintenance bypass switch and voltage regulated bypass transformer. The output shall feed a dedicated AC distribution panel and shall be rated to carry actual connected load plus 20%. Battery capacity (ampere hour rating) shall be determined by the Contractor.

Bumpless transfer to and from AC source and the battery shall be ensured via the static transfer switch. Transfer to and from “bypass” mode shall also be bump less and require specific sequence switching. “Bypass” mode shall be visually indicated on the local UPS panel and the operator interface in the control room.

Under normal operating conditions, the AC load shall be supplied by the inverter system via the static transfer switch.

Upon an inverter fault, the static switch shall transfer the ac load to the ac input supply or an auxiliary ac supply line with a “no break” in power supply and inhibit further switching until the fault is rectified.

UPS status and fault conditions shall be signaled at the operator interface.

13.3 Batteries Performance

Batteries shall comply and be sized in accordance with IEEE 485 "Recommended Practice for Sizing Batteries for Power Stations".

Each battery shall be the high performance, low-maintenance, valve-regulated nickel-cadmium type. The battery shall be designed for a life expectancy of at least 18 years at an average ambient temperature of 30°C.

Battery capacity shall be suitably derated to allow for ageing factor, temperature, and maintenance factors. An ageing factor of at least 125% shall be used in the capacity calculation. An additional spare capacity for future growth of load shall be allowed of at least 20%.

All battery cells shall be numbered consecutively and each terminal shall be marked to show polarity.

Each battery shall have three spare cells installed and kept fully charged by connecting in parallel with cells in the battery or by other approved manner.

Batteries shall be mounted on multi-tier racks braced to withstand earthquake forces. Racks and mountings shall be designed to allow easy inspection and replacement of individual cells. The separate battery room shall have sufficient space to access batteries. The room shall be ventilated to remove hydrogen gas and optimise life of battery.
Section 14

Lighting and Small Power Supply System
14. Lighting And Small Power Supply

14.1 General
14.2 Distribution Boards
14.3 Cables
14.4 Lighting and Small Power
14.5 Emergency Lighting
14.6 Miscellaneous Materials
14. Lighting and Small Power Supply

14.1 GENERAL

(1) Scope of Works

The Contractor shall design, manufacture, deliver and install power station lighting and small power supply complete with all the accessories at the site as specified hereinafter.

(2) Details

Detail description and drawings of all lighting fittings, distribution boards, switches, DC equipment, socket outlets, poles, glands, etc., comprising the offer shall be submitted with Tender.

(3) Electricity Supply

Supplies for lighting distribution boards of 415 Volts 3 phase 4 wire 50 Hz shall be taken from the station auxiliary switchboard.

The DC supply/ UPS supply required for emergency lighting services shall be obtained from the batteries supplied under the Section 13. Under normal AC failure conditions emergency lighting to be installed shall be automatically switched on.

14.2 DISTRIBUTION BOARDS

The distribution boards and all component parts shall be manufactured and tested in accordance with the latest IEC standard. Distribution boards shall have dust proof sheet steel, galvanised, weatherproof cases. The metal casing is to be provided with knockouts or other approved form of cable entries, corresponding to the circuit capacity, together with a suitably screened brass earthing stud.

The distribution boards shall be either double pole or neutral types as required and shall be equipped with means to provide over load protection to each circuit. This protection shall comprise moulded case circuit breaker.

14.3 CABLES

All cabling associated with the lighting and small power socket outlets services shall be stranded annealed copper conductor, PVC insulated galvanised steel wire or steel tape armoured and PVC sheathed as appropriate or mineral insulated copper sheathed cable depending upon the service required.

The Contractor shall select conductor sizes for the respective circuits to fulfil the following conditions:

a. Minimum conductor sizes for lighting circuits shall be 2.0 sq. mm and for socket outlets 3.5 sq. mm.

b. The size shall be adequate for the current to be carried.
c. The size shall be adequate to limit the voltage drop in phase and neutral conductor to the farthest lighting or power point under normal full load conditions to within 2.5 %.

14.4 LIGHTING AND SMALL POWER

The following lighting and small power arrangements shall be provided as a minimum by the Contractor.

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Illumination Level (Lux)</th>
<th>Type of Fitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Power Generating Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside of packing except control package</td>
<td>100</td>
<td>Fluorescent lamp or incandescent lamp with reflector and guard if necessary explosion proof type shall be used.</td>
<td></td>
</tr>
<tr>
<td>Inside of control package</td>
<td>500</td>
<td>Fluorescent lamp with reflector guard</td>
<td></td>
</tr>
<tr>
<td>Inside of crane rain shelter</td>
<td>20</td>
<td>Fluorescent lamp or mercury vapour lamp with reflector and diffuser</td>
<td></td>
</tr>
<tr>
<td>Around GT unit</td>
<td>20</td>
<td>Mercury vapour lamp with floodlight fitting</td>
<td></td>
</tr>
<tr>
<td>Road or path</td>
<td>10</td>
<td>Mercury vapour lamp with highway fitting or floodlight fitting</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>230 KV Switchyard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Around Switchgear</td>
<td>20</td>
<td>Mercury vapour lamp with floodlight fitting</td>
<td></td>
</tr>
<tr>
<td>Roadways</td>
<td>10</td>
<td>mercury vapour lamp with highway fitting</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control room</td>
<td>500</td>
<td>Fluorescent lamp with reflector and diffuser</td>
<td></td>
</tr>
<tr>
<td>Electrical room and cable room</td>
<td>50</td>
<td>Fluorescent lamp with reflector and guard</td>
<td></td>
</tr>
<tr>
<td>Office</td>
<td>500</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>Toiler, corridor, etc.</td>
<td>50</td>
<td>-do-</td>
<td></td>
</tr>
</tbody>
</table>

f. Plug Sockets

Plug sockets shall be located so that any point inside the GTG/STG package, inside a building or outside in the high voltage areas can be reached within the following distances from a plug socket.

(i) Single phase plug socket

- Indoor - :10.0 m
- Outdoor- :20.0 m

(ii) Three phase plug socket

- Outdoor- :45.0 m

At least two plug sockets shall be installed within the vicinity of an indoor
control board and no plug socket shall be installed within a battery room.

14.5  
**EMERGENCY LIGHTING**

The Contractor shall design DC/ UPS AC emergency lighting and power supply system for the power station, and illumination level of emergency lighting shall be as follows.

The lighting shall consist of incandescent luminaries.

<table>
<thead>
<tr>
<th>Location</th>
<th>Illumination Level (Lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control room and inside of control package</td>
<td>15</td>
</tr>
<tr>
<td>Inside of other package</td>
<td>1</td>
</tr>
<tr>
<td>The other area surrounding GTG units</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Additional emergency lighting arrangement, independent emergency light units operated from built-in charger and batteries charged by 230 V AC shall also be provided strategically. Total ten units shall be included in the Tender.

14.6  
**MISCELLANEOUS MATERIALS**

(1) **Lighting Poles**

Lighting poles shall comprise tubular or octagonal metal or reinforced concrete construction with a base of sufficient section to house an inspection trap, lockable door, cable entry and terminations suitable for the incoming cables and the secondary cables feeding the light sources, all of which shall be supplied with the pole. All poles shall be suitable for burying to a depth of 1.5 m and have an adequate concrete foundation.

Metal poles shall be either hot dip galvanised or covered with a bituminous base protective area with the fitting erected and a safety factor of 2.5 allowed.

(2) **Conduits Pipes**

The rigid steel conduit pipes shall be galvanised and have a minimum thickness of 2.3 mm and minimum inside diameter of 16 mm.

(3) **Outlet Switches, Junction Boxes and Fittings**

The boxes to be concealed in the concrete shall be of galvanised sheet steel and shall be fitted with appropriate covers so as to be flush with the finished surface of the concrete structure. The boxes in the exposed work shall be of galvanised steel or alloy fitted with appropriate covers.
(4) Tumbler Switches

The wall switches shall be of the enclose flush or surface mounting tumbler type, single pole, 250 V, 10A and fully installed in the boxes fitted with suitable plates for covering them.

(5) Miscellaneous

All apparatus, accessories and materials which have not been specifically mentioned but which are necessary for the completion of the work shall be provided by the Contractor.
Section 15

Fuel Handling Facilities
15. FUEL GAS HANDLING FACILITIES

15.1 Scope of work

15.2 Natural Gas Supply System

15.3 Natural Gas Booster Compressors
15. **Fuel Gas Handling Facilities**

15.1 **SCOPE OF WORK**

The Contractor shall design, manufacture, inspect, test, delivery to the site and install of natural gas handling facilities (including gas booster compressors) with all accessories as specified hereunder for the plant.

The gas turbine unit shall be furnished with a complete gas fuel system. The gas handling system shall also be provided.

15.2 **NATURAL GAS SUPPLY SYSTEM**

There are 2 pipe lines (each one 20" dia.) coming from adjacent Karnaphuli Gas distribution Company’s CMS to the existing power plant. Each pipe line goes to supply header of existing each 210 MW Steam Turbine Unit to run the units. Now BPDB will install & run the 400±10% MW CCPP by connecting with the existing 2 Gas pipe lines keeping existing 2X210 MW Steam Turbine Unit in standby mode. The contractor shall design the gas supply system and make necessary arrangement with adequate capacity in a way that the incoming 2 pipe lines will be converted to 3 outgoing pipe lines (1 line will go the RMS for GT, the remaining 2 lines will go to supply header of existing 2x210 MW ST Units). Proper arrangement (Header, valves, meters, pipes etc.) should be made by the contractor so that as per requirement of BPDB either Upcoming 400±10% MW CCPP or existing 2x210 MW ST Units can run independently.

To forward the natural gas from the main gas supply header (as mentioned above) to the gas turbine unit and to adjust its supply pressure to normal operating pressure as well as the gas properties, the Contractor shall furnish one (1) complete factory assembled skid mounted Pressure Regulating & metering Station (RMS) & Gas booster Compressors including all accessories and necessary pipe connections to the Board’s gas supply header for gas turbine unit.

Gas handling unit for this CCPP shall comprise at least the following major items:

- Inlet strainer
- A flow meter (Ultrasonic & Turbine) with bypass system
- Knock Out Drum (KOD) Unit
- Flow Computer Unit
- Station outlet
- Pressure gauges
- Pressure regulating equipment
- Safety valve and relief valve
- Condensate Tank
- A gas conditioner (scrubber, separator and others as per GT inlet designed Fuel gas properties)
- Heater (if required as per GT inlet designed fuel gas temperature)
- Other equipment for satisfactory completion of the work.
Gas handling unit for this CCPP shall have guaranteed capacity, which matches or exceeds the gas turbine needs under all load-operating conditions at all temperature as well as site conditions.

Typical Composition of natural gas is shown on Annexure for Tender purpose only. However during design period the Tenderer should collect the appropriate specification of natural gas from competent authority/ Karnaphuli Gas Distribution Company Limited. However the contractor will be responsible for gas conditioning & filtering as per requirement of GBC & GT. No question shall be arisen regarding gas properties/ condition for any damage of GBC & GT.

**QUALIFICATION OF CONTRACTOR OF GAS REGULATING & METERING STATION (RMS)**

Qualification of Contractor for Gas Regulating & Metering Station (RMS) shall be as follows:

The Contractor of Gas Regulating & Metering Station (RMS) shall have a minimum 5 years experience in Design, Supply, Installation / Fabrication / Erection / Construction, Testing and Commissioning of Skid Mounted Gas Regulating and Metering Station

The Manufacturer/Contractor of RMS must have successfully completed at least 2 (two) Natural Gas Pressure Regulating & Metering Station (RMS) contract having capacity of minimum 50 (fifty) MMSCFD and above on design, engineering, procurement, fabrication / construction, installation and testing & commissioning, and at least one of said RMS for Bangladesh public utilities within the last 5 (five) years and shall have been in continuous commercial operations for at least 1 (one) years prior to the date of singing of EPC contract for Power Plant project. To this effect Certificates from End Users together with Work Completion Certificates (FAC/PAC, Completion Certificate or Operational Acceptance Certificates) and Copies of Contract Agreements must be submitted after signing of EPC contract for Power Plant project & before engagement of RMS contractor to get approval from BPDB.

**QUALIFICATION OF MANUFACTURER OF GAS REGULATING & METERING STATION (RMS)**

Manufacturers of Plant /Equipment of RMS viz, Pressure Regulators, Safety Shut-Off Valves, Senior Orifice/ Ultrasonic Meters, Gas Chromatograph, Flow Computers, Turbine Meter, Chart Recorders, shall have their country of origin from America/ Europe/Japan.

The manufacturers of Pressure Vessels of RMS must possess ASME U-Stamp Certificate for at least 10 years.

The manufacturers of Valves of RMS must possess API 6D certificate for at least 10 years.
Manufacturers of Inlet Separator / Knock Out Drum Unit, Filter Separators, Water Bath Heaters, Vane Mist Separator, Pressure Regulators, Safety Shut-Off Valves, Safety Relief Valves, Senior Orifice Meters, Gas Chromatograph, Flow Computers, Pressure / Differential Pressure / Temperature Transmitters, Turbine Meter, Chart Recorders, Ball / Check & Globe Valves, Pressure and Temperature Gauges, Condensate Tank, Pipes must possess ISO-9001 Certificates for at least 10 (ten) years. 1st issue and current valid issues of ISO-9001 Certificate of all the manufacturers

Tenderer shall submit the following documents along with their proposal after singing of EPC contract for Power Plant project and before finalization of RMS contractor:

Manufacturers' ISO Certificates / APIQ1 / Equivalent (1st issue & current valid issue) of all major products / components of RMS

API 6D, Fire Safe Design (API 607/6Fa) Certificates / Equivalent for Valve Manufactures of RMS

ASME and U-Stamp Certificates / Equivalent for Pressure Vessel

DVGW and Sil3 Certificates for Pressure Regulators, Safety Shut-Off Valves.

National Sub-Contractor for RMS shall fulfill the following qualification requirements and shall submit copy of licenses along with their Bid:

For Mechanical Works: Subcontracting is awarded for mechanical works (fabrication, assembling, erection, installation etc.), the Subcontractor shall have proven experience in Construction of minimum one gas Regulating and Metering station of minimum 40 MMSCFD capacity and similar Pressure designations during last five years and shall be enlisted under any Company of Petrobangla (Bangladesh Oil Gas and Mineral Corporation) for category 1.4 as a gas pipeline contractor.

For Civil Works: Enlistment certificates for class-1 category with Public Works Department (PWD) of the Government of Bangladesh or of equivalent category with any other Government, Semi Government / Autonomous bodies of Bangladesh

For Electrical Works: ABC license from the Electrical Licensing Board of the Government of Bangladesh.

All the technical specification, parameters and construction philosophy shall be followed as per Guideline of Karnaphuli Gas Distribution Company Limited.
15.3 **Natural Gas Booster Compressors**

The plant shall require centrifugal type gas booster compressors (GBC manufacturer will be ATLAS COPCO, USA or Germany / MAN TURBO, Germany/ INGERSOLL RAND, USA) as the supply pressure of natural gas is in the range of 80 - 150 psig. Bypass system will be installed by the Contractor, If the gas supply pressure is sufficient to run the combined cycle power plant, then bypass system will be used instead of operation of GBC.

The capacity of the compressors have to be 3 x 50% for maximum gas requirement of the plant including auto changeover system without interrupting operation of the plant with rated pressure & flow and at all modes of operation & at any temperature prevailing in the site of the GTG unit.

The gas booster compressors have to be centrifugal type, 6.6 KV motor driven. Appropriate control, sealing, cooling & anti-surge system with all necessary ancillaries and auxiliaries shall have to be provided including compressor house.
Section 16

Fire Detection & Protection Facilities
16. Fire Detection & Protection Facilities

16.1 General
16.2 Design Requirements
16.3 CO₂ Gas Fire Protection System
16.4 Hydrant System
16.4.1 Hydrant
16.4.2 Piping
16.5 Portable Equipment
16. **Fire Detection & Protection Facilities**

16.1 **GENERAL**

The Contractor shall design, manufacture, deliver to the Site, install, test and commission the fire fighting and fire detection equipment to protect the steam & gas turbine, generating units and all associated equipment. In particular, the following shall be included:

- C0₂ Gas fire protection system for the gas turbine packaged units.
- Water hydrant system including motor & diesel engine driven pumps, jockey pump, water main, hydrant stands, hoses etc.
- Portable fire fighting equipment

16.2 **DESIGN REQUIREMENTS**

The general design of the fire protection facilities shall take into account that the basic operating policy for the power station will have the minimum of personnel supervision for the gas turbines.

Where automatic systems are provided, alternative manual initiation facilities shall also be provided.

All fire protection installations shall comply with the requirements of the codes of practice of the National Fire Protection Association, Boston, Massachusetts, U.S.A., as appropriate for the respective systems, to the approval of the Engineer. The codes and practice of the Japanese Fire Protection may also be considered.

16.3 **CO₂ GAS FIRE PROTECTION SYSTEM**

An automatic Carbon Dioxide (CO₂) gas fire protection system shall be provided in all machinery enclosures of gas turbine generating units except in the unit local control package. The fire protection system shall comply with the requirements of National Fire Code No. 12A published by the National Fire Protection Association, Boston, Massachusetts, U.S.A. or equivalent.

The equipment shall consist essentially of fire detectors distributed strategically within the enclosures which, on sensing a dangerous condition at any location, will initiate audible and visual alarms, trip all running plant including ventilation equipment, and release C0₂ gas into the affected enclosure. Actuation of the fire protection system shall also. Trip gas turbine generating unit and immediately shut off the fuel supplies to the unit at a point external to the enclosures. There will be time lag of 30 seconds between the ringing of alarm and discharge of C0₂ gas, so that the personnel working in the package could leave safely.

Facilities for alternative manual actuation of the fire protection system shall also be provided such that, when the manual mode has been selected the protection sequence will not proceed beyond the alarm stage without manual action by an operator.
System of lock off to (but not exit from) the enclosure affected shall also be provided.

The fire protection system shall be segregated into separate zones so that at least the protection for any one compartment can be selected to the manual mode whilst, at the same time, retaining the automatic mode for the remaining enclosures.

Lock-off boxes shall be provided at all entries to enclosures, with switches whereby an operator may inhibit automatic release of extinguishant. These boxes shall be provided with status indicators signifying 'Auto on' 'Auto-off' and 'Extinguishing Released' and a red lamp shall also be illuminated at the box in the event of extinguishing release. The status shall be indicated at the control panel of the control building also.

Fire detection shall be by means of ultra violet flame detectors with a backup system utilising rate-of-rise temperature detectors. The use of smoke detectors shall be subject to specific approval by the Engineer as regards their type and location.

Audible and visual fire alarms shall be provided in all machinery enclosures, the local control cabs and in the control room of the control building. Additional audible alarms shall also be provided external to the turbine generator enclosures.

Particular areas of high fire risk such as confined spaces where lubricating oil could possibly come into contact with high temperature surfaces shall receive special consideration. Such areas shall be treated as separate fire protection zones with detection and CO₂ gas injection facilities operating independently of the system provided for the machinery enclosure concerned.

The fire protection equipment shall be complete in all respects including pipework, valves, fire detectors, nozzles, control equipment, fully charged CO₂ gas cylinders and cylinder racks.

16.4 HYDRANT SYSTEM

Fire hydrant of water type shall be provided in the power station.

16.4.1 HYDRANT

Hydrants shall be installed at required places around the gas & steam turbine generating units, HRSG, Gas station, GBC, Chemical Plant electrical building, Outdoor transformers. Each hydrant stand shall be fitted with an isolating valve and approved type of instantaneous hose complying 30-m hose with combined jet/water-fog nozzle shall be provided in the cabinet adjacent to each hydrant.

Fire fighting water pool/ storage tank capacity will be minimum 04 hours requirement at worst scenario of fire incidents.
16.4.2 PIPING

The fire fighting water mains shall consist of buried piping of at least 150 mm diameter. The underground pipework shall be provided with an approved protective coating unless the pipe is manufactured from an approved non-corrosive material.

16.5 PORTABLE EQUIPMENT

The following portable fire fighting equipment or equivalent shall be provided:

(1) Thirty nos. 5 kg CO₂ extinguishers
(2) Ten nos. 20 kg CO₂ extinguishers with trolley
(3) Thirty nos. 5 kg Dry chemical extinguishers
(4) Ten nos. 10 kg Dry chemical extinguishers.

The portable equipment offered shall be of a type for which replacement cartridges and dry powder refills shall be readily available locally.
Section 17

Communication Facilities
17. Communication Facilities

17.1 General
17.2 Internal Telephone System
17.2.1 Private Automatic Branch Exchange
17.2.2 Telephone Facilities
17.3 Paging System
17.3.1 General
17.3.2 Function
17.3.3 Equipment
17.3.4 Locations of Handsets and Speaker

17.4 Coaxial Cable
17.5 Power Supply
17.6 Telemetering facility
17.7 Communication and SCADA equipment
17. Communication Facilities

17.1 GENERAL

The Contractor shall design, manufacture, deliver to the Site and install the following communication facilities:

a. Internal telephone system
b. Paging system
c. Telemetering, Communication, SCADA system & integration with NLDC (PGCB)

17.2 INTERNAL TELEPHONE SYSTEM

17.2.1 PRIVATE AUTOMATIC BRANCH EXCHANGE

The exchange shall be of a PABX type approved by the Ministry of Communications for connection to the public telephone network and installed with in the central control room of the power station.

The initial installed capacity shall be 10 exchange lines and 50 extension lines. The exchange shall be capable of expansion to a capacity of more than 20 exchange lines and 100 extension lines. A single operator's position shall be provided.

All internal telephone connections within the power station boundary shall be the responsibility of the Contractor, but the interconnecting cables between the PABX and the public telephone network shall not be the responsibility of the Contractor except all facilities for the connection of this service within the building.

(1) Functions

The PABX system shall be provided with the following functions:

a. Extension to extension calls shall be made by direct dialling.

d. Extension to exchange lines and PLC lines for dialling a single access digit shall make outgoing calls.

e. Operator access from extension by dialling a single digit shall be required.

f. Trunk barring on outgoing calls shall be provided as required on selected extensions.

g. Provision for limited barring on outgoing calls from selected extensions shall be provided.

h. Operator recall from an extension engaged with an incoming or outgoing call shall be effected by operation of a recall button followed by dialling the operator access digit.

i. Call transfer between extensions on incoming and outgoing public exchange calls shall be provided.
j. Operator intrusion into an established call in order to offer an exchange call or urgent message shall be provided. An intrusion tone shall be introduced.

i. Exchange alarms shall be extended to the operator's console or switchboard.

J. Six (6) extensions shall have a priority facility to intrude into extension to extension calls. An intrusion tones shall be introduced.

(2) Equipment to be provided shall include, but not limited to:

a. A main distribution frame of sufficient size to accommodate the future expansion.
b. Automatic switching equipment.
c. Manual switchboard or console.
d. A necessary inters unit cabling and cables supports.
e. Concealed wiring to each office, workshop, administration building, etc. to accommodate a single instrument at each point.
f. 50 telephone instruments complete which will be connected at telephone points to be advised by the Engineer.

17.2.2 TELEPHONE FACILITIES

PABX telephones should be located as follows:

a. Control room (2)
b. Each control package of gas turbine unit
c. Telephone cubicle (1)
d. Auxiliary room (1)
e. Office, Managers room, Workshop, etc (Total 10)
f. Administration building, guard houses and other buildings (Total 25)
g. Spare
   Total: 50 Numbers

17.3 PAGING SYSTEM

17.3.1 GENERAL

The paging system, which shall consist of amplifiers, control equipment, handsets and speakers, shall be provided.

The system shall be provided with one channel.

17.3.2 FUNCTION

Commanding Communication

Commanding and paging shall be made from any handsets through the local speaker sets.
(2) General Communication
When the other party answers the paging, general communication is established by releasing the page button. Simultaneous two way conversations shall be possible on one same channel.

(3) Emergency Alarm
1,000 Hz alarm note shall be sound from all speakers by pushing the button located on the control panel and desk in the central control room

17.3.3 EQUIPMENT

(1) Handset
Flush type : 5 sets
Indoor wall type : 12 sets
Outdoor wall type : 7 sets

Handsets installed indoors shall be of noise-proof type.

(2) Speaker Set
15 W outdoor type : 10 sets
5 - 10 W indoor type : 13 sets

All speaker shall be able to adjust their output.

(3) Amplifier Cubicle
All Silicon transistor amplifiers shall be mounted in the amplifier cubicle. The amplifiers shall be suitable for the driving of the above speakers all together and shall be divided into adequate capacity.

One set spare amplifier shall be furnished and it shall be put into operation automatically when the normal use amplifier fails.

(4) Control Panel
a. Relay Panel
Relays shall be provided for the starting and stopping amplifier and to establish the commanding talk from the handsets. The talking shall be indicated with a lamp on all handsets. The relays shall be of semiconductor static type or wire spring relay with sulphuric acid proof type.

b. Change-over Panel
When one set amplifier fails, the failed amplifier's circuit shall be transferred to the spare amplifier's circuit with relays. Manual change-over switch shall also be provided.

c. Amplifier Protection
Protection for the amplifier shall be provided according to the manufacturer's standard.
d. Test device

Ammeter for measuring the emitter current of each transistor and changeover switch and power source voltmeter shall be provided on the front of the panel. Red lamps for the indication of operation and orange lamps for the warming shall be provided on the front panel.

e. Terminal block

Terminal block shall be provided in order to connect the incoming cables from handsets and speakers.

17.3.4 LOCATIONS OF HANDSETS AND SPEAKER

The location of handsets and speakers will be advised by the Engineer after award of the Contract.

17.4 COAXIAL CABLE

Coaxial cables shall be of stranded copper conductor (7/0.4 mm), solid dielectric coaxial type with polyethylene insulated, annealed copper wire braided and with PVC sheathed.

The electric characteristics at 20 deg. C shall be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric strength (for 1 minute)</td>
<td>6KV AC</td>
</tr>
<tr>
<td>Between conductor and outer conductor</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>More than 10 M ohms / km</td>
</tr>
<tr>
<td>Attenuation</td>
<td>3.2dB/km at 300 kHz</td>
</tr>
<tr>
<td>Impedance (nominal)</td>
<td>77ohms at 300 kHz</td>
</tr>
</tbody>
</table>

Sufficient length of the coaxial cables and cords with all the necessary cable connectors shall be supplied to each station for making connections between the coupling capacitors and the coupling filters, the coupling filters and the line protective devices, and the line protective devices and the PLC telephone terminals.

17.5 POWER SUPPLY

The communication facilities to be furnished shall be operated by a 240 V, 50 Hz single phase AC (with UPS) and/or DC 50 V. These power supply facilities shall be provided by the Contractor.

DC 50 V system shall be designed and provided based on the following requirements:

1. Battery

   Type of battery : Ni-Cd Alkaline.
   Capacity        : Capable of loads continuously for five(S) hours without voltage dropping 90% of nominal voltage, but not less than 50 AH (5 hr rate).
   Number of cells : 48 cells.
(2) Battery Charger

Type : Thyristor type with automatic voltage regulator, 240V single phase input.

Capacity : 150% current of battery 5 hour rate charging current at minimum.

Performance : Performance shall be same as these shown on Section 13.2 (3).

Required Number : 1 set.

17.6 Telemetering Facility

Separate Marshalling Kiosk shall be provided for Telemetering terminal with SCADA.

17.7 Communication & SCADA Equipment

All equipment's and materials for interconnection & integration with Load Dispatch Centre (LDC) of PGCB (Power Grid Company of Bangladesh) and said power plant, SCADA, telecommunication facilities such as Compatible Multiplexer with optical fiber, RTU (Remote Terminal Unit) as per respective IEC standard, IP telephone set with accessories and others. All necessary interconnection & integration will be done by the Contractor as per PGCB guideline & related cost for the interconnection shall be borne by the Contractor.

Interface equipment shall be provided to facilitate communications with the Load Dispatch Centre (LDC). Communication Facility at Power Plant for telephone communication with NLDC through existing PGCB Grid substation telecommunication system (OPGW) must be provided. The system design & equipment confirmation should be got approval from PGCB.

Communication & SCADA Equipment shall be comprised of but not limited to the following:

a) Compatible Multiplexer with optical fiber

b) RTU (Remote Terminal Unit) with IEC60870-5-104 interoperability if ECS (Electrical control system) with the protocol 104 is not present.

c) One IP telephone set (Cisco) with accessories.

d) Two general telephone sets for Administrative Telephone system with accessories.

Contractor will bear all cost for establishing necessary interconnection and SCADA facility.

17.8 Closed Circuit Television (CCTV) System

Security and surveillance of different operating areas in the plant as an aid to operators, IP based CCTV system shall have to be provided as per requirement of BPDB. Adequate number of dome type cameras with facilities like Zoom, pan, tilt etc. would be provided at various operating areas. The monitors would be located at control locations such as Administrative Building (Chief Engineer, Manager), central control room, Operation in-charge room etc.
The camera pictures shall be displayed at the Administrative Building (Chief Engineer, Manager), CCR and Operation in-charge room where the camera view or combination of views, selected by an operator shall be displayed on colour LCD video monitors. A secondary CCTV display station shall be provided at the guard house.

A digital video recording system shall also be provided to allow a permanent record to be made from all or selected channels. The system shall store the CCTV data for at least 1 (one) month. The complete system, as specified including, but not limited to the following:

- high resolution color cameras including lenses, mountings and housings.
- Camera for CCTV have capabilities to cover capturing outdoor video ranging minimum 50 meter.
- color monitors
- pan/tilt units for moveable cameras
- video matrix switcher and control system
- Hard Disk / DVD recorder
- video multiplexers
- Video transmission system including ca bling, launch, line, equalizing, repeating amplifiers, etc.

These specific areas as listed below shall be considered as minimum requirements. As minimum, the following areas of the plant shall be covered by video surveillance (CCTV):

- Control Room
- Building gate entrance area.
- electronic/computer rooms
- turbine hall
- GBC hall
- switch gear rooms
- HRSG (e.g. Drum level monitoring)
- control building
- C.W. pump House
- store rooms
- chemical plant
- workshop
- fire fighting station
- water treatment plant
- gas handling area
- security gate
- Substation
Section 18

Maintenance Facilities
18. Maintenance Facilities

18.1 Overhead Electric Crane

18.1.1 Scope
18.1.2 Extent of Supply
18.1.3 Type of Crane
18.1.4 Rating
18.1.5 Requirements for Characteristics
18.1.6 Requirements for Materials
18.1.7 Structural Design
18.1.8 Electrical Design
18.1.9 Gantry Structure, Rails and Girders
18.1.10 Site Tests

18.2 Mobile Cranes

18.2.1 General
18.2.2 Type and Rating

18.3 Tools

18.3.1 Special Tools
18.3.2 Hoist
18. Maintenance Facilities

18.1 Overhead Electric Crane

18.1.1 SCOPE

The Contractor shall provide and install four (4) Overhead electric crane (GTG, ST, CW Pump House, GBC house) complete with longitudinal gantry structure, gantry rails, conductors, weather protection shed, control, power supply etc. GTG and STG EOT main hoist capacity minimum 125 ton and auxiliary hoist capacity minimum 20 ton. All EOT crane must have capacity required for lifting the heaviest single piece with 20% margin.

18.1.2 EXTENT OF SUPPLY

The equipment to be supplied by the Contractor under this specification shall include, but shall not be limited to, the following:-

a. Four (4) semi-indoor/ indoor type electric overhead crane complete with main and auxiliary hoists, driving motors and control equipment. The hoist capacity of main and auxiliary shall not be less than the following respectively.

Main hoist: 120% of maximum heaviest item. Main hoist capacity will be sufficient enough to lift the weight of Generator rotor as well as weight of the fully bladed gas turbine & Steam turbine rotor separately.

Auxiliary hoist: For turbine hall crane 20 ton, for CWP house and GBC house 5 ton.

b. Sufficient sets of steel wire hoisting ropes
c. All integral electric cabling and wiring
d. All limit switches
e. One (1) set of gantry structure, gantry rails, girders, holding down bolts, securing plates, abutments, and weather protection shed.
f. One (1) set of power supply cables and trolley conductors complete with supporting brackets and one (1) set of power supply indication lamp
g. One (1) alarm bell
h. All lifting eyes, rings and bolts to facilitate erection and maintenance
i. All catwalks, ladders, platforms and handrails to provide safe access to items requiring regular maintenance

J. Special tools required for the maintenance of the crane

k. All other equipment required for the safe and efficient operation of the crane
18.1.3 TYPE OF CRANE

The crane shall be of the semi-indoor/ indoor and low speed overhead electric," travelling type equipped with single trolley, one (1) main and one (1) auxiliary hoist.

18.1.4 RATING

The rating of the crane shall be as follows:

(1) Hoisting capacity

Main hoist: 120% of maximum heaviest item. Main hoist capacity will be sufficient enough to lift the weight of Generator rotor as well as weight of the fully bladed gas turbine & Steam turbine rotor separately.

Auxiliary hoist: For turbine hall crane 20 ton, for CWP house and GBC house 5 ton

(2) Span : Not less than 11.5 m
(3) Lift : Not less than 10 m
(4) Speed
  a. Hoisting speed
     Main hoist : 5 m/min
     Auxiliary hoist : 10 m/min
  b. Trolley travel : 15 m/min
  c. Bridge travel : 15 m/min

(5) Operating power source and terminal voltage : 3 phase, 4 wire, 415 V AC, 50 Hz
(6) Bridge travelling rail : 37 kg/m (min.)
(7) Space limit of the crane : Determined by the requirement of the plant.

18.1.5 REQUIREMENT FOR CHARACTERISTICS

(1) The brake for hoisting shall be capable of stopping and holding 150% of the rated capacity.

(2) Deflection of bridge girder under load on main hook at the centre of the bridge girder shall not more than 1/500 of the span.

(3) The crane shall be capable of raising, lowering, holding and transporting the rated load without damage to, or excessive deflection of any crane parts,

(4) Operation of Hoists
     Each hoist shall be controlled individually by the relevant controller equipped in the operator's cab.

18.1.6 REQUIREMENTS FOR MATERIALS

(1) All materials used for the crane shall be new and conform to the latest revision of ISO or approved equivalent standards.
(2) Safety factors shall not be less than the following:

- Shaft and axles : 5.0
- Gears and pinions : 5.0
- Wire rope : 6.0
- Steel structure : 3.0

18.1.7 STRUCTURAL DESIGN

(1) Bridge and End Truck Frames

The bridge structures shall be of welded construction, but with all field connections designed for high-strength bolting. The various parts of the main structure of the crane shall be sub-assembled and the field connections reamed.

The end truck frames shall be either one-piece steel castings or built-up structural steel members.

(2) Trolley Frame

The trolley frame shall be fabricated from steel sections or cast steels and shall be designed to support the hoisting machinery.

(3) Walkway and Ladders

Steel safety tread walkways and ladders shall be provided to allow access to all parts of the crane for inspection, repairs and maintenance. Where required, cross walkways shall be provided, connecting walkways on opposite sides of the crane.

Walkways shall be at least 0.70 m wide and provided with a substantial toe-guard at least 0.10 m high and hand-railing not less than 1 m high over the entire length and ends. Ladders shall be provided where required for access between the walkways and operator's cab. The Contractor shall prepare access from the floor to the operator's cab.

(4) Operator's cab

An operator's cab shall be located on each crane and in such a manner as to allow maximum travel of the hooks and maximum visibility for the operator. The cab frame shall be fabricated from steel. All the enclosed walls of the cab shall be of transparent material.

The following controls shall be located inside of cab:

a. Manually operated controllers and master switches
b. Main air circuit breaker
c. Push - button switch for main contactor
d. Individual switches for lighting, warning signal, etc.
e. Volt meter for power source

18.1.8 ELECTRICAL DESIGN

The Contractor shall furnish and install all electrical equipment on the crane including all motors, electrically operated brakes, air circuit breakers, switches, contractors, controllers, resistors, control panels, relays, limit
switches, trolley travel conductors, current collectors, transformers, complete lighting system, receptacles, conduit, wiring, cabling, insulators, anchors and other electrical equipment necessary for the safe and proper operation and control of the crane.

The Contractor shall also supply the main runway conductors, insulators, brackets and associated accessories.

The main power supply shall have a short circuit capability of 50 kA. All electrical equipment shall conform to the appropriate IEC.

All motors, controllers, auxiliary apparatus and conduit shall be substantially grounded to the structural parts of the crane.

Motors:
All electric motors shall be of the wound rotor, drip-proof, protected type and tropicalized. They shall be in accordance with the latest edition of IEC Standard for crane motors.

(2) Controller
The controllers shall be readily accessible for maintenance and inspection purposes. The nominal 415 volts, three phase, 50 Hz power supply from the main collectors shall be controlled by means of a suitable manually operated main air circuit breaker located in the operator's cab.

The main power supply breaker shall be identified by a nameplate instructing the operator to open the breaker when leaving the cab upon completion of work.

a. Bridge and Trolley Travelling
The travel motion of the bridge and trolley shall be controlled by the normal methods of acceleration, reversing and plugging the motor. Multi-pole contactors may be used. Within limits of each required speed, the drive shall be controlled to provide substantially uniform speed regardless of load. The control shall include all necessary relays, timers, and limit switches required, for smooth and safe operation.

b. Hoisting and Lowering Control
The hoist drive shall be controlled to provide substantially uniform speed on each master switch step regardless of load.

(3) Main Circuit Contactor
A main circuit contactor shall be provided in common for main power supply circuit of main and auxiliary hoists, and for bridge and trolley travel.

The main circuit contactor shall be controlled manually by a pushbutton switch located in the operator's cab and it's control circuit shall have necessary interlocking circuit as follows, but not limited to these.
(4) Master Switch

The master switches for the main hoist, auxiliary hoist, trolley travel, and bridge travel shall be on the cam operated type, with a contact operating mechanism to ensure, positive operation of the contracts in both directions. Contacts shall be double break, spring-operated, readily renewable without disturbing the wiring and with automatically adjusting fingers to reduce wear.

(5) Limit Switch

Automatic reset, totally enclosed, heavy duty, adjustable limit switches shall be provided to limit the travel of the trolley and the bridge. The switches shall disconnect power supply to the motor when either the bridge or the trolley has travelled to within braking distance of its respective stop at either end of the travel. A warning signal, preferably a buzzer installed in the cab, shall alert the crane operator when the trolley approaches its stops. The signal shall be activated ahead of the trolley's limit switch.

(6) Protective Panel

All power circuits to motors and all secondary circuits such as lighting shall be placed in the panel. The panel shall also include all overload relays, low voltage control, and all other necessary equipment recommended by the Contractor.

(7) Runway Conductors and Trolley Conductor

The Contractor shall furnish the main runway conductors, insulators, support brackets, and all other necessary equipment required for installation. The Contractor shall also furnish and install the trolley conductors, insulators and accessories required for the complete operating system. The insulators shall be brown glazed porcelain insulators. The size of conductor shall not be less than 125 sq. mm solid copper.

(8) Cabling

All cabling, collector gear and power supply conductors required for the operation of the crane shall be supplied by the Contractor. The crane shall be capable of travelling the full length of the turbine area as shown on the Drawing.

Support brackets, suitably insulated, shall be supplied by the Contractor for power supply conductors. Power cables and isolation switch for the supply to the power supply conductors shall also be supplied by the Contractor.

18.1.9 GANTRY STRUCTURE, RAILS AND GIRDER

The Contractor shall supply a set of gantry structure complete with weather protection shed, rails and girders holding down bolts and abutment plates located at the ends of each rail. Gantry rails and girders shall run over the full length of the turbine area and adequate allowance for thermal expansion shall be provided in the design. The structural steel shall be designed and fabricated conform to the Section “21.5.1”, Vol.2 of 3.

The weather protection shed shall be provided to cover the working area of
the crane as shown on the attached Drawings. The material of
the shed shall be corrugated asbestos cement sheet. The thickness of
asbestos cement sheet shall not be less than 5 mm.

18.1.10 SITE TESTS

(1) Control and protective equipment

Static tests of all automatic sequences.

(2) Running tests

The assembled crane shall be load tested including overload test with
a load equal to 125% full lifting capacity after erection by the
Contractor and all tests shall be in accordance with the relevant IEC
Standard.

The Engineer and the Board shall witness these tests.

The Contractor shall supply all equipment including weights for the above
tests. The Contractor shall also be responsible for the disposal of the
materials used for the test load.

18.2 MOBILE CRANES

18.2.1 GENERAL

The Contractor shall provide the following mobile cranes which will be
utilised for erection works and for maintenance works after Taking over of
the Plant.
The crane shall be complete with all necessary appurtenances to ensure its
safe and efficient operation.

a. One (1) 30 ton self-propelled diesel engine driven mobile telescopic
   crane.
b. One (1) 5 ton truck with 3 ton jib crane

18.2.2 TYPE AND RATING

(1) 30 ton mobile truck crane

a. Maximum lifting capacity : not less than 30 ton
b. Basic boom length : approx. 9.23-28.49 m
C. Maximum boom length : not less than 28.6 m
d. Wire speed for lifting : max. Approx. 100 m/min.
e. Boom telescopic speed : approx. 4 m/sec.
f. Crane turning : by manually
g. Type of carrier : Diesel engine driven truck type with
   rubber tires.
h. Type of boom control : Hydraulic
i. Maximum running speed : not less than 70 km/hr.
J. Climbing capacity (tan 0) : not less than 0.30
k. Minimum rotating radius : not exceeds 7 m
l. Type of outer rigger : Hydraulic
m. Safety apparatus : Over load limiter, safety interlocks
   etc. shall be provided.
(2) 5 ton truck with 3 ton jib crane.
The jib crane shall have a following features at the minimum:

a. Maximum lifting capacity: not less than 3 ton
b. Basic boom length: approx. 4 m
C. Maximum boom length: not less than 10 m
d. Wire speed for lifting: max. Approx. 100 m/min.
e. Boom telescopic speed: approx. 4 m/sec.
f. Crane turning: by manually
g. Type of carrier: Diesel engine driven truck type with rubber tires.
h. Type of boom control: Hydraulic
i. Maximum running speed: not less than 70 km/hr.
j. Climbing capacity (tan 0): not less than 0.30
k. Minimum rotating radius: not exceeds 7 m
l. Type of outer rigger: Hydraulic
m. Safety apparatus: Over load limiter, safety interlocks etc. shall be provided.

18.3 One 5 ton Forklift (Engine driven)
18.4 One 5 ton truck/lorry for transportation of materials
18.5 One half truck (01 ton) for transportation of materials
18.6 TOOLS

18.6.1 GENERAL

The following tools and equipment shall be supplied under this Contract and the Tenderer is required to give a full list with details in the Schedule of Tools and Appliances when submitting his Tender.

Each set of tools and appliances shall be provided with conveniently sized, robust, lockable boxes suitably inscribed with the name of the Plant for which they are to be used.

The tools and appliances with the boxes shall be handed over to the Board at the time of issue of the Operational Acceptance Certificate.

18.6.2 SPECIAL TOOLS

One set of special tools, gauges and equipment required for the normal maintenance of the whole of the Plant shall be provided by the Contractor.

One set of special lifting and handling appliances required for the normal maintenance (such as lifting of turbine casing, lifting of rotor) of the whole Plant and equipment shall be provided by the Contractor. Special tool list with unit price shall be submitted with Tender.

18.6.3 HOIST

The hoist shall be of electrical or chain-block type and the capacity shall be selected taking into consideration of highest weight of object/equipment. The hoist shall be provided with the monorail, supporting materials for rail and anchor bolts. The hoists shall be installed in the following area, but not be limited to, for the convenience of maintenance:

EDG room, River intake pump house, Fire fighting pump house, Chemical plant, Workshop Building (Mechanical & Electrical) and Store Building.
Section 19

Tests and Inspections
19. Tests and Inspections

19.1 General
19.2 Workshop Test
19.2.1 Gas Turbine
19.2.2 Generator
19.2.3 Exciter
19.2.4 Step-up Transformer
19.2.5 230 kV Switchgear Equipment
19.2.6 Control and Protection System
19.2.7 Other Materials and Equipment
19.3. Tests at Site
19.3.1 Tests and Completion
19.3.2 Field Inspections and Tests on Gas Turbine Units
19.3.3 Field Inspections and Tests on Switchgear Equipment
19.4. Acceptance and interim Operation
19. Tests and Inspections

19.1 GENERAL

The Contractor shall perform all tests and inspections necessary to ensure that the material and workmanship conform to the Contract and design drawings. Those tests and inspections shall demonstrate that the equipment will comply with the requirements of this Specification and meet the specified guarantees.

The Board and the Engineer shall have a right to access the Contractor's or sub-Contractor's works to determine or assess compliance with the provisions of this Specification or to witness the Contractor's inspections or tests.

The contractor shall supply to the Engineer/Board as soon as practicable which shall contain details of each test performed and shall be prepared as required by the Engineer/Board, records, results and calculation of all electrical tests shall be provided.

19.2 WORKSHOP TEST

(1) 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 Contract.

(2) Type, sample and routine 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.

(3) 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 Engineer. 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.

(4) The Contractor shall submit evidence to the Engineer 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.

(1) Factory Acceptance Test: During test, transfer of Technology and Technical know-how regarding Equipment, parameters and testing procedure including familiarization/ testing of equipment to BPDB Engineer is to be performed. The Contractor shall bear the cost of round air tickets, hotel accommodations, per diem allowances, and internal transportations and out of pocket expenses @ US $ 100.00 per person per day. The Contractor shall at its own expense carry out at the place of manufacture all such tests and/or inspections for (1) Gas Turbine, (2) Steam Turbine, (3) Generator, (4) Generator Circuit Breaker, (5) Unit Transformer, (6) DCS, (7) Gas Booster Compressor, (8) CW Pump, (9) Feed Water Pump, (10) On Load Tap Changer (GSUT), (11) Condenser, (12) Emergency Diesel Generator (EDG), (13) Control & Protection System, (14) 230 KV Switchgear, (15) As per requirement of BPDB for one other item. Fifteen (15) round trips (two Engineers/ round trip) and seven working days/ Inspection shall be
considered. Such witness/inspection/ test shall not relieve the supplier from any obligation to supply/install the equipment in accordance with contract document. For the above mentioned test, Invitation letter should be submitted to the Purchaser at least 03 (three) months prior to the schedule date of the witness and tests.

19.2.1 Gas Turbine

The gas turbine unit shall be assembled as a complete unit and run under simulated operating conditions at the manufacturer's works. The unit shall be tested to ensure smooth running and satisfactory operation of the accessories.

The Contractor shall state in his proposal the performance and reliability tests to be carried out in the works. The tests to be carried out shall include, but not be limited to, the following:-

- Dynamic balancing together with over-speed tests of the turbine and Compressor rotors
- Bench testing of all accessories
- No load operation of the turbine assembly to test the followings:-
  - Vibration
  - Lubrication system
  - Fuel system
  - Wheel space temperature
  - Exhaust temperature
  - Governor system
  - Temperature control system
  - Air system
  - Over-speed trip
  - Water system
  - Individual accessories

19.2.2 HEAT RECOVERY STEAM GENERATOR AND ANCILLARIES

The HRSG & ancillaries shall be tested on the factory, those tests shall include, but not be limited to, the following:

1) Hydraulic tests:
   Steam generator drum, header, boxes and other forged components, high pressure steam valves & safety fittings shall be tested on completion of welding and after heat treatment for a period of not less than 30 minutes.

2) Mechanical tests:
   a) X-ray inspection throughout the length of welds.
   b) Vibration or noise test on the auxiliary plant & all motors in running condition.

3) Electrical tests:
   a) Power frequency high voltage withstand test on small wiring of 2 KV.
   b) On all motors as per relevant IEC.
19.2.3 STEAM TURBINE AND ANCILLARIES

The Steam Turbine and ancillaries shall be tested on the factory, those tests shall include, but not be limited to, the following:

1) Hydraulic tests:
   The following hydraulic tests shall be applied for a period of not less than 30 minutes:
   a) Turbine casing.
   b) High pressure steam valves, chests, pipings etc.
   c) Low pressure valves & pipings.
   d) Oil coolers.
   e) Water heat exchangers.
   f) Condensers.
   g) Air ejectors.
   h) Pumps.

2) Mechanical tests:
   The Turbine rotor shall, after completion be tested to an overspeed of 15% for 5 minutes.
   All auxiliary plant, the rotor of the generator & exciter shall also be tested.

3) Electrical tests: (as per relevant IEC)
   a) All motors.
   b) Small wiring of 2 KV.
   c) CT, VT etc.

19.2.4 GENERATOR

Each generator shall be operated at no-load on the factory test floor with the following observations and respective data so reported and reference to IEC Standard shall be made:-

b. Mechanical inspection and balance.
c. No-load field current at rated voltages and frequency.
d. Voltage phase balance and phase sequence.
e. Dielectric tests.
f. Insulation resistance of field and armature.
g. Standard no-load and short circuit tests.
h. Characteristic "V" curve test and efficiency tests.
i. Generator fixed losses.
J. Generator variable losses (at loads available with driving motor).
k. Measurement of vibration
l. Temperature rise test

19.2.5 EXCITER

Each exciter shall be operated at no-loads on the factory test floor with the following observations and respective data so reported and reference to IEC Standard should be made:-

a. Saturation run.
b. Mechanical balance.
c. Resistance.
d. Dielectric tests.
e. Insulation resistance of windings.
f. Exciter characteristics tests

### 19.2.6 STEP-UP TRANSFORMER

The transformer shall be completely assembled at the factory and shall be subjected to the following tests by the Contractor, in accordance with the latest revisions of IEC 60076 "Power transformers" and 60551 "Measurement of transformer and reactor sound levels".

a. General inspection
b. Measurements of Winding resistance
c. Voltage ratio measurement and check of polarity
d. Measurement of impedance voltages
C. Measurement of load loss
f. Measurement of no-load loss and current
g. Test of temperature rise
h. Induced over-voltage withstand test
i. Separate-source voltage-withstand test
J. Insulation resistance measurement (megger)
l. Results of shop tests to be submitted.
- Results of type tests of lightning impulse-voltage withstand test
- Test of protective relays
- Characteristic test of bushing type current transformers

### 19.2.7 230 KV SWITCHGEAR EQUIPMENT

#### (1) Circuit Breakers

The tests shall be performed in accordance with IEC 56-4 'High-voltage alternating-current circuit-breakers, Part 4: Type tests and routine tests'.

- General inspection
- Insulation resistance measurement
- Dielectric withstand voltage test
- Operation test

In accordance with the requirements of IEC 56, details of the transient recovery voltage to which the circuit breaker will be subjected during short circuit testing shall be submitted to the Engineer for approval.

The Engineer may require in addition any of the following tests to be carried out, the details of which will be agreed between the Engineer and the Contractor:-

- Earth fault interruption tests
- Out of phase switching tests according to IEC 267
- Capacitance switching tests
- Small inductive breaking current switching tests
- Tests under environmental conditions
- Voltage withstand test after breaking capacity tests

#### (2) Isolators and Earthing Switch

The tests shall be performed in accordance with IEC 129 "Alternating
current disconnectors (isolators) and earthing switches).

- General inspection
- Insulation resistance measurement
- Dielectric withstand voltage test
- Operation test

(3) Current Transformers

The test shall be performed in accordance with IEC 185 "Current Transformers".

- General inspection
- Polarity test
- Insulation resistance measurement
- Dielectric withstand voltage test
- Characteristic test

(4) Voltage Transformers

The test shall be performed in accordance with IEC 60044 "Voltage transformers"

- General inspection
- Polarity test
- Insulation resistance measurement
- Dielectric withstand voltage test
- Characteristic test

(5) Lightning Arresters

The test shall be performed in accordance with IEC 99-1 "Lightning arresters, Part 1: Non-linear resistor type arresters for AC system".

- General inspection
- Power frequency spark-over voltage test
- Lightning impulse spark-over voltage test
- Measurement of leakage current and insulation resistance

(6) Steel Structures

General inspection
Material quality and quantity check

(7) Bus Support, Insulators and Wiring Materials

The following shop tests shall be performed by sampling inspection method and number of samples for the test shall be decided after award of the Contract.

a. Bus Supports
   - General inspection
   - Dielectric test of power frequency
   - Tension proof test

b. Insulator Assemblies and Grounding Wire Attachment
   - General inspection
- Dielectric test of power frequency
- Breakdown test of insulator
- Dimension measurement of hardware
- Tension proof test

c. Stranded Conductors for Overhead Line and Grounding System
   - General inspection
   - Tensile strength test

d. Other Materials
   - General inspection

19.2.8 CONTROL AND PROTECTION SYSTEM

The following tests for the control and protection system shall be performed at the workshop.
- General inspection
- Measurement of insulation resistance
- Dielectric withstands voltage test
- Performance test of relay Error test of meter
- Sequential operation test

19.2.9 OTHER MATERIALS AND EQUIPMENT

All other materials and equipment shall be tested at the Contractor's workshops in accordance with latest IEC, ISO, other approved Standard and/or the request of the Engineer.

19.3 TESTS AT SITE

(1) Responsibility for Tests

a. The Contractor shall conduct the tests at the Site in accordance with these clauses and the conditions of the Contract.

b. The Contractor shall provide all equipment and personnel required to carry out the tests, including the provision, installation and removal of all test instruments, the connection and disconnection of plant items and obtaining of all records. The Board will provide electricity, fuel and water required for the tests on completion without charge to the Contractor.

c. The Contractor shall prepare and submit to the Engineer at least three months prior to the commencement of testing, schedules in approved format for each test together with a programs provided by all Contractors.

The Engineer will also be responsible for overall co-ordination and safety control of tests.

d. The Contractor shall submit one copy of the results of each of the tests at the Site to the resident Engineer within one week of the tests being carried out. Four copies of the certificates shall be provided to the Engineer within one month of the tests being carried out.

e. The Board's staff will observe and participate in the tests on Completion.
f. The Contractor shall submit evidence to the Engineer that the instruments used for the tests have been calibrated at an approved testing laboratory within a period of up to six months.

(2) Scope of Tests

The tests to be carried out and passed before taking over of the works by the Board/Engineer shall be deemed to comprise two main stages of testing as follows:

a. Preliminary tests (Pre-Commissioning) which are tests performed prior to rotation of energising at normal voltage or admission of normal water or air pressure to the main or auxiliary plant under test.

b. Tests (Commissioning) on completions which are tests to progressively prove the correct operation of complete auxiliary systems and of the main plant items. These tests shall be carried out in accordance with the conditions of the Contract.

19.3.1 TESTS ON COMPLETION

Followed as per Volume 1.

19.3.2 FIELD INSPECTIONS AND TESTS ON GAS TURBINE/ HRSG/ STEAM TURBINE UNITS

The following field inspections and tests will be carried out in the sequence detailed below, and the successful performance and completion of all the tests taken together shall constitute the Board's acceptance tests:-

(1) Inspection and Checking of Units

After completion of erection and/or installation, and before put into operation of the unit and all its appurtenances (compressor, gas turbine, motors, pumps, heaters, fans, piping, valves and all other mechanical and electrical equipment and material) shall be thoroughly cleaned and then inspected under the supervision of the Engineer and in presence of the Board for correctness and completeness of installation and acceptability for placing in operation. The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.

(2) Start-up and Trial Operation

Following the satisfactory completion of the inspections and checking of unit, the same will be placed in trial operation during which all necessary adjustments, repairs etc. shall be made as required, then the unit being shut down as required. When the equipment is operating properly its characteristics shall be recorded on the start-up report sheets. Start-up reports for all the equipment must be completed before the start of the Reliability Test period. The time consumed in start-up and trial operation shall be considered as a
part of the erection and installation period.

(3) Reliability Test Period

a. The tests on completion shall include a reliability test period for Combined Cycle unit and auxiliaries, which shall commence when the Contractor has notified the Engineer that the unit is ready for commercial operation. Before start of the Initial Commercial Operation, said Reliability Test Run of the Combined Cycle Unit & auxiliaries shall be performed for 72 hrs. After successful completion of the Reliability Test Run, the unit will be ready for Initial Commercial Operation.

(3) Initial Commercial Operation (ICO)

The Contractor shall be responsible for running on initial commercial operation period at the Site on Combined Cycle unit, including all auxiliaries and controls for the Plant. The Contractor shall operate the units at various loads as specified by the Engineer after synchronising the system.

The initial commercial operation shall start on the specified date and shall last for one hundred sixty eighty (168) hours during which time the unit and auxiliaries will operate continuously, uninterrupted without adjustment or repair to the satisfaction of the Engineer at all loads up to and including the maximum loads at base load, peak load and Free Governing Mode Operation (FGMO).

On the completion of continuous operation for one hundred sixty eighty (168) hours on all automatic and supervisory controls, the Engineer may instruct cycling operation, shutdown and start-up during the next seven (7) days. After satisfactory completion of these observations, the unit shall be considered to have been put on initial commercial operation from the date of start of the initial commercial operation.

(4) Performance and Acceptance Tests (Guarantee Test)

Soon after the initial commercial operation tests have been run, performance tests shall be run to determine whether the equipment complies with the guarantee provided that unit is made ready for performance test by the Contractor and certified by Engineer. The tests shall be conducted in accordance with ISO or PTC and the latest ASME-IEEE Power Test Codes using previously approved correction curves and complying with the following special conditions unless otherwise specified. The chemical analysis and lower heating values of the fuels shall be determined in the Board's laboratory and two other laboratories to be chosen respectively, one by the Board, the other by the Contractor.

The Board shall provide without charge such labour, electricity, fuel and water (as mentioned in Vol-1 of tender document) as may be reasonably required to conduct the performance and acceptance tests. The gross station efficiencies under different load conditions established during a four (4) hours continuous test, shall be calculated in a manner as approved by the Engineer. Power measurements at the generator terminals and at the incoming circuit of unit motor control centre shall be made with totalizing meters.
Generator power output shall be held as constant as possible during the performance test.

The Generator shall run at 50%, 75% and 100% load (for CC mode) of base rating, peak load and Free Governing Mode Operation (FGMO) prior to placing into commercial operation and to prove that sudden load rejections from loads up to maximum capability can be accommodated by the turbines without the speed rise being sufficient to cause the over-speed trip to initiate.

The output and heat rate tests will be carried out in the following manner:

i) 1/2 hour at 1/2 load  
ii) 1 hour at 3/4 load  
iii) 1 hour at 4/4 load

Full load at Generator step-up transformer HT side for the purpose of the test will be calculated from the guaranteed output according to the site ambient installation conditions.

Correction factors for variations of test conditions from the specified design conditions shall be stated in the Tender.

Note:
1. Please note that during Performance & Acceptance test for measuring Net output/ Net heat rate, operation of any ancillary equipment/ arrangement, such as water/steam/air injection, evaporator, chiller etc shall not be used for any purpose even for NOx control. For demonstration of declared guaranteed figure of NOx emission, separate test will be conducted with water injection.

2. Performance & Acceptance test shall be carried out for Combine Cycle to judge the Guarantee parameter. However simple cycle operation to be carried out by Shut down of steam turbine from 100% load, 75% load to ensure i) GTG is running at the same load that was running before ST shutdown ii) diverter dampers of GT are open to bypass stack iii) LP/HP steam bypass are working perfectly with relevant steam control valves & auxiliaries. In addition, a separate test will be carried out that Gas Turbine operation can be performed independently in simple cycle mode.

(5) Test Reports

The Contractor shall submit to the Engineer within three (3) months after the signing of the Contract, the detailed procedure for the conductance of the performance and acceptance tests for approval.

The procedure shall include the following for such test or group of tests:-

a. The time duration of each test at each load.  
b. The number of test runs at each load.  
c. The sequence of the tests to be conducted.  
d. A list of instruments that will be used for each test.

The list shall designate which instruments are:

i) Special test instruments  
ii) Certified
iii) To be calibrated before and after each test  
iv) Check instruments  
v) Station supply instruments.

Schematic diagrams showing all test points and cross references to the instrument list shall also be included.

e. All formulas, calculations, conversion factors, curves, correction curves, etc., to be used in the conductance of the tests and the calculations of the test results.

f. Sample test reports or data sheets and all specific result sheet forms that will be used for the test.

g. Written procedure and description of conducting the test.

h. All test data to be recorded by the Contractor and the Engineer.

19.3.3 FIELD INSPECTIONS AND TESTS ON SWITCHGEAR, EQUIPMENT

The following site tests shall be performed by the Contractor.

(1) Protection, Control, Alarm, Measurement and Indication Equipment

a. Wiring

Insulation resistance test using 500 V Megger shall be carried out on all AC and DC protection, control, and alarm and indication circuit.

The insulation of all circuits shall be checked before proceeding with other tests and it is also essential that all AC wiring is correctly connected relay contacts, auxiliary contacts, etc., being closed, as necessary, to verify this. Checks shall be made on cable glands, cable jointing, fuse or circuit breaker and small panel items, such as indicating lamps. Static equipment which may be damaged by the application of test voltage shall have the appropriate terminals short circuited. Inter relay, inter unit and cubicle wiring carried out at the Site shall be checked to the appropriate circuit and/or wiring diagram.

Where, it is found necessary during pre commissioning work to effect site modifications to the secondary wiring, site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with the Engineer before the circuit is commissioned. Loop resistance measurements shall be made on all current transformer circuits. Separate values are required for current transformer circuits.

b. Mechanical Check

All relays shall be examined to ensure that they are in proper working condition and correctly adjusted, correctly labelled, and the relay case, cover, glass and gaskets are in good order and properly fitting.

c. Secondary Injection
Secondary injection shall be carried out on all AC instruments and relays, using voltage and current of sinusoidal waveform and rated power frequency.

(2) Current Transformer Magnetising Tests

The magnetisation characteristic of all current transformers shall be checked at the minimum of two points to identify the current transformers with reference to the manufacturer's estimated design curve, and to determine the suitability of the current transformer for its intended duty. It may be noted that it is not normally necessary to check the characteristic up to the knee-point for this purpose. Special measures may have to be taken to ensure that the core is fully de-magnetised before commencing the test.

a Primary Injection

Primary current injection tests shall be carried out by the Contractor. The primary injection methods employed for a particular installation shall therefore be agreed with the Engineer.

Tests shall be carried out as follows:-

-Local primary injection to establish the ratio and polarity of current transformers of similar ratio.

-Overall primary injection to prove correct inter-connections between current transformer groups and associated relays.

-Fault setting tests to establish, where practicable, the value of current necessary to produce operation of the relays. If not practicable, these tests are to be carried out by secondary injection applied at the wiring close to the current transformer.

(3) DC Operations

Tests shall be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indicating and alarms.

(4) On Load Tests

In view of the hazards inherent in these tests, they shall be carried out under the direct supervision of the Engineer.

An operation and stability test shall be carried out for on load commissioning of unit type protection.

Test for restraint shall be carried out to prove the characteristics of protective systems with directional characteristics,

On load checks shall be made after the protection gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed, as well as to confirm the integrity of the current
transformer circuits. Where necessary voltage readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete. Special attention shall be paid to broken delta voltages and residual current circuits where zero voltage or current respectively may not be proof of the completeness of the circuit.

(5) Step-up Transformer

a. General mechanical checks.
b. Core and winding insulation tests.
c. Ratio and HV magnetising current tests.
d. Vector group check.
e. Motors overload protection tests.
f. Buchholz device tests.
g. Temperature instrument calibration and tests.
h. Operational tests on tap change equipment.
i. Dielectric strength tests of insulation oil.

The above tests shall be recorded on approved test sheets, two signed copies of which shall be forwarded to the Engineer immediately after a test or series of tests has been completed.

The Engineer shall countersign the test sheets if found to be satisfactory and retain one copy. The Contractor shall provide to the Engineer six bound copies of all site test sheet as final records.

(6) 230 kV Switchgear

a. General Check

A general check of all the main switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, arcing ring and horn gaps, painted surfaces, cables, wiring, pipework, valves, blanking plates and all other auxiliary and ancillary items. Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items which are to be handed over the Board, e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over.

b. Circuit Breakers

Following completion of erection of circuit breakers and all high voltage circuits, power frequency withstand voltage test at a level to be agreed shall be applied.

Local air components associated with pneumatic operation, including air compressors, shall be tested and air loss measurements and pressure and alarm settings checked. Tests shall be made also on mechanical and hydraulic operating systems.

Contact resistance tests shall be carried out with not less than 100 amperes passing through the contacts. In the case of multi-interrupter circuit-breakers, resistance tests will be required at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.
Operational tests will include local and remote trip/close. SF6 gas type circuit-breakers testing shall be required on the gas system to prove the gas quantity, its dryness and its dielectric strength. The gas leakage shall also be measured.

c. Isolators and Earthing Switches

Manually operated equipment shall be subject to operational tests to confirm contact pressures, contact resistance, synchronism of operation of all phases and the ease of operation.

Checks shall be made of the local and remote indications and operation of auxiliary contacts. Motorised equipment shall be tested to prove the motor operation, including local and remote operation. Timing tests shall also be carried out.

Earth switches and maintenance earthing devices shall be tested to confirm the opening and closing sequences and checks shall be made on the earth mat, indications and manual locking devices.

d. Voltage Transformers

All voltage transformers shall be checked for polarity phasing and for secondary output.

e. Lightning Arresters

General inspection shall be carried out to verify the condition and satisfactory mounting of the arrester and its earth connections and electrodes.

(7) Interlocking

All interlocking arrangements both electrical and mechanical shall be fully checked and tested.

(8) Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion attack on the earthing system.

(9) Others

All other equipment and/or systems shall be tested in accordance with the instruction by the Board and/or the Engineer.
19.4 ACCEPTANCE AND INTERIM OPERATION

(1) After the performance tests, if the equipment supplied by the Contractor is found to meet the guarantees and any other specified requirement, and if all other work called for hereunder has been completed, the Board's acceptance will be forthcoming. This acceptance shall, however, not relieve the Contractor of his responsibility for first inspection.

(2) Should the equipment furnished by the Contractor fail to operate as required, or in case of failure to meet any of its guarantees, the Board shall have the right to operate the equipment, using the Contractor's supervisory operating personnel, until such defects have been remedied and guarantees met with. In the event that defects necessitate to the rejection of the equipment or any part thereof, the Board shall have the right to operate the equipment until such time as new equipment is provided to replace the rejected equipment. Such operation shall not be deemed an acceptance of any equipment.
Section 20

Civil Works
20. CIVIL WORKS

20.1 General
20.1.1 General Requirement
20.1.2 Topographic Surveys
20.1.3 (a) Site Investigation
20.1.3 (b) Subsoil Investigation
20.1.4 Site Laboratory
20.1.5 Records and Drawings
20.1.6 Samples, Testing and Inspection
20.1.7 Standards and Codes of Practice
20.1.8 Preparation of Design and Drawings

20.2 Scope of Civil Works

20.3 Earthworks
20.3.1 General
20.3.2 Excavation
20.3.3 Filling
20.3.4 Backfilling
20.3.5 Measurement and Payment

20.4 Foundation
20.4.1 General
20.4.2 piling
20.4.3 Foundation of Gas Turbine Generator
20.4.4 Foundation for Building and Other Equipment
20.4.5 Hardcore
20.4.6 Replacement of Unsuitable Materials

20.5 Deleted.

20.6 Concrete Works
20.6.1 General
20.6.2 Composition
20.6.3 Tests
20.6.4 Cement
20.6.5 Admixture
20.6.6 Water
20.6.7 Aggregate
20.6.8 Standard Grading
20.6.9 Concrete Mixing
20.6.10 Placing
20.6.11 Transportation
20.6.12 Curing
20.6.13 Formwork and Timbering
20.6.14 Waterstops and Expansion Joints
20.6.15 Finish and Repair of Concrete
20.6.16 Reinforcement Bar
20.6.17 Payment
20.7 Roads and Surfacings
20.7.1 Concrete Pavement
20.7.2 Gravel Surfacing
20.7.3 Landscaping and Turfing
20.8 Drainage System
20.8.1 Design Conditions
20.8.2 Drain Laying
20.9 Sewage Works
20.9.1 General
20.9.2 Sewer, Manholes and Septic Tanks
20.10 Water Reticulation System
20.10.1 Internal Water Reticulation System
20.10.2 Water requirement.
20.10.3 Design Parameters and Standard
20.10.4 Materials and Workmanship
20.10.5 Deepwell and Deepwell Pumps
20.11 Ducts
20.12 Fencing and Gates
20.12.1 Fencing
20.12.2 Gates
20.12.3 Flag, Poles
20.12.4 Site Boundary Wall
20.13 Water intake and discharge facilities
20.14 Platform for Loading & Unloading
20. Civil Works

20.1 GENERAL

The General Conditions, Tender Drawings and Schedule of Rates shall be read in conjunction with this Specification. Matters described in one are not necessarily repeated in the others.

20.1.1 GENERAL REQUIREMENTS

The Tenderer's proposal shall cover all requirements of the Tender Documents and any other items not specifically mentioned but which are deemed to be necessary for the satisfactory design, supply of materials, construction, and supervision of the civil works on the basis of a turnkey contract.

The Contractor shall upon examining the design of the foundations and major structures incorporated in the bid drawings, develop and prepare the detailed design and the construction drawings of all civil structures for the approval of the Engineer which shall meet the equipment and structures specification, to be supplied by the Contractor for the Project.

The Engineer shall reserve the right to examine the Contractor's design and to instruct a change or modification by the Contractor.

These modifications shall be carried out by the Contractor without additional cost as a result of any claims made by the Contractor on the Board.

Approval of the design by the Engineer shall not relieve the Contractor of liability for the construction works.

The Tenderer shall familiarise himself with the site levels, subsoil and other data necessary to enable him to estimate the bearing capacity and foundation requirements, for use in the preparation of his tender.

It is the Contractor's entire responsibility to search for filling material for land reclamation work and to make all arrangements necessary for the satisfactory completion of the land reclamation work within the Project. His tender shall include for all local eventualities.

The Tenderer shall quote firm prices which shall remain valid throughout the Contract Period on all items in the Price Schedule unless otherwise stipulated.

20.1.2 TOPOGRAPHIC SURVEYS

The Contractor shall carry out surveys as are necessary for the proper design and execution of the Works. The results of such additional surveys together with the survey drawings shall be submitted to the Engineer for approval.
20.1.3 (a) SITE INVESTIGATION

The Contractor can conduct soil investigation, ambient air quality investigation, river water/underground water quality investigation if deemed necessary at his own cost before submission of the bid. However, after signing of contract the soil investigation, land filling, soil improvement/development, ambient air quality investigation, river water/underground water quality investigation at the cost of the contractor is mandatory for detailed design of the civil work/other equipment. Soil improvement/development (if required) shall have to be done by the Contractor at his own cost. Additional money cannot be claimed for poor quality of soil/air/water.

20.1.3 (b) SUBSOIL INVESTIGATION

Subsoil investigation shall be done considering nature, load bearing capacity, earthquake impact capability and settlement capacity of the soil before constructing a building, structure or foundation for power plant equipment. This subsoil investigation shall be done as per BNBC and ASTM standards.

20.1.4 SITE LABORATORY

The Contractor shall provide a site laboratory with a concrete floor space of not less than 4m x 6m adequately equipped to carry out quality control tests of material and workmanship in accordance with the procedures and tests as described in the relevant ASTM Standard or other approved Standard. He may as an alternative to the provision of laboratory equipment, make arrangement for all necessary tests to be carried out by personnel with relevant experience from an approved laboratory.

20.1.5 RECORDS AND DRAWINGS

The Contractor shall keep at the Site accurate and up-to-date records and drawings of the Works, and shall submit these records to the Engineer at the end of every week. Such record shall include the amount of labour, plant and materials employed upon the Site during that week.

20.1.6 SAMPLES, TESTING AND INSPECTION

The Engineer may request at any time to test or inspect sample of material and workmanship proposed and the Contractor shall furnish these immediately. When the Engineer has approved the samples, material, and workmanship not corresponding in quality and character with the samples approved shall be rejected. The costs of all sampling and testing to be conducted either on the Site or in an approved laboratory shall be borne by the Contractor.

20.1.7 STANDARDS AND CODES OF PRACTICE

The Civil Works shall be designed and constructed in accordance with the Specifications, relevant Standards and Codes of Practice approved by the Engineer. The Contractor shall submit together with his bid a schedule of standards and codes of practice to be followed in the design and construction of the Works. Copies of these codes and standards shall be
made available to the Engineer during the design and construction period. In the case of the Standards and Codes not published in English, the Contractor shall obtain English translations when required and send them to the Engineer. The Contractor shall be responsible for the establishment of design parameters to satisfy the requirement of the project.

Basic design conditions shall be as follows:

- **a. Seismic coefficient at Ground Level (Horizontal) (PGA):** As per Seismic Map of approved Latest BNBC
- **b. Design Storm:** Based on frequency-intensity Duration curves prepared for Chattogram Zone
- **c. Wind velocity:** As per latest Wind Map
- **d. Design load for road:** H20-S16-44 (AASHO)
- **e. Standards and codes of practice:** ASTM, ACI, and international codes of practice and other Standards to be approved by the Engineer

### 20.1.8 PREPARATION OF DESIGN AND DRAWINGS

The Contractor shall prepare all designs and detailed working drawings as deemed necessary for the execution and completion of the Works. The Contractor shall be responsible for ensuring that the design satisfies the requirements of all local and national authorities. Design calculations shall be in accordance with an approved method and should take into account the most critical combination of dead load, wind load, and seismic load. Design calculations and detailed drawings shall be submitted to the Engineer for approval. The Contractor may commence construction on the Site only after drawings are approved by the Engineer.

### 20.2 SCOPE OF CIVIL WORKS

The civil works shall include collection of site data, detailed design, production of working drawings, provision of labour, supply of construction plant and materials, construction and rectification of defects during the Warranty Period of the Works.

The Scope of Work shall include, but not be necessarily limited to, the following:

- **a. Site Works:** Site clearance, excavation and filling of the Site to formation level (0.8 meter above High Flood Level or 1.0 meter above nearest Highway which one is higher) including running surplus excavated materials to disposal area, sheet piling work, site roads and surfacing, water supply, sewage treatment cable ducting, pipe ducting, drainage, landscaping, fencing and gates.

- **b. Foundation:** For all plants and structures supplied under this Contract. Suitable foundations shall be provided for the gas/steam
turbine generating unit, HRSG, Gas Booster Compressor, Transformers, 230 kV switchgear, and elevated water tank, water/steam supply system, cooling tower, overhead travelling crane, Platform/ standard permanent jetty for loading & Unloading at riverside, buildings, equipment and structures.

c) Temporary works as necessary to construct the permanent works. Provision of site office for the Engineer and the Project Director including all services, furnishings, and attendance for the period required by the Engineer but not exceeding one month after the final taking-over date.

20.3 EARTHWORKS

20.3.1 GENERAL

The Contractor shall prepare the drawing necessary for his construction purpose based on the attached drawings and the specification, and submit them to the Engineer for approval. The Contractor shall be responsible for and shall complete all the earthworks as shown on the approved drawings or as directed by the Engineer.

20.3.2 EXCAVATION

Before commencing any excavation on the Site, the Contractor shall notify the Engineer at least 48 hours before starting any additional surveys. He shall carry out, where directed by the Engineer extra surveys required to resolve any doubts which may arise as to correctness of any surveys or record. Thereafter the decision of the Engineer regarding what shall be recorded as the correct survey shall be final.

Excavations shall be carried out to the width, lengths and depths shown on the approved drawings. The Contractor may excavate by any method he considers suitable, subject to the approval of the Engineer.

Selected granular materials from the excavation as approved by the Engineer shall be used in the embankment construction and filling. Unsuitable materials shall be removed from the Site to disposal areas.

Cut and fill slopes shall be designed for to be thorough stability. Unless otherwise indicated on the Drawing the exposed surfaces of all cuttings and embankments shall be soiled and turfed to the satisfaction of the Engineer.

The Contractor shall take particular care during the excavation of the foundation to avoid deterioration of the ground due to exposure to the weather. The final 150 mm of excavation above formation level shall be carried out by hand immediately before the next stage of construction is to start. A similar method shall be adopted in the ease of the sides of excavation against which the structure is to bear.

The Contractor shall provide all strutting and shoring necessary for the safe execution of the Works and shall provide the necessary pumps, de-watering facilities, and temporary drains to ensure that all excavation shall
be carried out in the dry.

The rates for excavation and filling shall be deemed to have included for the full cost of excavation and filling of the materials including site clearing, stripping of top soil, all pumping and temporary works necessary to keep the excavation and filling free from water, temporary shoring and timbering, trimming to line and level, stock-piling, handling, compaction, cutting, slope protection, removing surplus excavated material to spoil tips, together with all other costs incurred in complying with the contract requirements.

20.3.3 FILLING

The area to be filled shall be cleared of vegetation and the top soil shall be stripped and stockpiled. All soft yielding material shall be removed and replaced with granular selected material. Where fill has to be deposited against the hill slope, the Contractor shall take all necessary precautions to ensure that a good bond is achieved between the fill and the original ground.

No fill shall be deposited in the area to be filled until the Engineer has inspected and given approval. Filling to the formation level shall be brought up from the bottom in uniform compacted layers. Excavated material obtained from the Site may be used for embankment construction and filling.

Filling, levelling and compaction on the Site shall be carried out in layers not exceeding 300mm thickness. The Contractor shall carry out all necessary quality control works including in-situ soil density tests, moisture content and other laboratory testing to ensure that all materials used in the embankment or filling elsewhere are compacted in accordance with the specified requirements.

The maximum dry density (MDD) for the purpose of this specification shall be determined by the following procedures or equivalent.

a. Selected materials used in the embankment other than below buildings shall be compacted to a density not less than 95% MDD.

b. Sub-grade for road below formation level to a depth 650mm shall be compacted to a density not less than 95% MDD or as approved by the Engineer.

c. Location of buildings and equipment foundations shall be compacted to a density not less than 95% MDD or as approved by the Engineer.

The following standards tests (any one) shall be conducted for determination of MDD.

(1) Standard Proctor Method
(2) Modified AASHTO Test

20.3.4 BACKFILLING

This section shall apply to the performance of all work in connection with
the required backfill for the permanent works.

(1) Material

Material for backfill shall be obtained from excavated soil or other sources approved by the Engineer

(2) Workmanship

Backfill to all foundations trenches, pits, etc., shall not be placed until the work has been inspected and approved. Backfill around sewers, water mains and other utility lines shall be carefully placed so that the piping will not be displaced or damaged. Fill in contact with pipes shall be entirely free of rocks. Backfill around service pipe shall be of sandy material. The backfill shall be compacted at optimum moisture content in layers not exceeding 15cm to 92% of the maximum dry density. Compaction shall be carried out by vibratory plate compactor.

20.3.5 MEASUREMENT AND PAYMENT

(1) Land reclamation works

Measurement by volume, for the payment of filling for the land reclamation works shall be made on the basis of the original ground surface and the site formation levels shown on the approved drawings. The quantity of filling given in the Schedule was estimated for Tendering purposes. If the final quantity of the filling work varies beyond 10 (ten) percent, the Contractor shall notify the Engineer for approval regarding the re-measurement and subsequent a variation the contract amount will be adjusted. Payment for the filling of the land reclamation works shall be made based on the unit price fixed by the Tenderer.

(2) Foundations and Ducts etc.

All expenses required for excavation and backfilling of foundations, ducts, trenches, roads and all other structures shall be included in the lump sum price bid for the respective work item in the Schedule. The lump sum price bid shall not be modified or subject to adjustment for any design variation due to a change of geological or other conditions.

20.4 FOUNDATION

20.4.1 GENERAL

The Contractor shall take full responsibility for the suitability of the type of foundations he proposes to use and shall guarantee the performance of the foundations.

All foundation shall be designed in accordance with the requirement as laid down in CP2004: 1972 Foundation\* or other approved Standards and Codes of Practice/BNBC.
20.4.2 PILING

Pile foundations shall be designed and applied to buildings, equipment, and structure where required based on available information obtained from the subsoil investigation to be carried out at the Project Site by the Contractor.

In the event that piled foundations are proposed, the Contractor shall submit a detailed design for piled foundations to the Engineer for approval. The Contractor can apply any type of pile design to satisfy the soil condition. The bid price for piling shall be lump sum and shall remain firm irrespective of the type of design.

(1) General

The Contractor shall supply, install and test at least one of the types of pile specified herein, or in accordance with the approved design and the drawing showing the piling arrangement. Each pile shall be suit existing the sub-strata at the Site. The Engineer reserves the right to order additional test piles at no extra cost if the type of pile or the sub-strata differs from the one originally driven and tested.

The Contractor shall take full responsibility for the suitability of the type of piles he proposes to use and shall guarantee that each pile will carry a test load equal to twice the working load in accordance with this specification.

The standard of workmanship shall be as laid down in CP.2004; 1972 "Foundations" or other approved standard.

(3) Pre-cast Piles

The Contractor's arrangements for the provision of piles shall be to the approval of the Engineer. The Contractor shall submit full details of the manufacture including details of formwork, placing of concrete, vibrators, curing, handling, storage, and transport.

All concrete, reinforcement and other materials used for the manufacturing of piles shall comply with the requirements of the relevant sections of the Specification. Concrete may need to be made from sulphate resisting cement where necessary.

The reinforcement for a pile shall be fabricated to form a rigid cage. The main longitudinal reinforcement shall be in one continuous length except where otherwise approved and shall be finished level and cut square at the head of the pile, and shall bear against pile shoe. The minimum cover to the main reinforcement shall be 65mm. The spacer blocks shall be made of concrete of the same grade as that used in piles. Cast-in threaded inserts or metal tubes of an approved type shall be used to form holes in the piles where required.

Pile shoes shall be firmly fixed during concreting to prevent any displacement. The whole of the concrete in any pile shall be poured continuously. After a pile has been cast, the date of casting and reference number shall be clearly inscribed near the pile head.

The maximum variations permitted on the specified cross section dimen-
sions shall be -3mm to +6mm. The maximum departure from alignment on the face of the pile shall not exceed +6mm over a 3 metre length and 12mm over the total length of the pile.

Piles shall not be lifted without permission of the Engineer and such permission will not normally be given until the concrete in the pile has attained a strength of 175kg/cm². During lifting, adequate precautions shall be taken not to cause undue stress to the piles. Piles shall be stored on adequate supports correctly located and spaced to avoid undue bending in the piles. Due consideration shall be given to future handling, curing and withdrawal of older piles without disturbing newer piles.

All piles shall be kept continuously wet for a minimum 7 days from the date of casting, or as directed by the Engineer.

No pile shall be driven until the concrete has reached the strength specified on the drawings or as otherwise described.

(3) Driving Piles

The Contractor shall submit with his tender full details of the performance, size and type of his driving plant together with information on the type of hammer and the number of rigs he proposes to employ on the works.

The driving rig shall be approved by the Engineer.

Piles shall be adequately guided whilst being driven and the guides shall be held rigidly in position down to the lowest level reached by the hammer.

The maximum departure of any pile head at cut-off level from the position indicated on the drawings shall not exceed 75mm. The Maximum departure from the vertical or the correct angle of rake shall not exceed 1 in 50.

The Contractor shall provide the Engineer with three copies of the driving record for each pile, these records shall reach the Engineer’s Representative not later than the day following the driving of the relevant pile and shall contain details of the following:

(a) Location

(b) Pile details such as reference number, date of casting, length, and dimensions.

(c) Date and time of driving

(d) Type, weight and drop-of hammer or equivalent information if other type of equipment is used.

(e) Information on number and thickness of packing used during the driving of the pile and their condition after removal from the pile head.

(f) Number of blows per 300mm over the last 3 meters of penetration.

(g) Number of blows per 50mm over the last 300mm of penetration.
(h) Toe level of pile.

(i) Other relevant information as may be required by the Engineer.

If any pile is in any way considered unsatisfactory by the Engineer, he reserves the right to order the Contractor to remove the pile and/or to install replacement piles at positions selected by the Engineer, all at the cost of the Contractor.

(4) In-Situ Piles

Before commencing the piling, the Contractor shall submit details of the type and number of rigs to be used for insitu piles.

Jetting shall be permitted only with the approval of the Engineer.

The spoil from the pile holes and material remaining from the cutting of piles shall be removed by the Contractor to a tip to be provided by him.

Before pouring concrete into the core, the reinforcement for each pile shall be made up to form a rigid cage and lowered into the core. Arrangements are to be made to ensure that the minimum cover to the main reinforcement is 50mm. The main longitudinal reinforcement shall be in one continuous length except where otherwise approved and the main bars shall extend at least 1 metre above cut-off level.

The concrete for the pile cores shall comply with the concrete specification. Concrete may need to be made from sulphate resisting cement where necessary. Concreting of the core shall not commence until the Engineer has inspected.

The concrete shall be transported and placed in such a way that it is homogeneous with a high density, and care shall be taken to avoid segregation. The method of placing and compacting the concrete shall be to the complete satisfaction of the Engineer. Care shall be taken that harmful materials do not fall into the pile hole during concreting.

Curing of pile-heads expose to the atmosphere below cut-off level shall comply with the concrete Specification where practicable.

The concrete shall be finished 40mm above cut-off level. Concrete shall not normally be placed in or through water. In particular circumstances only, the Engineer may allow the Contractor at his own expense to place concrete (using suitable mix) through water by means of a termite pipe. If the Contractor's piling system does not normally exclude water during concreting, he should allow in his tender for the use of compressed air or other method to keep the pile hole free from water whilst the concrete is being placed.

(5) Steel Piles

The Contractor shall take all necessary precautions to prevent damage to steel piles and fittings when handling, pitching and driving piles. Adequate bearers shall be provided under stacks of piles at positions to prevent
distortion of the piles. Any piles which are permanently deformed will be rejected.

Details and jointing lengths- of piles will only be permitted with the Engineer's approval. The type of joint and weld details shall be in accordance with the pile manufactures recommendations.

Where the completed pile will be subjected to long term corrosion adequate measures shall be taken to protect the surface of the exposed pile by casing in concrete or such other means satisfactory to the Engineer.

(6) Miscellaneous Piling Systems and Subsoil Improvement Method

The Contractor can propose any system of piling or subsoil improvement method not covered by the foregoing specification and shall submit his proposal thereon to the Engineer for approval in sufficient time to allow the suitability of the system in the ground conditions prevailing on this Site to be investigated fully.

(7) Testing

The Contractor shall install at least two piles solely for testing purposes and shall submit a detailed driving record and other data as directed by the Engineer for the purpose of proving the proposed pile design. If this pile test does not satisfy the specified settlement, further piles shall be installed and tested.

The Contractor shall provide all the equipment required for carrying out load tests on piles together with the apparatus for measuring shall be to the satisfaction of the Engineer.

Measurement of pile movement during testing shall be by a means capable of reading to 0.1 mm. This shall be related to a bench mark situated at a sufficient distance from the pile to ensure a permanent datum.

The loading system shall incorporate a proving ring, load cell or other apparatus capable of measuring the load to an accuracy with 2%.

(8) Test Pile Load

The test pile load shall be twice the specified working load and shall be applied in steps not exceeding 10 tons. Displacement readings shall be taken every 5 minutes after application of the load increment until two consecutive readings show that the displacement has ceased. When the test load reaches the specified working load, the displacement readings shall continue until it is established that no further displacement has occurred over a 15 minute period.

The working load shall be then maintained for a further 24 hours, displacement readings taken every 2 hours.

When no further displacement is apparent on completion of the 24 hour period or when approved by the Engineer, the load shall be removed in one stage and the recovery readings taken every 15 minutes until recovery has ceased.
The pile shall then be reloaded in one stage to the specified working load, readings being taken every 15 minutes until displacement has again ceased. The load shall be then increased in equal increments up to twice the specified working load, the same procedure being followed as stipulated for the beginning of the test. The maximum load shall be maintained for 24 hours or as directed by the Engineer after all displacement has ceased, and readings shall be taken every 2 hours during this period.

On completion of this period or when approved by the Engineer, all loads shall be removed and the displacement on recovery noted.

(9) Settlement Under Test Loads

The settlement of the pile head under test load shall not exceed the following figures under the loads stated:

- Under 150% working load, settlement of 8mm.
- Under 200% working load, settlement of 25mm.

After removal of test load immediate residual settlement of 3mm for 150% working load and 15mm for 200% working load.

On completion of each pile test the Contractor shall supply the Engineer with two copies of a complete report which shall include graphs of load-settlement, load-time-settlement and recovery of the pile as the load is removed.

(10) Rejection of Piles

If any pile is in any way unsatisfactory to the Engineer he reserves the right to order the Contractor to install replacement piles at the locations selected by the Engineer at no extra cost.

20.4.3 FOUNDATION OF GAS/ STEAM TURBINE GENERATOR

Appropriate foundations shall be provided for the gas/steam turbine generating units & HRSG. The gas/steam turbine generating units & HRSG shall be supported by the reinforced block foundation.

The Tenderer shall together with his Bid provide adequate information and data required for the design of the gas turbine generating units foundation.

The design drawings and calculation sheets shall be submitted to the Engineer for approval prior to commence the construction.

(I) Design load and Combination

The following loads and external forces shall be considered for structural analysis of the gas turbine generating unit foundations.

- a. Concrete weight
- b. Machine weight
- C. Dynamic load (vertical direction)
- d. Dynamic load (horizontal direction)
e. Short circuit force of generator
f. Seismic load: As per Seismic Map of approved Latest BNBC

In following load cases, the worst case shall be selected for the design of the gas turbine generating unit foundation.

- Long term
  a+b+c or a+b+d
- Short term
  a+b+e or a+b+c+f or a+b+d+f

20.4.4 FOUNDATION FOR BUILDING AND OTHER EQUIPMENT

Suitable foundations shall be provided for the elevated water tank, switchyard equipment, radiators, overhead travelling crane, buildings, equipment, and miscellaneous structures.

20.4.5 HARDCORE

The Contractor shall place where required hardcore under the foundations of the equipment. The material shall be crushed rock or natural rubble stone not larger than 15cm in size containing suitable quantities of fines to a grading and quality approved by the Engineer.

20.4.6 REPLACEMENT OF UNSUITABLE MATERIAL

In a case where the in-situ soils are found unsuitable for proper construction of the foundations, such materials shall be excavated and replaced with sand or other suitable granular material to be approved by the Engineer. The Contractor shall submit materials samples, laboratory test results and the proposed method of compaction and construction to the Engineer for approval prior to commence the construction.

20.5 STEEL SHEET PILING WALL

Tenderer shall submit together with his tender the outlined drawings and calculation sheet concerning the design of the steel sheet piling wall.

The contractor shall take full responsibility for the suitability of steel sheet piling wall proposed for use in the project.

20.6 CONCRETE WORKS

20.6.1 GENERAL

Standards of design, materials, and workmanship shall be in conformity with this Specification, ACI Standard or other internationally accepted Standards approved by the Engineer.

For the purpose of the Contract, this Specification shall be applicable to all concrete works to be included in the civil engineering and building works.
20.6.2 COMPOSITION

The Contractor shall make trial mixes using samples of aggregates and cements typical of those to be used at least four weeks before commencing any concreting in the Works. The strength requirements for each grade of concrete proposed in the design shall be determined by the Contractor by means of trial mixes to satisfy the conditions specified in Table 20.1.

<table>
<thead>
<tr>
<th>Class</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum size of aggregate (mm)</td>
<td>20 – 40</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Water-cement ratio</td>
<td>Less than</td>
<td>Less than</td>
<td>Less</td>
</tr>
<tr>
<td>Maximum slump (In cm)</td>
<td>7 - 10</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Compressive strength at 28th day cylinder (kgf/sq. cm)</td>
<td>240</td>
<td>210</td>
<td>160</td>
</tr>
<tr>
<td>Approximate Percentage of air content</td>
<td>2 ± 1</td>
<td>2 ± 1</td>
<td>2 ± 1</td>
</tr>
<tr>
<td>Fineness Modulus of fine aggregate</td>
<td>2.3 - 2.4</td>
<td>2.3-2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>Applicable to</td>
<td>Foundation, Column, slab, beam, wall</td>
<td>Trenches, drain-channel, corner stone,</td>
<td>Levelling</td>
</tr>
<tr>
<td></td>
<td>pile, road, pavement</td>
<td>ducts</td>
<td></td>
</tr>
</tbody>
</table>

20.6.3 TESTS

In order to control the quality of concrete to be placed, samples of concrete for testing shall be taken and cubes made as and when directed by the Engineer. Tests shall be done in accordance with this Specification or equivalent Standards approved by the Engineer.

a. Slump test
b. Compression test
C. Air test

For each grade of concrete, six test cylinders conforming to ACI or equivalent shall be prepared for each 30 cubic meters of concrete in each day's work. Three cylinders shall be tested on the 7th day and the remaining three on the 28th day. The slump and compression tests shall be carried out and the results shall submitted to the Engineer in written
form.
The cost of preparing, storing and transporting test specimens to the place of testing and testing shall be borne by the Contractor.

20.6.4 CEMENT
All cement shall be of normal Portland cement complying with BSTI or other approved standard. When required by the Engineer, the Contractor shall obtain for him the manufacturer's test certificate prior to any delivery. All cement shall be stored dry in a well-ventilated and weatherproof building. The cement shall be furnished either in bulk or in bags from the cement factory approved by the Engineer.

20.6.5 ADMIXTURE
The Contractor may use water-reducing and set-retarding agents, but the use of admixture must have the prior approval of the Engineer.

20.6.6 WATER
The water used for making concrete, mortar and grout shall be clean, fresh and free from injurious amounts of oil, organic-matter or any other deleterious substance.

20.6.7 AGGREGATE
The fine and coarse aggregates shall be durable, non-reactive hard materials complying with internationally accepted standards approved by the Engineer. All aggregates shall be washed prior to use in order to remove clay, silt, dust and adherent materials.

The aggregates shall be stored on drained concrete paved areas in such a manner that intermingling of different sizes and types of aggregates is prevented. The stock piles of the aggregates shall be protected from rubbish or wind blown dust.

Coarse and fine aggregates shall be well graded within the standard limits specified as follows.

20.6.8 STANDARD GRADING

a. Coarse aggregate

<table>
<thead>
<tr>
<th>SIZE</th>
<th>PERCENTAGE BY WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50.8</td>
</tr>
<tr>
<td>Coarse Aggregate (40-5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>(20-5 mm)</td>
<td>-</td>
</tr>
</tbody>
</table>
b. Fine aggregate

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Percentage passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.52</td>
<td>100</td>
</tr>
<tr>
<td>4.76</td>
<td>90 - 100</td>
</tr>
<tr>
<td>2.38</td>
<td>80 100</td>
</tr>
<tr>
<td>1.19</td>
<td>50 90</td>
</tr>
<tr>
<td>0.595</td>
<td>25 65</td>
</tr>
<tr>
<td>0.297</td>
<td>10 35</td>
</tr>
<tr>
<td>0.149</td>
<td>2 20</td>
</tr>
</tbody>
</table>

Limits of injurious material content Maximum (percent by weight)

<table>
<thead>
<tr>
<th></th>
<th>Silt/Clay</th>
<th>Volume lost by washing test</th>
<th>Less than specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse aggregate</td>
<td>0.25</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>1.0</td>
<td>7.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

20.6.9 CONCRETE MIXING

All concrete except where specifically approved by the Engineer shall be mixed in weigh batch mixing machines. The machine shall have a Water storage tank with a gauge so that a predetermined quantity of water can be injected direct into the mixer drum. If concrete is to be mixed by hand, it shall be approved by the Engineer. The Contractor shall take all precautions to protect the concrete from the effects of injurious materials.

20.6.10 PLACING

The concrete shall be placed in the positions and sequences indicated on the approved drawings immediately after mixing under the supervision of the Engineer or his representative.

Prior to placing the concrete all deleterious substance such as organic matter, standing water, flowing water, wood fragments shall be removed from the surf ace against which the concrete is to be placed. When concrete is to be placed against a construction joint or adjacent to a set surface the whole surface shall be thoroughly roughened. It shall be cleared of all loose and foreign matter and washed with water immediately before fresh concrete is placed.

The concrete shall be fully compacted throughout the layer and it shall be thoroughly worked against the formwork and round the reinforcement without displacing theme Unless otherwise directed by the Engineer, approved power driven vibrators of the immersion type shall be used. Vibrators shall penetrate to the full depth of the concrete layer and shall re-vibrate that layer to ensure that the successive layers are well knitted.
together. The placing of concrete shall not be permitted under the following conditions unless specifically approved by the Engineer.

a. If it rains
b. If it is poorly illuminated during night work
C. If ordered to stop by the Engineer or his representative

20.6.11 TRANSPORTATION

Ready mixed concrete shall be transported speedily to the point of placing by a means that shall be approved by the Engineer and which shall give little chance for segregation of materials. Generally, the transportation of ready mixed concrete shall be limited to within one hour. Concrete delivered in excess of the time limit shall be rejected. When concrete is observed to have segregated or started solidifying at the transportation of placing, it shall be rejected and replaced.

20.6.12 CURING

Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, hot weather and rain or running water. The concrete shall generally be wet-cured as per Bangladesh National Building Code. The curing method for concrete shall be submitted to the Engineer for approval.

20.6.13 FORMWORK AND TIMBERING

Formwork and timbering shall be so designed and constructed that the required finishes in concrete works are achieved. Formworks shall be constructed accurately to the required shape, position and level and shall have sufficient strength to withstand the compaction pressure. The materials to be used for formwork, shall be approved by the Engineer.

Forms shall be removed without damage to the concrete. The use of form oil or other release agents shall be approved by the Engineer.

The removal time of formwork and timbering shall be as follows

Walls, beams, and column : As per Bangladesh National Building Code
Beam soffits (props left under) : As per Bangladesh National Building Code
Slab soffits (props left under) : As per Bangladesh National Building Code

20.6.14 WATERSTOPS AND EXPANSION JOINTS

The Contractor shall place waterstops, water proofing membrane and expansion joints at locations as are necessary for the proper construction of the concrete structure. The materials to be used shall be submitted in advance to the Engineer for approval.
20.6.15 FINISH AND REPAIR OF CONCRETE

(1) General

The classes of finishes and the requirement for finishing concrete surfaces shall be as specified in this clause or as shown on the approved drawings. Surface irregularities in finishes shall be distinguished from construction tolerances, which are allowable deviations from established lines, grades and dimensions, as described herein.

Surface irregularities are designated "abrupt" and "gradual" for purposes of classifying finishes. Offsets resulting from displaced, misplaced, or mismatched forms or by loose knots in forms, or other similar forms of defects shall be considered "abrupt" irregularities and will be checked by direct measurement. All other surface irregularities shall be considered "gradual" irregularities and will be measured as a departure from the testing edge of three meter template.

Finishing of concrete surfaces shall be performed only by skilled workmen.

Concrete surfaces shall be free from imperfections such as honeycombs and cracks. The Contractor shall at his own expense repair honeycombs, cracks, and irregularities promptly as directed by the Engineer.

(2) Concrete Construction Tolerances

Variations in alignment, grade and dimensions of the structures from the established alignment, grade and dimensions shown on the approved drawings shall be within the tolerances specified in the following tables. Concrete work that exceeds the tolerance limits specified herein may be required by the Engineer to be remedied or removed and replaced by the Contractor.

Construction Tolerances for Concrete

a. Variation from vertical:
   - In the lines & surfaces of columns, walls and towers:
     - In 3 m: 5 mm
     - In 6 m: 10 mm
     - In 12 m or more: 20 mm
   - For exposed columns, joint grooves and other conspicuous lines:
     - In 3 m max.: 10 mm
     - In 12 m or more: 15 mm

b. Variation from the level or from the grades indicated on the approved drawings:
   - In floors, inverts:
     - In 6 m max.: 15 mm
     - In 12 m or more: 20 mm
   - In any bay or 6 m max.: 20 mm
   - In any bay or 6 m max.: 20 mm

b. Variation of the linear structure lines from established position in plan and related position of walls:
   - In 12 m or more: 30 mm
d. Variation in locations of sleeves and sizes and locations of floor openings and wall openings 10 mm

e. Variation in cross-section @1 minus 10 mm dimensions or columns, beams and in the thickness of slabs and walls Plus 15 mm

f. Variation in steps:
   In a flight of stairs Rise 3 mm
   In consecutive steps Tread 5 mm
   Rise 2 mm
   Tread 3 mm

g. Variation in other structure 30 mm

Construction Tolerance for Placing Reinforcing Steel

a. Variation of protective covering
   50 mm cover or less 10 mm
   more than 50 mm cover 15 mm

b. Variation from indicated spacing (any one bar) 25 mm

(3) Repair of concrete

The Contractor shall repair at his own expense the imperfections of concrete surfaces and the irregularities which do not meet the allowance specified in the preceding item. Repairing works shall be performed and completed within 24 hours after the removal of forms, in accordance with the direction of the Engineer.

20.6.16 REINFORCEMENT BAR

The reinforcement bars for the gas turbine generating units foundation blocks shall be deformed steel bars. Dimension, shapes, tensile strength, yield point and other mechanical properties of the reinforcement bars shall comply with relevant approved standards. All reinforcement must be free from oil, grease, paint, dirt, loose scale or rust at the time of concreting.

The physical properties of the reinforcement bar shall have the following values

Yield point : more than 3500 kg/cm²
Ultimate tensile strength : more than 4000 kg/cm²

Reinforcement bars shall be stacked off the ground on sufficient sup-ports to prevent distortion of the bars. Prior to fabricating and placing the reinforcement, the Contractor shall prepare a bar bending schedule, and
drawings for submission to the Engineer for approval. Reinforcement shall generally be bent cold by an approved means to the dimensions shown on the approved bar bending schedule and shall be rigidly fixed in the positions shown on the approved reinforcement drawings using annealed soft black iron binding wire to prevent movement during concreting. The Engineer shall have the right to select at any time samples of reinforcement bar for testing for compliance with the Specifications. The spacer blocks, prior to using, shall be submitted to the Engineer for approval.

20.6.17 PAYMENT

All costs associated with concrete work and reinforcing bar for equipment foundations, ditches, roads, buildings, drainage system and all other structures shall be deemed to include in the lump sum price bid for the respective work item in the Schedule. The lump sum price bid shall not be modified or subject to any adjustment for design variations due to changes of geological and other conditions.

20.7 ROADS AND SURFACINGS

The Contractor shall furnish all designs and construct the roads, yards, paths, surfacing as necessary for the proper functioning of the power station.

The roads and yards as indicated in the Drawings or directed by the Engineer shall be generally designed with raised kerb, in compliance with the approved Standard and to satisfy the following basic design requirement:

- Maximum grade: 7%
- Pavement width: as per approved Drawing
- Turning radius: more than 10 m

20.7.1 CONCRETE PAVEMENT

The roads and yards shall be paved with reinforced cement concrete and shall be designed in accordance with the procedures as outlined in the AASHTO Standard or any other acceptable international standard or Design of Pavement Structures or other internationally accepted methods approved by the Engineer. Basic design conditions are as follows:

- Design load: Minimum 15 ton axle weight (H20-S16-44)
- Minimum thickness of concrete pavement: 15cm

20.7.1.1 Sub-grade Preparation and Test

The aggregate sub-base for the concrete pavement shall be prepared by bringing the sub-grade to a firm and unyielding surface by rolling the entire area with an approved roller weighing not less than ten (10) tons. The sub-grade shall be sprinkled with water, if necessary, to attain satisfactory compaction. All soft, yielding material which will not compact readily when rolled shall be removed as directed. All holes or depressions shall be filled with suitable material and the whole surface compacted uniformly. In cut, sections, the ground below the surface of the sub-grade, shall not be
plowed or disturbed, except as otherwise directed by the Engineer. When necessary, additional approved material shall be added to bring the subgrade to the desired elevations and cross section, and the whole shall be rolled until compacted thoroughly.

The Contractor shall perform a bearing test by a method to be instructed by the Engineer on the surface of the sub-grade and he shall examine the thickness of sub-base as indicated on the bid drawings. The Engineer may instruct a modification to the design of pavement, if required based on test results without any claim on the Board.

20.7.1.2 Aggregate Sub-base Materials for Concrete Pavement

Aggregate sub-base material for concrete pavement (roadways, parking areas, etc.) and roadway shoulder shall consist of hard, durable fragments of crushed gravel and stone or other similar materials, including additional selected filler for blending under the direction of the Engineer. The maximum dimension of any particle shall not be greater than two-thirds of the required thickness in which it is to be placed. Oversized material, if present, shall be removed at the quarry by screens, grizzlies, or by hand. When necessary to obtain proper uniformity, additional filler shall be blended by mixing on the roadway. The fraction of the aggregate sub-base material, including any additional filler passing the No.200 sieve shall not be more than of that passing the No.40 sieve. The fraction of the material passing No.40 sieve shall have a liquid limit not greater than 25 and a plasticity index of not more than 6.

The following gradation requirements shall apply to the sub-base for concrete pavement and the thickness of sub-base shall be not less than 20 cm after it is compacted or as otherwise agreed with the Engineer.

<table>
<thead>
<tr>
<th>Sieve designation (Square Mesh Sieves)</th>
<th>Percentage by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.1 mm (1 1/2&quot;)</td>
<td>95 100</td>
</tr>
<tr>
<td>19.1 mm (3/4&quot;)</td>
<td>60 90</td>
</tr>
<tr>
<td>2.5mm (No.8)</td>
<td>20 50</td>
</tr>
<tr>
<td>0.074 mm (No.200)</td>
<td>2 10</td>
</tr>
</tbody>
</table>

20.7.1.3 Construction of Aggregate Sub-base for Concrete Pavement

The aggregate sub-base material shall be placed on the prepared and approved sub-grade. The deposition and spreading of the material shall be as directed by the Engineer. It shall start at the point farthest from the point of loading, and shall progress continuously without breaks. The materials shall be deposited and spread in a uniform layer and without segregation of size, to such a loose depth of not more than 15 cm each layer, making allowance for any filler to be blended on the road, that when compacted, the layer shall have the required thickness. Spreading shall be from spreader boxes or from moving vehicles, or by placing in a windrow followed by spreading to required depth and width by means of a blade grader. After the sub-base material has been spread, it shall be bladed to a smooth surface conforming to the cross section.

The Contractor shall schedule his operations so as to assure completion of spreading within 48 hours after processing. Immediately following the final
spreading and smoothing, all materials placed shall be compacted to the full width by rolling with a power roller weighing not less than 10 tons. The rolling shall start longitudinally at the sides and shall progress toward the centre, overlapping on successive trips by at least one-half of the width of the roller unit. In confined areas the direction of rolling shall be as ordered by the Engineer. Alternate trips of the roller shall be slightly different in length. The rollers, unless directed otherwise, shall operate at a speed between 3 to 5 kilometres per hour. Rolling shall be accompanied by watering if necessary and as directed by the Engineer.

20.7.1.4 Concrete Pavement

(1) Materials

(i) Cement and reinforcing steel will be furnished by the Contractor. The concrete to be used for concrete pavement shall be not less than 3500kg/sq.cm in the strength at 28 days. The concrete pavement shall be 20cm in thickness or as designed.

(ii) Fine and coarse aggregates, and water shall conform to the applicable Section of the Specification.

(iii) Preformed Expansion Joint Filler Board - The preformed expansion joint filler for the concrete pavement shall be 19mm (3/4") in thickness, non-extruding type, shall conform to the requirements of ASTM DI 752-67, "Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction, Non-extruding and Resilient Non-bituminous Types", Type II.

(iv) Dowel bars All dowel bars except at the expansion joints, shall be deformed steel bars and shall conform to ASTM A6 15 Grade 60.

(v) Joint Sealer Concrete joint bituminous sealer for all joints shall conform to ASTM DI 850-67, "Specifications for Concrete Joint Sealer, Cold-Application Type".

(vi) Slab reinforcement The slab reinforcement shall be made of steel bars of 10 mm conforming to ASTM A615 Grade 60. The longitudinal and transverse spacing shall be 15cm respectively or as design each intersection shall be firmly bound by binding wires or fixed by an adequate method approved by the Engineer. It shall be embedded in the concrete at 6cm below the surface.

(2) Construction Method

(i) Formwork

The concrete pavement shall be constructed one lane at a time. The side forms for the concrete pavement shall be made of shaped steel sections which shall have sufficient strength when staked down to resist the pressure of the concrete mixer and finishing machine, or finishing tools, without springing. They shall be straight and of a depth equal to the thickness of the pavement at the edge and free from warps or bends at all times. Flexible or curved forms of proper
radius shall be used for curves 30 metres radius or less. The form base shall not be less than twenty (20) centimetres wide for forms twenty (20) centimetres or more in height. Flange braces shall extend outward on the base not less than two-thirds (2/3) of the height of the form. The use of wooden side forms may be permitted.

Timber formwork shall be oiled or greased at all times to prevent warping or cracking.

When placing the forms, they must be seated firmly and in contact with the sub-base surface for their entire length, exactly on the desired line and grade.

Before the mixing of concrete, forms shall have already been set for a sufficient length well in advance of the forward end point where the concrete is to be placed, but in no case less than the length between expansion joints, except for closures which may require a shorter length. Sufficient forms shall be provided so that it will not be necessary to move those in place within twenty four (24) or more hours after the concrete has been poured. All forms shall be cleaned and oiled each time they are used. In the pouring of sections, construction joints shall be located at expansion joints. Should it be necessary to make construction joints beyond the expansion joint, such construction joints shall be made at the location of contraction joints.

(ii) Joints

(a) Longitudinal Joint: The longitudinal joint running at the centre line of the pavement shall be formed in accordance with the section and dimension shown on the approved drawings. Before concreting the next lane, the longitudinal joint shall be painted with two (2) coats of liquid asphalt applied at a temperature of 65⁰ to 135⁰ Fahrenheit. The asphalt should be completely dry beforecommencing pour to the next lane.

(b) Transverse Joints: The transverse joints consist of the expansion joints and contraction joints. The expansion joint shall in principle be formed at every 40m and the contraction joint shall be formed at an interval of every 8m between the expansion joints. In the expansion joints, 19mm (3/4") preformed expansion moulding strip shall be placed and bituminous Dealers shall be poured after removing the strip and before opening the road to traffic.

(c) Dowels: In all longitudinal joints, 75cm long tie dowel bars of 3/4" diameters shall be used for concrete pavements. In all contraction joints, 75cm long slip dowel bars of 3/4" diameter shall be embedded in the concrete. All dowel bars shall be placed at an interval of 75 cm. The remaining half of the dowel bars for the transverse joints shall be painted, greased, and wrapped with wax paper before concreting the next slab. The slip dowel bars in the expansion joints shall provide a cap having adequate size and type at the end of the bars.

(iii) Mixing
Hand mixing of concrete will not be permitted. Machine mixers, if used, shall have a standard mixer of an approved type with a capacity of at least 0.76cu.m. (1 cubic yard). Truck mixers, if used, shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to ensure uniform distribution of material throughout the mass. The procedures of concrete mixing shall be in accordance with the Specification for Concrete Work Section.

(iv) Placing

Concrete shall be placed only on aggregate sub-base that has been prepared as previously prescribed and approved by the Engineer. The concrete shall be deposited in such a manner as to require as little handling as possible, and shall immediately be distributed or spread by shovelling or by other approved methods, to such depth, and grade, that when compacted, the finished grade of the pavement will be attained correctly. Vibrators of approved type and capacity for the purpose intended shall be used to sufficiently compact the concrete.

(v) Finishing

After the concrete has been deposited, distributed and vibrated, the concrete shall be struck off and screeded by mechanical means approved by the Engineer. The finishing machine shall be of the screeding and troweling type designed and operated both to strike off and to compact. Hand finishing may be employed in limited areas where finishing machines can not be operated. Finishing of concrete shall be done, as directed to the satisfaction of the Engineer. All finished surfaces shall be tested with a 3-meter straight edge and it shall not vary more than 1cm in 3m from the designed surface. Any variation of the surface from the desired crown or cross-section shall be properly corrected.

(vi) Removal of Formwork and Repair

All forms for concrete shall remain in place undisturbed for not less than twenty-four (24) hours after the concrete is placed, after which the forms may be removed. In the removal of formwork, care should be taken so as not to break the edges of the pavement. In case portions of the concrete are spalled, they shall be immediately repaired, at the expense of the Contractor, with fresh mortar mixed in the proportion of one (1) part cement to two (2) parts clean sand. Major honeycombed area will be considered as defective work and shall be removed and replaced at the expense of the Contractor. Any area or section removed shall not be less than 3 meters in length nor less than the full width of the lane involved.

The Contractor shall repair at his own expense all imperfections, or irregularities of the concrete pavement in accordance with the direction of the Engineer.
(vii) Curing
As soon as the concrete has sufficiently set, and to prevent the maring of the surface, the pavement shall be covered with burlap or canvas, which shall be kept wet with clean water for a period of not less than twenty-four (24) hours.

After removing the burlap, the pavement shall be covered immediately with either a layer of earth or sand four (4) centimetres in thickness and shall be kept wet for a period of not less than fourteen (14) days. Ponding of the surface of the pavement may also be adopted for curing the concrete, in which case, the pavement shall be kept under water during the same length of time.

(viii) Opening to Traffic
From the start of curing, the pavement shall be closed entirely to traffic until twenty-eight (28) days have elapsed after the concrete was poured.

(ix) Cleaning and Sealing Joints
After completion of the required curing and before opening the pavement to traffic, all Joints shall be thoroughly cleaned of all concrete or aggregate fragments, earth or other foreign material. Longitudinal, expansion and contraction Joints shall be poured with bituminous sealant to the depth of 40mm from the top concrete surface. Only after the joint sealant has thoroughly hardened shall the pavement be opened to traffic.

(x) Protection of Adjacent Construction
Any adjacent construction such as concrete pavement, curb and gutter, stone masonry and handrails shall be protected by shields, covers or other means. If concrete is applied to adjacent construction either by accident or because of inadequate protection, the Contractor shall remove such material as directed and at his expense.

(xi) Maintenance
The Contractor shall be responsible for the maintenance of the surface for a period of twenty eight (28) days or until such time as the Engineer may direct, after which the work shall be accepted in writing by the Engineer.
No extra compensation will be made to Contractor for any maintenance work required as specified. All costs attendant thereto shall be included in the lump sum price bid for Road and Parking Area in the Schedule.

20.7.2 Gravel Surfacing
The Contractor shall supply and place a layer of gravel not less than 10cm in areas other than the paved and lawned areas in the power station as shown on the Drawing or as directed by the Engineer. Materials for graveling shall be 3 to 7cm in size conforming to the grading requirement of the Specification.
20.7.3 Landscaping and Turfing

Areas around the power house building, administration building shall be turfed as shown on the Drawings or as directed by the Engineer.

Turf shall be freshly cut approved carpet grass free from thorns and weeds. The area to be turfed shall be provided with a layer of 20cm top soil suitable for the growth of the lawn. The Contractor shall maintain and replace all dead turf at his own expense until the end of maintenance period.

The Contractor shall submit a detailed proposal on landscaping for the Site. Trees, flowers and other plants adaptable to the climate and soil conditions of the Site shall be planted in the open spaces provided adjacent to the control and administration building area and along the perimeter of the boundaries to form a green belt around the power station. A proposal which shall include a landscape drawing with a schedule showing types of trees, planting positions and other details shall be submitted to the Engineer for approval.

20.8 Drainage System

20.8.1 Design Conditions

The design of the storm water drainage system comprising the interceptor, roadside and perimeter drains for buildings, powerhouse, and switchyard shall be submitted to the Engineer for approval.

The Contractor shall carry out detailed designs of the storm water drains using the rational method or other approved procedures. The work shall be carried out in accordance with the rules and regulations of the local and other authorities.

Design conditions for drainage system shall be as follows:

- Rainfall intensity: 100 mm/hr
- Run-off coefficient: 0.6
- Manning's roughness coefficient for concrete lined channel: 0.013

All drains or channels shall be concrete lined. Concrete sumps, silt traps, screens and drain covers shall be incorporated in the design where it is appropriate.

20.8.2 Drain Laying

All trenches and drains are to be set out accurately to line and fall as specified. Trenching for pipes shall be excavated with sufficient width to allow adequate working space for pipe jointing. Backfilling of trenches to a height 300 mm above the top of the pipes using selected materials shall be hand packed and well rammed against the side of the pipes.

The laying of each length of drain is to be commenced at the lower end and socketed pipes shall be laid with their sockets at the higher end.
is to be accurately levelled and securely held in position before the joint is made.

All surface water channels shall be made from concrete grade B as described in Section 20.6.

The Contractor shall keep sumps, drains, trenches and ditches free from water at all times until, in the opinion of the Engineer, the concrete works has hardened.

Man-holes, inspection chambers and catch-pits shall be constructed.

20.9 Sewage Works

20.9.1 General

As there is no existing government central sewage treatment system operating in the vicinity of the Site, individual septic tanks shall be provided in the Site.

20.9.2 Sewer, Manholes And Septic Tanks

Pipes proposed for use in the sewer shall be approved by the Engineer, cast iron pipes and fittings complying in all respects with B.S.78 and/or B.S.437 shall be used. Manholes or inspection chambers with covers shall be provided at every change in direction or gradient to satisfy the requirement of the Local Authority.

The sewer shall be laid accurately to the design levels and gradient. Each length of sewer shall be carefully water tested to the satisfaction of the Engineer before the concrete haunching is placed and before the trench is back filled. Septic tanks shall be constructed in accordance with the details shown on the approved drawings.

20.10 Water Reticulation System

20.10.1 Internal Water Reticulation System

The water supply system shall be designed to serve a dual purpose of providing potable water for domestic consumption and fire-fighting.

20.10.2 Water Requirement

The system shall be designed to meet the project requirement as follows:

1. Plumbing

The facilities for general plumbing comprises two (2) deep well not less than 150 m in depth with pump and G.I pipes of appropriate sizes connecting the supply to the internal plumbing facilities provided for electrical building connection with existing water supply system at a suitable point. The supply system shall be extended with sufficient number of taps to provide water for lawns.

20.10.3 Design Parameters And Standard

The water reticulation system shall be designed and installed in compliance with the requirement of the local and other authorities. The parameters and criteria to be adopted for design are:
a. Design population : 100 persons  
b. Storage requirement for plumbing system : 3 times the average daily demand  
e. Minimum fire flow : 2.5 m³/min  
d. Minimum diameter of fire-fighting main (steel):150 mm  
e. Pressure in pipe : 7 bar  
f. Maximum spacing of fire hydrant : 60 m

20.10.4 Materials And Workmanship

All pipes, fittings, jointing materials and valves which are necessary for the complete installation of the system shall be supplied and installed in compliance with the approved standards and workmanship.

The Contractor shall supply all pipe, special fittings, valves, joints, jointing materials and other necessary materials for the complete installation of the system as shown on the approved drawings.

The installed system shall be tested to the satisfaction of the Engineer.

20.10.5 Deep-well And Deep-well Pump

20.10.5.1 General

(1) Scope of Work
In accordance with the Specification and as shown on the bid drawings or as directed by the Engineer, the scope of this work shall cover the supply, fabrication, construction, installation, erection and all the necessary materials, labour, tools and equipment for the complete and satisfactory operation of the domestic water supply system from deep-well (2 x 100% capacity) to storage tank.

All materials, equipment and accessories shall be new and unused, free from defects and imperfections and best suited for the purpose intended. Materials used in the manufacture and installation of all equipment to be furnished shall be of the required quality used in commercial products of reputable manufacturers. All equipment or substitute materials and equipment to be used shall conform to the latest specifications and provisions of approved Standards of the Engineering Institutes or other equivalent standards approved by the Engineer.

One deep-well pump shall be installed for each well.

(2) Instruction Book

The Contractor shall submit ten (10) copies of instruction books on the operation and maintenance of equipment furnished and installed by him under this clause two (2) months before he starts on the installation work.

(3) Painting

All metal, wooden and textile surfaces of materials furnished and installed by the Contractor under this Section shall be painted in accordance with Section 21.6, except as listed below. Performance of painting work shall be
as specified in the Section 21.6 of the Specifications.

a) Portions to be embedded in concrete or in the soil 
b) Plated surfaces other than zinc plating 
c) Concealed zinc plated portions 
d) Surfaces treated with special decorative finishes 
e) Surfaces where so indicated by the Engineer

Colour of paint shall be as directed by the Engineer.

(4) Concrete, Plastering and Earth Work

Concrete, reinforcing, plastering and earth work to be executed under this clause shall be performed according to the applicable provisions of the relevant clauses of the Specifications.

20.10.5.2 Drilling, Developing And Testing the Deep-well

(1) General

The Contractor shall provide plant, labour, material, equipment and perform all operations in connection with the drilling, developing, placing of casings and well screens, and pumping tests for the deep-well which shall be drilled to a depth as indicated below.

(2) Drilling

Drilling of the deep-well shall be carried out by an appropriate method most suited to the conditions of the deep-well site to be drilled. When necessary, temporary casings shall be used in sections of the hole through over burden or unstable material to prevent the caving-in of the well. The location of the well drilling site shall be as shown on the bid drawings or as directed by the Engineer.

(3) Well Log

A written record of the drilling information which is called a Well Log shall be kept by the drillers and shall be available for examination by the Engineer at any time during the work and a complete typewritten copy of the well log shall be submitted to the Engineer within ten (10) days after completion of the work. The well log shall show amongst other things the type of materials encountered, colour of the return water, depth at which circulation as lost, manner of drilling, length of casings installed, and other pertinent drilling data.

(4) Well Completion and Development

The Contractor shall undertake all operations pertaining to the completion and development of the well which shall consist of the installation of casings, installing well screen within a sand and gravel formation, developing the water-bearing formation, grout filling of the upper section of the well casing (from collar to at least 6m deep), surging and back-washing. The well casings to be installed shall be carbon steel, ASTM A-53, seamless, Grade B or equivalent. Openings of the well screens shall be so designated to prevent clogging and shall be free from jagged edges and irregularities so as to avoid clogging and corrosion.
(5) Pumping Test for Yield and Draw-down

Pumping tests shall be performed to determine the deep-well capacity and other hydraulic characteristics of the water-bearing strata.

The Contractor shall furnish and operate a pump for this purpose that is capable of continuous operation at a sustained delivery of 380 lit/min or more in a duration of at least five (5) hours of pumping test operation. Measurements of the volume of water pumped per minute, the depth of static water level before pumping started, the depth of the pumping level at one or more constant rates of pumpage, the rate of recovery of the water level after pumping test stopped and the length of pumping time of each pumping rate shall be made by the Contractor in the presence of the Engineer. The Contractor shall construct any other structures necessary to conduct water away from the deep-well.

For a comprehensive test of the well, the pump shall be operated continuously at about 1/3 of its capacity until pumping level is attained. After making the necessary measurements, the pump rate is adjusted to about 2/3 of the pump capacity and measurements are repeated when the pumping level becomes constant. By increasing the rate of pumpage to produce maximum draw-down; or increasing it to the full capacity of the pump and making measurements a third time when the pumping level becomes stable.

All the necessary equipment the measuring devices for testing the deep-well shall be calibrated and provided by the Contractor at his own expense.

After developing and testing operations are completed to the satisfaction of the Engineer, the Contractor shall measure the depth of the well and record the total open depth of the casing. Sterilisation of the well is done by pouring a solution of 450 grams of high test Calcium Hypochlorite (HTH) in 45 litters of water.

Upon completion of the drilling, the Contractor shall submit to the Engineer the complete well-draw-down test results for check and determination of the actual head and setting of the deep well pump.

(6) Data to be Submitted with Bids

A complete list and description of equipment, plant and tools for executing the work in accordance with these Specifications and their location at the time of opening of bids in order that they may be inspected by the Engineer.

20.10.5.3 Deep-well Pump

(1) General

The Contractor shall furnish, deliver, install and test motor-driven pumps (2 x 100% capacity) complete with accessories and housing at the top of the well in accordance with these Specification.
(2) Type and Description

The deep-well pump shall be a submersible type with a cast iron body, bronze impeller, high-grade steel discharge column and stainless steel shaft. The discharge pipe column and drive shaft of ample size shall be supplied with interchangeable sections of not greater than 3.0 m in length.

This pump shall be operated in conjunction with the float switch to be installed in both the elevated water tank and fire fighting storage tank.

All water passages of the pump shall be smooth and long term corrosion-resistance of dependable operation.

(3) Rated Capacity

The deep-well pump shall be rated to as per requirement but minimum discharge capacity of 600 lit/min against a total dynamic head of the system as determined. The total head of each pump may vary and it is required that the pump be capable of satisfactory operation within fluctuations of head.

The pump shall be guaranteed to circulate not less than the specified quantity of water when pumping and without producing excessive vibration and noise. The efficiency of the unit shall be as high as good engineering practice will permit.

(4) Electrical Works

a) Pump Motor

The motor shall be submersible type, full voltage starting and with torque-locked rotor current and slip characteristics conforming to standard equivalent to those of the IEC Standard.

It shall be of the continuous duty type for operation on 415 volt, 3-phase, 50-flz. Motors shall be capable of operating continuously at rated output plus or minus 5% of the rated frequency and at any voltage within plus or minus 10% of the rated value.

b) Control Equipment

The control equipment shall be of the float-switch actuated control type installed in the water storage tanks and shall be of suitable switch for draw-down in the deep-well. One of the two deep-well pumps shall start operation alternately when the water level in the water storage tank goes down to the designated level.

When the water level of the deep-well goes down to the designated level, the deep-well pump shall be stopped immediately, and the other deep-well pump shall be started automatically. Breakdown of deep-well pumps shall be connected to an alarmed on the control board in the control room.

c) Control Board

The control board shall be installed in the fire pump-house.
A boxed knife switch shall be provided in the fire pump-house for each pump.

d) Signal Indicators

i) All indicator lights shall be of AC type with coloured glass or plastic lens and shall be so constructed that the lamp can be readily fitted and removed and the lens changed from the front of the boards.

ii) Ammeters shall be capable of accepting the starting current characteristics of the corresponding motor and shall be suitably calibrated to indicate the full load running current at three quarter full scale deflection.

e) Conduit Piping and Wiring

Conduit piping and wiring for the work shall comply with the applicable provisions of the Specification.

(5) Installation

The Contractor shall construct a concrete base foundation for accurate mounting of the pumping unit and shall provide foundation bolts for anchoring the pump, which shall be carefully levelled and grouted in place.

The pumping unit and control equipment shall be housed for all weather protection.

(6) Accessories

The following accessories shall be equipped for each pump:

- Sluice valve : 1 Pc
- Check valve : 1 Pc
- Air release valve : 1 Pc
- Pressure gauge with cock : 1 Pc
- Water pipe : Required Length
- Well cover : 1 Pc
- Submersible cable : Required Length
- Flanges : 1 Set
- Foundation bolts : 1 Set
- Other necessary accessories : 1 lot

(7) Data to be submitted with Bids

Complete specifications of the supply including the physical dimensions and materials used for the principal parts of the supply.

Pump discharge capacities, efficiencies, horsepower input and performance characteristic curves at various heads on pump settings.

Guaranteed brochures, catalogues and other related technical data concerning the operation of the supply.
(8)  Piping

Materials and Performance 0 piping for the work shall be in accordance with the applicable provisions of the Specification.

20.11  Ducts

The concrete ducts to install cables and pipes shall be provided. The ducts shall be covered with concrete or steel checkered plate, both having enough strength, and shall be provided with the, necessary number of racks for cable and pipes. The thickness of the concrete ducts shall be not less than 18cm, width and depth of ducts shall be more than 40cm respectively and an appropriate drainage system shall be designed within the duct.

The Contractor shall submit design drawing to the Engineer for approval.

20.12  FENCING AND GATES, FLAG POLES AND SITE BOUNDARY WALL

20.12.1  Fencing

Chain link fencing shall be installed as directed by the Engineer. The chain link fencing shall be 2.4 m high with 3 strands of barbed wire at the top, generally complying with B.S. 1722 or other approved Standards.

Posts and struts shall be fabricated from 100 mm x 100 mm x 6.5 mm thick angles and set in concrete. The struts shall be fitted to all end and corner posts at changes in direction or acute variations in levels and at intervals not exceeding 9 meters in straight lengths of fence. All posts shall be hot dip galvanised.

Prior to the supply and installation, the Contractor shall submit samples of fencing materials, structures and colour to be adopted to the Engineer for approval.

20.12.2  Gates

Sliding metal gates of 2.4 meter high and pedestrian swing gates of 2.0 meter height shall be constructed at suitable locations as directed by the Engineer.

Decorative brick walls to be incorporated in the work next to the pedestrian gate at the power station shall have the following dimensions:

<table>
<thead>
<tr>
<th>Height</th>
<th>2.4 metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>5.0 metres</td>
</tr>
<tr>
<td>Thickness</td>
<td>0.25 metre</td>
</tr>
</tbody>
</table>

The Contractor shall submit design drawings showing details of the gates for approval of the Engineer.

20.12.3  Flag Poles

Three (3) flag poles shall be erected at locations as directed by the Engineer.

The poles shall be of tapered steel pipe, about 15 m in height with a diameter of 20 cm at the bottom. The pole shall be firmly held to a concrete foundation. It shall be equipped with a brass pulley near the top and nylon rope for hoisting
the flag.

The pole shall be painted in accordance with the specification for painting to the satisfaction of the Engineer.

20.12.4 Site Boundary Wall

The site boundary wall shall be installed around the power station as directed by the Engineer. The site boundary wall shall be of brick wall with RCC frame in accordance with KPI Standard and 2.40 m high and 0.25 m thickness.

20.13 WATER INTAKE AND DISCHARGE FACILITIES

The contractor shall take full responsibility for the suitability of water intake facilities and design for the platform for the pump station on the river in accordance with the requirements of the specification.

The design of water intake facilities shall be submitted to the Engineer for approval.

There are 2 (two) nos. of existing pipe lines alongside of Chattogram- Rangunia highway coming from water intake system (situated beside Kurnophuli river) around 8 K.M away from Power Plant. 3 x50% nos. of Water intake pumps with each pump capacity minimum 600 m$^3$/hr but not less than the requirement are installed with each intake pipe line. Through these pipelines water is storing into 3 nos. reservoirs (pond) inside power plant premises. The contractor has to renovate one of these two water intake system by changing Pipe (minimum 600-800mm dia or as per BPDB requirements), required valves, Pumps (3x50% capacity) etc. complete in all respect. Also required renovation of the existing reservoirs has to be done by the Contractor.

20.14 Platform for Loading & Unloading

1. The Platform for loading/unloading of equipment/materials at river site shall be the concrete paved after construction of the sheet pile wall.

2. Standard permanent jetty shall be constructed for the Power Station.
Section 21

Building Works
21 Building Works

21.1 General
21.1.1 Contractor's Responsibilities
21.1.2 Building Sub-contractor
21.1.3 Construction Schedule
21.1.4 Records
21.1.5 Samples Testing and Inspection
21.1.6 Temporary Services
21.2 Scope of The Works
21.3 Design of The Works
21.3.2 Standards and Codes of Practice
and Other Design Conditions....
21.3.3 Submission of Designs and Drawings
21.4 Building and Services

21.4.1 Electrical Building
21.4.2 Rain Water Leaders
21.4.3 Air Conditioning System
21.4.4 Ventilation System
21.4.5 Plumbing and Sanitary Installation
21.4.6 Lighting
21.5 Materials and Workmanship
21.5.1 Structural Steel
21.5.2 Concrete
21.5.3 Grouting of Structural Steelwork
21.5.4 Roofing and Brickwork

21.5.5 Carpentry and Joinery
21.5.6 Doors and Windows
21.5.7 Glazing Works
21.5.8 Metal Works
21.5.9 Floor-laying
21.5.10 Wall and Ceiling Finishes

21.6 Painting
21.6.1 Materials
21.6.2 Surface Preparation
21.6.3 Workmanship
21.6.4 Priming
21.6.5 Number of Coats
21.6.6 Storage
21. Building Works

21.1 General

The General Conditions, Tender Drawings, relevant Specifications On materials and workmanship described elsewhere in this Documents, Schedule of Rates shall be read in conjunction with this Specifica

tion. During design of buildings, natural air and light are to be ensured.

21.1.1 Contractor's Responsibilities

This is a turnkey contract which includes all building works and services. The Tender shall cover all requirements of the Tender Documents and any other items not specifically mentioned but which are deemed to be necessary for the complete execution of the Works to the entire satisfaction of the Engineer. No additional cost will be considered for any item which the Contractor has over looked but are essential for the full completion of the Project in every respect.

The Tender shall include the building works proposal complete with out-line drawings indicating any variation or improvement which he deems technically or financially justified for tile works shown on the Tender Drawings, schedule of materials and finishes on which the tender has been based. The Building shall generally conform to the sizes shown on the Tender Drawings.

The Contractor shall be responsible for all performance in the detailed design, supply of material, labour, plants and equipment, construction and relevant works incidental to the completion of the Building Works.

The Contractor shall perform the Works thoroughly in accordance with the agreed construction schedule and direction to be made by the Engineer during the Contract Period.

21.1.2 Building Sub-Contractor

The Contractor may employ a building subcontractor for building works. If the Contractor intends to subcontract the building works design and/or construction, his tender shall include full details of comparable works carried out elsewhere by the subcontractor, together with details of the financial stability and general efficiency of the proposed subcontractor.

21.1.3 Construction Schedule

A preliminary building construction schedule showing the completion time for the building works shall be submitted by the Tenderer based on the overall project implementation schedule. The Contractor shall prepare and submit to the Engineer for approval a detailed construction schedule for the building works developed from the preliminary building construction schedule before commencement of the Work on the Site. The approved construction schedule shall not be altered without the written consent of the Engineer.
21.1.4 Records

The Contractor shall keep accurate and up-to-date records and drawings of the Works at the Site and shall provide the Engineer with copies of these records. The Contractor shall submit to the Engineer weekly reports of labour, plant and materials employed on the Site.

21.1.5 Samples Testing and Inspection

The Contractor shall perform testing and inspection of materials and shall submit sample materials, test certificates and workmanship details to the Engineer for approval. The costs of all samples and testing shall be borne by the Contractor.

21.1.6 Temporary Services

The Contractor shall be responsible for arranging the provision of electricity, water, drainage, etc. necessary for the proper execution of the Works. All costs for these services shall be borne by the Contractor.

21.2 Scope of the Works

The building works shall include collection of the Site information, detailed design, production of working drawings, and provision of labour, plant and materials, tests/inspection, construction and remedy of defects during the Warranty Period. The Building shall generally conform to the sizes as mentioned below. Works also include supply of adequate standard office furnitures to all office buildings and domestic gas supply to residential buildings.

a) GT, ST hall, Control & Administrative building, Fire Fighting pump house, GBC house, Emergency Generator house, Water treatment plant building, Chemical Plant, Cooling tower pump house, River Intake Pump House with renovation of pipeline, Workshop (Electrical & Mechanical- Electric Hoist with standard Capacity), Store, Guard houses, Rest house, Officers’ Dormitory, Staffs Quarter, Medical Centre, fencing, internal roads, boundary wall, drainage system etc. shall be constructed by the Contractor within the Power Plant premises.

b) Dimensions and number of rooms of the Buildings mentioned shall be to the standard practice based on the size and number of Equipment and acceptable to Board.

However, dimension & minimum specification are given below:

1) Control building: 2 (two) storied, 10 (ten) air-conditioned rooms (with proper office furniture) including control room, battery room, auxiliary room. Each floor area shall not be less than 500 sq. metres.

2) Administrative building: 5 (Five) storied with air conditioned room with proper office furniture as per international Standard for Chief Engineer, Managers, Executive engineers, and conference hall. Each floor area shall not be less than 400 sq. metres. Provision for Car parking facility in Ground Floor, security & cleaners room, electromechanical room etc at ground floor. 2 (two) nos. passenger lift with carrying capacity of minimum 12 per-
sons/lift to be installed in this building.

3) Rest house building: 3 (three) storied building (each floor area shall not be less than 500 sq. meter) with car parking facility, Servant room, Guest waiting room, security room, electromechanical room etc at ground floor. All the rooms of 1st & 2nd floor, common space, dining hall shall be equipped with proper furniture as per international Standard and Air condition of sufficient capacity. Rest house building will be constructed in the place with dismantling of existing 2 storied rest house building. Design and foundation of this new building shall be done in a way that future vertical extension of at least 3 floors can be made. Provision shall be kept in this building for future installation of 1 (one) no. passenger lift with carrying capacity of minimum 12 persons.

4) Medical Centre: 2 (two) storied building (with proper office furniture) and each floor area shall not be less than 200 sq. meters. Medical centre building will be constructed in the place with dismantling of existing single storied rest house building. Standard office furniture for the medical officers and staff to be provided by the contractor.

5) Officers’ Dormitory: 6 (Six) storied Dormitory building. Each floor area shall not be less than 250 sq. meter. Approx.30-35 nos. of independent studio type accommodation to be made in this building, each accommodation shall include Room + Kitchen + Toilet). Provision for Car parking facility, Servant room, Guest waiting room, security room, electromechanical room etc at ground floor. 2 (two) nos. passenger lift with carrying capacity of minimum 8 persons/lift to be installed in this building. All the independent studio type accommodation shall be equipped with standard room furniture.

6) Staff Quarter: 6 (Six) storied building (4 Units each floor, each unit area shall not be less than 900 sq. feet) with car parking facility, Guest waiting room, security room, electromechanical room etc at ground floor. 1 (one) no. passenger lift with carrying capacity of minimum 8 persons to be installed in this building.

7) Workshop buildings (Electrical & Mechanical) will be used to accommodate workshop equipment as mentioned in tender document. Workshop buildings area and dimension will be finalised considering equipment’s dimension, maintenance facilities, industrial rules & regulations.

8) Store building will be used to accommodate and store the spares & consumables of the whole plant. Single storied store building having minimum 1000 sq meter area. Design & foundation of the building shall be done in a way that future vertical extension of two floors can be made. Electrical Hoist with standard capacity to be provided for handling of spares & heavy materials. Store building area and dimension will be finalised considering equipment’s dimension and industrial rules & regulations.

N.B: No of rooms, other facilities, design for buildings will be finalized during detail engineering stage.
21.3 Design of the Works

21.3.1 Designs and Drawings

The Contractor shall design in accordance with this Specification and prepare complete working drawings as necessary for the construction of the Works. All drawings shall be submitted for the approval of the Engineer.

21.3.2 Standards And Codes Of Practice And Other Design Conditions

Design and construction of building works shall conform to recognise authoritative intentional or national standards and codes of practice. The adopted standards or codes shall be consistent throughout any section of the works unless otherwise specified. The Contractor shall have full responsibility to investigate the existence of any decrees and local bylaws governing the proposed works and to fully comply with such requirements which are effective when the date of tender submission. Local code of practice shall be followed where code/ standard is not mentioned.

As described elsewhere in the documents the Contractor shall indicate in his tender standards and codes to be conformed in design and construction of the Works. Copies of these codes and standards shall be made available to the Engineer during the design and construction period.

a. Basic design conditions for buildings are outlined as follows:-
   
   Design wind speed : As per Latest Wind Map
   Coefficient for seismic force (horizontal) (GPA): As per Seismic Map of approved Latest BNBC
   - Ditto - (vertical) : Nil

b. Live load of each floor shall be more than as follows:
   Auxiliary room : 500 kg/sq.m
   Cable spreading room : ditto

   c. Live load for Ground floor area and Power house building: 1000 kg/m²

21.3.3 Submission of Designs And Drawings

The Contractor shall be required to produce full design calculations for the foundations, building structures, and detailed working drawings and reinforcement bar bending schedule etc. Design calculations shall be prepared in accordance with an approved method of computation based on the most unfavourable combination of dead load, live load or crane load and wind load. The Contractor shall be responsible for the detailed design, strength and safety of the structures, and ensuring that the design satisfies the requirements of all authorised local and international bodies.

Design calculations and detailed drawings shall be submitted to the Engineer for approval in accordance with the requirement set out in Section 17.3.1 of the Tender Documents. Construction on the Site shall only commence after drawings are finally approved.

Notwithstanding the Engineer's approval, the Contractor shall be held
responsible for the accuracy of his submitted information, designs and drawings.

21.4 Building And Services

21.4.1 Control Room Building

Construction Control Room Building

(1) Main construction materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>Reinforced concrete</td>
</tr>
<tr>
<td>Roof</td>
<td>Reinforced concrete roof with lime concrete water proofing.</td>
</tr>
<tr>
<td>Exterior wall</td>
<td>Reinforced concrete and/or brick.</td>
</tr>
<tr>
<td>Partition wall</td>
<td>Brick</td>
</tr>
<tr>
<td>Floor</td>
<td>Concrete with plastic tile, ordinary tile, trowelled mortar finish, etc</td>
</tr>
<tr>
<td>Foundation</td>
<td>The Contractor shall examine subsoil condition for design of foundation. Proper foundation shall be designed by the Contractor in accordance with the Specifications</td>
</tr>
</tbody>
</table>

(2) Windows:

Aluminium sash shall be provided. Window area shall be generally more than 1/10 of the room floor area unless otherwise indicated. All windows except toilet, store, and cable spread room windows shall be fitted with sun blinds of approved made.

(3) Machines and utilities:

Air conditioning system, ventilation system, water supply system, power supply system, drainage system, sanitary system and lighting system shall be provided.

(4) Finishes and room sizes:

The Contractor may submit the layout to suit any particular requirement subject to the approval of the Engineer.

(5) Other Requirement:

a. Control room : Noise level shall be kept to a value less than 45 dB(A).

b. Toilets : Toilets shall be provided with sanitary fittings as per requirement

c. Ventilation and air conditioning

All rooms shall be provided proper ventilation system. The control room, relay room, electronics spares store, shall be provided air conditioning system.
21.4.2 Rain water

Buildings shall have eaves gutters and down pipes which are of sufficient sectional areas to collect rain water from roofs and to channel it to the drainage system in the vicinity of the building.

21.4.3 AIR CONDITIONING SYSTEM

The detail design of air conditioning system for control building and administration building shall be based on the following criteria:

- Outside temperature: 36°C
- Inside temperature: 20°C
- Relative humidity: 60%
- Type of system: Package air conditioning units

Air-conditioned rooms:
- Control Building: Control room, Relay room(s), offices, conference room, electronics spares room and prayer room.

Design calculations and drawings shall be submitted to the Engineer for approval prior to commencement of the work.

Details of the equipment proposed shall be submitted with the Tender.

21.4.4 Ventilation System

All rooms in the control building, shall be designed and furnished proper ventilation system in principle.

Unless otherwise specified, natural ventilation will be acceptable for the minor buildings. All toilets, battery room and shall have exhaust fans of approved made.

All fans shall be statically and dynamically balanced to avoid vibration and shall have blades to secure quiet efficient operation.

21.4.5 Plumbing And Sanitary Installation

The whole of the plumbing works in the buildings shall be provided in accordance with the relevant bylaws and to the complete satisfaction of the Engineer. Pipes shall be connected to each point where water is required, with a minimum head of 2 metres at all outlets.

All cast iron pipe works and fittings as are necessary for the complete installation of the sanitary system shall be supplied and installed in accordance with the requirement of the local authorities and other standards approved by the Engineer.

21.4.6 Lighting

The whole of the power supply and lighting system for the buildings shall be designed and installed in accordance with the Section 14. Intensity of light shall be as per BNBC.
21.5 Materials And Workmanship

21.5.1 Structural Steel

(1) General

Structural steel, bolts and nuts shall comply with the requirement of an approved standard and this Specification in all respects and those shall be fabricated from hot rolled sections unless other wise specified or agreed in writing by the Engineer. Design methodology (combination of Load) shall be followed as per section 2.7 of BNBC (Bangladesh national building code).

(2) Materials

The materials to be used shall be free from harmful defects and rust. Samples of materials shall be tested, and copies of the test reports giving physical and chemical properties shall be submitted to the Engineer for approval. The Contractor shall carry out all necessary tests, at his own expenses, to prove that the materials offered for the intended purpose are in compliance with the approved Standard.

In lieu of these tests, mill sheets issued by the authorised manufacturers will be acceptable. The characteristic strength of the structural steel shall have the following values regardless of the standard and code used:

- a. Yield Point: not less than 3500 kg/sq.cm
- b. Tensile Strength: not less than 4100 kg/sq.cm
- c. Elongation: not less than 20%.

(3) Bolt and Shear Connector

High strength bolts, anchor bolts, ordinary bolts and shear connectors to be supplied for the erection of structures shall conform to the Standard approved by the Engineer and shall be of an approved manufacturer. Specially devised high strength bolts, if used, shall tightened in accordance with the manufacturer's instructions. Any bolt that has been fully, tightened and then un-tightened shall not he used in the permanent Works.

(4) Fabrication

Fabrication and erection drawings shall be submitted to the Engineer for approval prior to commencement of any fabrication and erection work. Steelwork shall be fabricated to the required details in a manner approved by the Engineer. The Contractor shall provide adequate facilities for the Engineer to inspect materials and fabrication works in the shop and at the Site when required.

(5) Welding

Welding of structural steel shall be performed to the required type and size by an electric arc process by qualified welders under approved conditions. The plant, equipment and the adopted testing and inspection method shall conform generally with the relevant approved standard and other details in
this Specification and shall all be to the satisfaction of the Engineer.

Welding shall not be performed when the ambient temperature is less than 0 deg C; when surfaces are wet or exposed to rain, or strong wind; or when welders are exposed to inclement weather conditions.

Surfaces to be welded shall be free from loose or thick scale, slag, rust, moisture, grease and other foreign material that will prevent proper welding or produce objectionable fumes. Welding shall be principally carried out in workshops. Where necessary the Engineer may approve site welding, subject to the satisfactory provision of effective protection and safeguards for welding works by the Contractor.

(6) Welding Procedure

Details of the proposed welding procedure, manufacturer, classification on, code type and size of electrodes to be used shall be submitted to the Engineer for approval. When necessary, welding tests shall include specimen weld details representative of the actual construction which shall be welded in a manner simulating to most unfavourable conditions liable to occur in the particular application. All costs of the tests shall be borne by the Contractor. All welds shall be finished full and made with correct number of runs. Slag and other inclusions shall be cleaned from all welds. Notwithstanding the approval of welding schedule and procedure by the Engineer, the Contractor shall bear full responsibility for correct welding and for minimising the distortion in the finished structure.

a. Preparation of Base Metal

Surface and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities, which will adversely affect the quality or strength of the weld. In the preparation of the fusion faces, shearing shall be limited to metal thickness not greater than 8 mm. All fusion faces shall be prepared by machining shall be limited to metal shall be prepared by machining or flame cutting, or where approved, by special oxygen cutting apparatus. Fusion faces, angle of level, root radius, and the like shall be properly prepared to give the approved weld forms. The parts to be jointed by fillet welds shall be brought in-to contact as close as practicable. The gap between parts shall normally not exceed 4.8 mm (3/16 in.). A butting parts to be joined by butt welds shall be carefully aligned and the correct gap and alignment maintained during the welding operation.

b. Butt Welded Joint

Ends of the welds shall have full throat thickness by means of runoff tab. Additional metal remaining after the removal of the tab shall be removed by machining, or by other approved means. Ends and surfaces of the welds shall be smoothly finished. All main butt welds shall have complete penetration and, except on tubes or partial penetration Joint, shall be welded from both sides. The back of the first run shall be suitably gouged out.

c. Intermittent Welds

Intermittent welds shall not be permitted without the approval of
(7) Paint

Prior to delivery after shop inspection, the whole of the steelwork shall be prepared for painting by an approved blast cleaning method.

All rust, grease, mill scale and harmful matter shall be removed. The surface shall be blast cleaned to:

a. Swedish Standard Sa 2 1/2 SIS OS 5900 1967
b. British Standard 4232 Second Quality
d. U.S.A. Standard commercial blast finish SSPC-SP-6-63

The first coat of primer of recommended by the manufacturer as suitable for use under the prevailing condition at the application site shall be applied immediately after blast cleaning (or within two hours).

No paint shall be applied to the surfaces to be embedded in concrete, to contact surfaces for joints using high strength friction bolts and to surfaces within 50 mm either side of joints to be welded.

Painting shall be carried out in a clean, dry building where air temperature shall not be allowed to drop below 5 deg.C. No paint shall be applied on the steelwork with condensation. Painting shall not be carried out when the relative humidity is over 90%, or if in the open, during rain, fog or mist. The welded areas and the edges of site joints shall be cleaned down, primed and painted all in accordance with the standards specified, after erection.

Each coat of the paint will be applied in different colour. When paintwork is damaged it shall be cleaned and re-painted following the procedures as approved by the Engineer. The manufacturer's instructions regarding intercoat intervals shall be strictly observed.

(8) Transportation and Storage of Steelwork

The whole of the steelwork shall be handled in such a manner that the shape and surfaces of the section shall not be damaged during lifting and transportation. The Contractor shall take all necessary measures, to ensure that steelwork members shall be handled, stored and erected without their being subject to stresses in excess of those for which they were designed. Chains and hooks will not be used in contact with the steel work and lifting slings shall be of nylon rope. Steel work shall be stored in clean, dry conditions off the ground. Separate pieces of steelwork shall have spacer blocks between them.

(9) Erection

The Contractor shall ensure the correctness of alignment, plumbing and stability of the various frames and members. He shall also take all necessary measures, by adequate resistance to wind and stability against collapse, during construction.
No permanent bolting and site welding shall be carried out until proper alignment has been obtained.

21.5.2 Concrete

The specifications for concrete works under Section 20 are applicable to building works.

21.5.3 Grouting of Structural Steelwork

(1) Materials for Grouting

The aggregate for grouting shall consist of hard siliceous sand, and grained chips, gravel or crushed stone, or other approved inert materials with similar characteristics. The materials shall be clean, free from lumps, soft or flaky particles, shale, crusher dust, silt, alkali, loam, organic matter or other deleterious substances. The aggregate shall be of uniform grading and shall be of such a size that 100% will pass through a 10 mm mesh and not more than 10% will pass through a 150 micron mesh. A pre-mixed non-shrink resin grout may be used. The manufacturer's instructions on mixing and the placing of the grout shall be observed.

(2) Admixtures

An admixture which acts as a non-shrinking agent shall be added to the grout only with the Engineer's approval. All proprietary admixtures shall be added and mixed strictly in accordance with the manufacturer's instructions.

(3) Surface Treatment

Concrete surface which is to be grouted shall be thoroughly cleaned and all laitance removed from the surface by means of a hammer and chisel. A power hammer shall not be used.

(4) Mixing

The Contractor shall submit to the Engineer for approval details of the mix and the methods he intends to use, prior to the commencement of the grouting.

(5) Placing

For cement based grouts the concrete surface to be grouted shall be thoroughly saturated with water at least two times before the commencement of grouting.

21.5.4 Roofing And Brickwork

(1) Roofing

Roofing material for administration building shall be of corrugated galvanised iron sheet. The Contractor shall submit samples and technical details of the roofing material for approval of the Engineer.

An insulation layer of glass fibre or rock wool board of minimum 25 mm
thick shall be incorporated in the roofing system. The thermal conductance of the composite roof cladding shall be less than 1.10 kcal/sq.m hr-deg C at 25°C.

All accessories and the method of fixing shall be strictly in accord-dance with the manufacturer's instructions and to the satisfaction of the Engineer.

(2) WaterProofing

Waterproofing for reinforced concrete flat roofs shall be of lime concrete. The minimum thickness of lime concrete shall be 10cm.

(3) Eaves Gutters and Down Pipes

Eaves gutters shall be of PVC or galvanised steel sheet coated with bituminastic painting to be approved by the Engineer. Where large section is required, steel sheet is preferable for strength. Down pipes shall be of PVC pipe, galvanised steel pipe or cast iron pipe to be approved by the Engineer.

(4) Brick Walls

Bricks to be used for walls shall be Bangladesh made. Unless otherwise specified or as shown in drawing, the thickness of brick-wall shall be more than 15 cm.

Mortar for use with brickwork shall be mixed in the proportions of 1:3 cement, sand or 1:2:5 cement, lime and sand by volume. Mortar may be mixed by hand or machine. Hand mixing shall be carried out on a clean, watertight platform. Cement shall be of a quality as described in the Section 20 for concrete. Sand shall be well-graded (2.5 mm down) hard and free from deleterious substances. Lime for mortar shall be pure calcium carbonate properly burned, then hydrated, and finely ground. All joints shall be completely filled with mortar. The thickness of the horizontal mortar joints shall not exceed 40 mm to every four joints. The mortar shall be used within 2 hours of mixing with water and any mortar not used then shall be discarded.

All brick-walls are to be reinforced with approved reinforcing material at every fourth course.

The damp proof course shall be provided at joint and intersections laid on a bed of cement sand (1:1), bedded in and coated on the upper surface with liquid bitumen.

External fair faced wall shall be weather struck; faces or wall which are to be plastered or rendered shall have their joints raked out to form key.

(5) Calking

The Contractor shall calk the joints to ensure water tightness of the building structures. Prior to calking materials and working method shall be approved by the Engineer.
21.5.5 Carpentry And Joinery

(1) Timber

All timber shall be of best quality, perfectly dry and well seasoned, sawn die square, free from sap, shakes, wanly edges, large loose or dead knots and all other defects and shall be to the approval of the Engineer.

(2) Preservative

Timber to be used in shower rooms or in contact with the ground floor, shall be treated with an approved preservative against rot or termite attack. The backs or frames to be fixed to walls and all other bedding surfaces shall be painted with two coats of preservative before fixing. All fixing blocks, pallets, and other hidden timber shall be so treated prior to fixing.

(3) Joinery Fittings

All timber for Joinery fiting shall be of selected type properly seasoned and dry to a agreed moisture content not exceeding 18%. The Engineer shall have the right to check all timbering used and to reject any timber found to have a moisture content exceeding 18%.

Joinery fittings and built-in cabinet are to be constructed exactly as shown on the approved drawings.

All work must be carried out by experienced cabinetmakers in a sound and workmanlike manner with properly fabricated joints, dovetailed, mitred or mortised and with concealed pins and screws. All joints shall be glued before pinning or screwing.

(4) Faults

Any defect in the wood works such as shrinks splits, fractures, etc shall be removed and replaced to the satisfaction of the Engineer.

21.5.6 Doors And Windows

Prior to furnishing and installing, the Contractor shall submit the shop drawings indicating shape, dimensions, material including hard wares and locking method of doors and windows for all buildings for the approval of the Engineer.

The standard requirements of doors and windows are as follows:

a. Steel doors
   Frame and Stile Plates : more than 2.3 mm thick
   Stile and Panel : more than 1.6 mm thick
   Thickness : 80 mm
   Size : double door 2.0 x 2.0 m, single door 1.0 x 2.0 m or other sizes as shown on the approved drawing

b. Wooden doors
   Plywood for panel : more than 5 mm thick
   Thickness : 40 mm
   Size : 0.9x2.0 m or other sized as shown on the approved
Hollow flush door shall be painted 2 coats of rust resistant paint and finish coat. Hollow flush door shall be of the waterproof type.

c. Aluminium window
   Thickness : 70mm
   Finishing : Aluminate
   Size      : double window 0.9 x 1.8 m
               single window 0.9 x 0.9 m or other
               sizes as shown on the approved
               drawing

   Glass (tinted) : 6mm

d. Aluminium swing doors
   Frame and stile plate : More than 2.3 mm thick
   Thickness : More than 45 mm
   Size : As shown on the drawing

All other type of doors, windows which are shown on the drawings but not specifically mentioned shall be provided to the satisfaction of the Engineer.

21.5.7 Glazing Works

(1) Materials

Sheet glass shall be of good quality, free flow unevenness and strain of bubbles. All the glass used on the ground floor shall be tinted glass (salon-radiation absorbing glass), and all the glass used on the first floor shall be clear glass. Where so required figured glass shall be used. Minimum thickness of tinted glass and clear glass shall be 6 mm. Glazing beads, sealant, putty, clips and setting block shall be of good quality and those recommended by the glass manufacturer. All the glass used in the following rooms shall be tinted wire glass.

Auxiliary room and cable spreading room
Warehouse and workshops
Stores

(2) All glass shall be installed tightly in accordance with the instructions of the glass manufacturer.

Upon completion of the works, glass shall be wiped clean and shall be inspected by the Engineer.

21.5.8 Metal Works

(1) General

The metal works will include handrails, drain pipes, steel ladders, step ladders, cable duct hatch cover plate, removable hatch cover plate, rain water leader, air duct, louver and others. Prior to fabrication work drawings and quality of materials shall be submitted to the Engineer for approval.

(2) Materials

The materials to be used in the Works shall be free from defects and conform to JIS Standard or relevant Standards approved by the Engineer,
(3) Workmanship

All plates and sections shall be true to form, free from twist and straightened before any fabrication work is started on them. The works of cutting, fabrication, welding, installation and painting shall be done in accordance with this Specification and relevant Standard. If difference quality metals are in contact with each other, these contact surfaces shall be separated by means of bituminous paint, felt strip, rubber sheet and other material to be approved by the Engineer.

21.5.9 Floor Laying

(1) PVC Flooring

PVC flooring shall be heat resisting vinyl tiles obtained from an approved manufacturer. The tiles shall be not less than 2.4 mm thick and laid by an specialist to a jointing layout approved by the Engineer. A matching PVC cove-type skirting is to be used in conjunction with the floor tiles. The tiles and skirting shall be laid on a flat, clean concrete floor, in strict accordance with the manufacturers instructions, using the recommended adhesive.

(2) Unglazed Vitreous Ceramic Tiles

The tiles shall be plain and of manufacture and colour approved by the Engineer. The tiles shall be laid by experienced craftsman, on a concrete slab accurately formed with a true, smooth surf ace. Joints shall be accurately aligned in both directions and matching covered skirtings. Expansion Joints shall be the same width as tile Joints, approximately 5 mm, and filled with approved filling material. The surface of the base shall be cleaned of all dirt, grease, grit, etc. and the tiles shall be dry and clean.

(3) In-situ Terrazzo

In-situ terrazzo paving is to consist of2 1/2 parts 6.5 mm 9.5 mm approved marble chippings, clean and free from dust, mixed with one part of "concrete" or "snowcrete" or approved equivalent according to the background required. The terrazzo shall be laid by a specialist.

The terrazzo is to be trowelled to a dense even surface, rubbed down and polished to approval. Where surface are required to be left rough finish the finishing coat shall be brushed with wire brush while still green to expose the aggregates.

Brass dividing strips 25 mm x 3.2 mm shall be provided at junctions of different floor finishes, finishing flush with flooring non-slip nosing tiles of approved manufacture and colour shall be provided in finishing works for steps and stair.

(4) Damp-Proof Membrane

An approved bitumen/PVC water-proof membrane shall be placed on the blinding concrete under concrete slabs, to exclude rising moisture.
21.5.10 Wall And Ceiling Finishes

(1) Materials

Cement, sand, hydrated lime, gypsum plaster, expanded metal lathing, flat headed galvanised nails, galvanised staples and wire shall all comply with approved standards. Materials shall be carefully store in a dry weatherproof store until required for use.

(2) Preparation of Backgrounds

Backgrounds for plaster work shall be carefully brushed out and removed dust and other deleterious matter likely to impair the bond of the under coat with the structure. When the background surface is dry and undue suction occurs, this shall be sprinkled with water to prevent drying the applied plaster.

(3) Plasterwork

Undercoat shall consist of Portland Cement, hydrated lime and sand gauged in the proportions 1:1:6. The undercoat shall be keyed to take the finishing coat and allowed to dry out completely before the latter is applied.

Finishing coats shall be applied in accordance with the recommendations of the manufacturer of the particular brand to be used. The total thickness of the two coats shall not be less than 15 mm thick.

(4) External Rendering

External rendering shall be applied in two coats, with an approved waterproof agent added to the mixes. The walls shall be wetted before the application of the first coat, which shall be finished flat and vertical by straight edge, and scored to form a key. The second coat shall not be applied until the first coat has dried out completely. Immediately before application of the second coat, the surface of the first coat shall be wetted, and the second coat shall be applied by machine, to give a "Tyrolean" finish of uniform thickness and texture.

An approved plasticizer may be used in both coats. All external rendering shall be protected from rain and direct sunlight for period of 7 days.

(5) Glazed Ceramic Tiling

Glazed ceramic wall tiles shall be of nominal size 100 mm x 100 mm x 5 mm, colour to be selected. Fittings shall be obtained from a supplier approved by the Engineer. The ceramic tile fixing and grouting materials shall be obtained from the same source.

The Contractor shall ensure that the rendering is accurately formed and has a true plumb surface which is free from all high spots and depressions.

The rendered backing for tiling shall be cleaned and will be wetted (just enough to prevent it from absorbing water from the fixing bed) immediately prior to tiling. All tiles shall be dipped in water to ensure that they are completely clean prior to fixing. All tiles shall be immersed in water in clean containers for at least half an hour before use. Tiles shall then be stacked lightly together on a clean surfaces to drain with the end tiles, turned glaze
outwards. They shall be fixed as soon as all surfaces water has evaporated they must not be allowed to dry out more than this.

Approximately two days after the fixing of the tiles, all joints shall be pointed with neat white grouting cement; the finish shall be flushed and free from all voids and irregularities.

All wall faces shall be finished plumb and flush throughout free from unevenness and irregularities of plain; all angles shall be straight and true. The finished work shall be left clean and free from all materials, which will scratch or in any way impair the finished work. Final polishing shall be done with a dry cloth. The Contractor shall be responsible for the adequate protection of the tiling from all damage until the handling over. Any damage which does occur shall be made good by the Contractor at his own expense. The whole of the work shall be left in a state satisfactory to the Engineer.

(6) Suspended Ceiling

Materials, samples and drawings showing details of construction of all types of ceiling required shall be submitted to the Engineer for approval.

Appropriate size of aluminium tees shall be grided to the module of standard panels to accommodate acoustic boards, or approved equivalent, the odd size panels at perimeter shall then be arranged to equal dimension.

Fixing of hanger to beams, floor slab and soffits must be capable of carrying the load of ceiling boards and ventilation grill should be supported from the strengthened aluminium tee grids.

(7) Gypsum Board Partitions

Gypsum panels shall be 1000 mm wide by 12 mm thick obtained from an approved manufacturer. Fire resistance as per BNBC.

The stud partition shall be extended from floor to ceiling with variation in heights to suit. Stud shall be formed of approximately 0.03 gauge cold rolled steel with pre-punched holes in the web 150 mm on centre to allow horizontal passage of utility lines. Studs shall be spaced 1000 mm on centre with horizontal spacer channels and framing materials.

Glass panel framing shall be anodised aluminium with glazing recess. Glazing shall be 6 mm clear sheet glass fitted with neoprene or vinyl gaskets.

The Contractor shall submit samples of metal and drawings showing details of constructions for approval of the Engineer.

21.6 Painting

21.6.1 Materials

All paint distempers and other materials shall be of an approved brand or brands and shall comply with JIS Standard or other, equivalent standard to be approved by the Engineer. Paint for use on concrete or brickwork shall be of a type specially prepared for this purpose. Each coat shall be of a distinct colour from the preceding one and all colours shall be approved by
the Engineer. Mixed paint and synthetic resin emulsion paint shall be applied based on the following method

<table>
<thead>
<tr>
<th></th>
<th>Mixed paint</th>
<th>Synthetic resin emulsion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metal</td>
<td>Wood</td>
</tr>
<tr>
<td>First paint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Rust inhibitive paint)</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Second paint</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Finishing paint</td>
<td>0.04</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Note: Rust inhibitive paint shall be either red lead or zinc rich lead type.

For painting of structural steelwork, see Section of 21.5.1(7).

21.6.2 Surface Preparation

Prior to painting, the dust, grease, injurious adherent substance, rust shall be removed from the surface to be painted. The planed grain, interlocked grain, fluff in wood shall be ridded with sandpaper and all cracks, manholes open; duct and other imperfection shall be made good with hard stopping consisting of paste white lead and gold size stiffened with whiting. Cracks and holes on the concrete surface shall be flattened with cement paste, mortar, or cement filler.

21.6.3 Workmanship

All painting and decoration shall be carried out by skilled workmen according to the best current practice in accordance with manufacturer's instructions.

All materials shall be applied by brush unless otherwise specified or approved.

21.6.4 Priming

All joinery, metal works to be painted shall be primed using appropriate and approved primer before delivery assembly or fixing. No primer is required on surfaces to be distempered or emulsion painted unless otherwise specified.

21.6.5 Number Of Coats

Unless otherwise specified, the required finishes shall consist of the following treatments, in addition to preparation, priming etc:-

a. Distempering Two coats
b. Emulsion painting Two coats
c. Oil painting Three coats on woodwork Two coats on elsewhere

21.6.6 Storage

The Contractor shall furnish an exclusive place for storing the combustible paints. The place for storage shall be fully ventilated. Adequate measures shall be taken against the ingress of dust and direct rays of the sun.
Section 22

Spare Parts
22. SPARE PARTS

22.1 Spares & consumables during Warrantee period
22. **Spare Parts**

22.1 **Spares & consumables during Warrantee period**

The Defect Liability Period shall be twenty four (24) months from the Operational Acceptance of the Facilities. Contractor will provide all spares & consumables whether listed or not in the contract for smooth operation of the plant during Defect Liability Period. During the Defect Liability Period, contractor will also provide normal operation spares & consumables (Lube Oil, Air Filters, Chemicals & others), wear & tear spares, spares required for schedule/ unscheduled maintenance and services required for complete combined cycle power plant & their auxiliaries (with all electrical equipment and control system) except schedule inspections’ spares for GTG & their auxiliaries (Spares for day to day, unscheduled, breakdown & others maintenance shall have to supplied by EPC contractor). In preparation of the list the tenderer have to consider plant factor as 80% and 50 nos. start/stop per year.
Section 23

Remote Monitoring System
23. Remote Monitoring System (RMS)
23.1 Remote Monitoring System (RMS):

Remote Monitoring System (RMS) means a system or systems that may be used from time to time by GTG OEM for monitoring of the Generating Unit/ Facility and or its equipment, generally consisting of hardware, software and a connection to a source of technical oversight or review.

Remote Monitoring System (RMS) Documentation means any user manuals or other printed materials designed to assist with the operation of those functions of the Remote Monitoring System (RMS) made available to Owner/ BPDB.

23.2 Terms and Conditions applicable to the Remote Monitoring System (RMS):

As a part of the Remote Monitoring System (RMS), Contractor will place On-Site Monitor(s) (“OSM”) on, and/or connect the OSM to, Facility equipment and/or systems. The OSM will be connected to an OEM’s centre.

The OSM consists of the following hardware components, or substitute components, as the same may be updated, modified, omitted or replaced from time to time:

- One Monitoring Computer System, including without limitation CPU, Monitor and Keyboard.
- One network connection per computer system to provide remote access.
- The required interconnection devices such as short haul modem pairs etc.
- An external backup device.
- Appropriate interface to the turbine control system, to the plant Distributed Control System (“DCS”) and the vibration measuring equipment.

The OSM also consists of the following software components, or substitute components, as the same may be updated, modified, omitted or replaced from time to time:

- The software package and configuration to collect and monitor data from the turbine control system and other specified devices, which may include some or all of the modules currently designed as trip analysis module and/or other modules.

Contractor will provide a configuration summary, giving an overview of the Remote Monitoring System (RMS) features to be applied to the Facility. Contractor will provide Owner with an updated configuration summary. Owner’s consent to the configuration summary and updates, if any, will not be unreasonably withheld.

23.3 Use and ownership of data collected by the Remote Monitoring System (RMS):

1. Owner/ BPDB shall maintain ownership of the data collected by the Remote Monitoring System (RMS) about the Facility.
2. Owner/ BPDB access to the Monitoring System information and to other information from time to time made available, will be through the Internet portal with cyber security as the same is maintained, updated and modified. The internet portal with cyber security is expected to include, among other features, functionality for the Owner to gain an overview of Best Practices developed by Contractor/ GTG OEM.

3. Contractor/ GTG OEM grants to Owner a non-transferable, non-exclusive license as long as the OSM remains in use in the Facility during the term of the Owner, to access and use the Contractor/ GTG OEM software package for the covered units, and to use the RMS Documentation. Contractor/ GTG OEM does not sell or license the Contractor/ GTG OEM Software package, and does not grant any ownership or license interest in the Contractor/ GTG OEM Software package to Owner by virtue of the use of the Contractor/ GTG OEM Software Package.

23.4 Provision, use and ownership of the Monitoring System Hardware and Software:

1. Title to the Remote Monitoring System (RMS) hardware components shall pass to Owner/ BPDB upon installation. Title to the Remote Monitoring System (RMS) software and to the GTG OEM Software package shall remain with the Owner/ BPDB.

2. Owner/ BPDB acknowledges that the GTG OEM Software Package contains certain other third party software, which the GTG OEM either owns or is licensed to use and that GTG OEM does not extend any license to any such software to owner.

3. Owner/ BPDB agrees to use the RMS in accordance with these Monitoring System Conditions and the licenses as granted herein, and that all associated documentation, copyrights, trademarks, trade names, logos and products developed by the Contractor/ GTG OEM. If at any time Owner ceases to use the Monitoring System, the non-perpetual licenses shall terminate immediately and Owner agrees that it will destroy or return to the GTG OEM any such licensed software that it may have upon termination of such license for any reason.

23.4 General Provisions regarding the Monitoring System:

1. Contractor shall arrange and provide a dedicated T-1 network line at its expense for the connectivity of the RMS to the OEM centre with cyber security facility. Contractor will provide enhanced connectivity of the Remote Monitoring System in OEM centre (if required). Owner/ BPDB shall not use any such connections whether T1 network lines or otherwise for any other communications or purpose, nor shall it allow others to do so. The connection shall be and remain connected to the Monitoring System.

2. Contractor will provide instruction to owner/ BPDB personnel On-Site concerning any Monitoring System features to which Owner/ BPDB will have access.
3. Contractor shall be responsible to arrange electric power source for the Monitoring System.

4. Contractor will provide Owner/ BPDB with a list of all data points connected to the OSM at the time of final completion of installation of the Monitoring System. Such data points may change from time to time.

5. RMS equipment that will be placed on or connected to the Facility equipment and/or systems is passive and will not interface with the operation of that equipment/Plant.

6. GTG OEM shall have a right to access the Monitoring System and its connection at the Facility at all reasonable times.
Section 24

LONG TERM SERVICE AGREEMENT (LTSA)
24. LONG TERM SERVICE AGREEMENT (LTSA)

LONG TERM SERVICE AGREEMENT (LTSA) proposal from the GTG OEM shall be submitted with the Technical & Financial Proposal as per Vol 2 of 2 (Part C).
Section 25

Appendices
<table>
<thead>
<tr>
<th>Annexure -1</th>
<th>Analysis of Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annexure-2</td>
<td>Site Location</td>
</tr>
<tr>
<td>Annexure-3</td>
<td>Environmental Standards</td>
</tr>
<tr>
<td>Annexure-4</td>
<td>Seismic zoning map of Bangladesh</td>
</tr>
<tr>
<td>Annexure-5</td>
<td>Basic Wind Speed map of Bangladesh</td>
</tr>
<tr>
<td>Annexure-6</td>
<td>Indicative Single Line Diagram</td>
</tr>
</tbody>
</table>
### ANALYSIS OF NATURAL GAS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject/ Particulars</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Chemical Composition</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Methane (CH₄)</td>
<td>92 to 97 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>b. Ethane (C₂H₆)</td>
<td>0 to 6.50 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>c. Propane (C₃H₈)</td>
<td>0 to 1.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>d. Butane (C₄H₁₀)</td>
<td>0 to 1.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>e. Pentane (C₅H₁₂) &amp; higher HC</td>
<td>0 to 2.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>f. Hydrogen Sulphide (H₂S)</td>
<td>0.5 grains per 10 S. Cu. ft.</td>
</tr>
<tr>
<td></td>
<td>g. Carbon Dioxide (CO₂)</td>
<td>0 to 0.80 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>h. Nitrogen (N₂)</td>
<td>0 to 0.60 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>i. Argon (Ar+O₂)</td>
<td>0 to 1.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>j. Inert Gas</td>
<td>0 to 5.00 Percent by volume</td>
</tr>
<tr>
<td>2.</td>
<td><strong>Physical Properties</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Calorific Value (LHV)</td>
<td>35,350 kJ/Nm³.</td>
</tr>
<tr>
<td></td>
<td>b. Temperature Range</td>
<td>15⁰c to 60⁰C</td>
</tr>
<tr>
<td></td>
<td>c. Total Sulphur</td>
<td>20 grains or less in per 100 SCF gas</td>
</tr>
<tr>
<td></td>
<td>d. Solid Substances</td>
<td>Free from solid material beyond 5 microns in size</td>
</tr>
<tr>
<td></td>
<td>e. Specific Gravity (air=1)</td>
<td>0.55 to 0.67</td>
</tr>
<tr>
<td></td>
<td>f. Water content</td>
<td>7 lbs per 100,000 SCF</td>
</tr>
<tr>
<td></td>
<td>g. Liquefiable Hydrocarbons</td>
<td>Not more than 2 American gallons per 100,000 SCF</td>
</tr>
<tr>
<td></td>
<td>h. Pressure Range</td>
<td>80 - 150 Psig</td>
</tr>
</tbody>
</table>
Site Location
Raozan 400 MW ± 10% CC Plant Project (Vol-2 of 2, PART A)
Environmental Standards
### SCHEDULE – 4

**Standards for Sound**

[See Rule 12]

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category of areas</th>
<th>Standards determined at dBa unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Silent zone</td>
<td>45</td>
</tr>
<tr>
<td>b.</td>
<td>Residential area</td>
<td>50</td>
</tr>
<tr>
<td>c.</td>
<td>Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes)</td>
<td>60</td>
</tr>
<tr>
<td>d.</td>
<td>Commercial area</td>
<td>70</td>
</tr>
<tr>
<td>e.</td>
<td>Industrial area</td>
<td>75</td>
</tr>
</tbody>
</table>

**Notes:**

1. The time from 6 a.m. to 9 p.m. is counted as daytime.
2. The time from 9 p.m. to 6 a.m. is counted as night time.
3. Area up to a radius of 100 meters around hospitals or educational institutions or special institutions/establishments identified/to be identified by the Government is designated as Silent Zones where use of horns of vehicles or other audio signals, and loudspeakers are prohibited.
**SCHEDULE – 9**

Standards for Sewage Discharge  
[See Rule 12]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Standard Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>miligram/l</td>
<td>40</td>
</tr>
<tr>
<td>Nitrate</td>
<td>&quot;</td>
<td>250</td>
</tr>
<tr>
<td>Phosphate</td>
<td>&quot;</td>
<td>35</td>
</tr>
<tr>
<td>Suspended Solids (SS)</td>
<td>&quot;</td>
<td>100</td>
</tr>
<tr>
<td>Temperature</td>
<td>Degree Centigrade</td>
<td>30</td>
</tr>
<tr>
<td>Coliform</td>
<td>number per 100 ml</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Notes:**

1. This limit shall be applicable to discharges into surface and inland waters bodies.
2. Sewage shall be chlorinated before final discharge.

**SCHEDULE – 10**

Standards for Waste From Industrial Units or Projects Waste  
[See Rule 13]

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Unit</th>
<th>Inland Surface Water</th>
<th>Public Sewerage system connected to treatment at second stage</th>
<th>Irrigated Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ammonical Nitrogen (as elementary N)</td>
<td>mg/l</td>
<td>50</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>Ammonia (as free ammonia)</td>
<td>&quot;</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Arsenic (as)</td>
<td>&quot;</td>
<td>0.2</td>
<td>0.05</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>( \text{BOD}_2 ) at 20°C</td>
<td>&quot;</td>
<td>50</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Boron</td>
<td>&quot;</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>6</td>
<td>Cadmium (as Cd)</td>
<td></td>
<td>0.50</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>7</td>
<td>Chloride</td>
<td></td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>8</td>
<td>Chromium (as total Cr)</td>
<td></td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>9</td>
<td>COD</td>
<td></td>
<td>200</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>10</td>
<td>Chromium (as hexavalent Cr)</td>
<td></td>
<td>0.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>11</td>
<td>Copper (as Cu)</td>
<td></td>
<td>0.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>12</td>
<td>Dissolved Oxygen (DO)</td>
<td></td>
<td>4.5 – 8</td>
<td>4.5 – 8</td>
<td>4.5 – 8</td>
</tr>
<tr>
<td>13</td>
<td>Electro-conductivity (EC)</td>
<td>microhm/cm</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>14</td>
<td>Total Dissolved Solids</td>
<td></td>
<td>2,100</td>
<td>2,100</td>
<td>2,100</td>
</tr>
<tr>
<td>15</td>
<td>Fluoride (as F)</td>
<td></td>
<td>2</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>Sulfide (as S)</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>Iron (as Fe)</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>Total Kjeldahl Nitrogen (as N)</td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>19</td>
<td>Lead (as Pb)</td>
<td></td>
<td>0.1</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>Manganese (as Mn)</td>
<td></td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>Mercury (as Hg)</td>
<td></td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>22</td>
<td>Nickel (as Ni)</td>
<td></td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>23</td>
<td>Nitrate (as elementary N)</td>
<td>mg/l</td>
<td>10.0</td>
<td>Not yet Fixed</td>
<td>10</td>
</tr>
<tr>
<td>24</td>
<td>Oil and Grease</td>
<td></td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>25</td>
<td>Phenolic Compounds (as C₆H₃OH)</td>
<td></td>
<td>1.0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>Dissolved Phosphorus (as P)</td>
<td></td>
<td>8</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>27</td>
<td>Radioactive substance</td>
<td>To be specified by Bangladesh Atomic Energy Commission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>pH</td>
<td></td>
<td>6 – 9</td>
<td>6 – 9</td>
<td>6 – 9</td>
</tr>
<tr>
<td>29</td>
<td>Selenium (as Se)</td>
<td>mg/l</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>30</td>
<td>Zinc (as Zn)</td>
<td>Degree</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Total Dissolved Solids</td>
<td>&quot;</td>
<td>2,100</td>
<td>2,100</td>
<td>2,100</td>
</tr>
<tr>
<td>32</td>
<td>Temperature</td>
<td>Centigrade</td>
<td>40</td>
<td>40</td>
<td>40-Summer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Suspended Solids (SS)</td>
<td>mg/l</td>
<td>150</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>34</td>
<td>Cyanide (as Cn)</td>
<td>&quot;</td>
<td>0.1</td>
<td>2.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Notes:

(1) These standards shall be applicable to all industries or projects other than those specified under the heading “Standards for sector-wise industrial effluent or emission.”

(2) Compliance with these standards shall be ensured from the moment an industrial unit starts trial production, and in other cases, from the moment a project starts operation.

(3) These standards shall be inviolable even in case of any sample collected instantly at any point of time. These standards may be enforced in a more stringent manner if considered necessary in view of the environmental conditions of a particular situation.

(4) Inland Surface Water means drains/ponds/tanks/water bodies/ditches, canals, rivers, springs and estuaries.

(5) Public sewerage system means treatment facilities of the first and second stage and also the combined and complete treatment facilities.

(6) Irrigable land means such land area which is sufficiently irrigated by waste water taking into consideration the quantity and quality of such water for cultivation of selected crops on that land.

(7) Inland Surface Water Standards shall apply to any discharge to a public sewerage system or to land if the discharge does not meet the requirements of the definitions in notes 5 and 6 above.
## SCHEDULE – 11

Standards for Gaseous Emission from Industries or Projects  
[See Rule 13]

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameters</th>
<th>Standard present in a unit of mg/Nm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Particulate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Power plant with capacity of 200 Megawatt or above.</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>(b) Power plant with capacity less than 200 Megawatt.</td>
<td>350</td>
</tr>
<tr>
<td>2.</td>
<td>Chlorine</td>
<td>150</td>
</tr>
<tr>
<td>3.</td>
<td>Hydrochloric acid vapor and mist</td>
<td>350</td>
</tr>
<tr>
<td>4.</td>
<td>Total Fluoride F</td>
<td>25</td>
</tr>
<tr>
<td>5.</td>
<td>Sulfuric acid mist</td>
<td>50</td>
</tr>
<tr>
<td>6.</td>
<td>Lead particulate</td>
<td>10</td>
</tr>
<tr>
<td>7.</td>
<td>Mercury particulate</td>
<td>0.2</td>
</tr>
<tr>
<td>8.</td>
<td>Sulfur dioxide</td>
<td>kg/ton acid</td>
</tr>
<tr>
<td></td>
<td>(a) Sulfuric acid production (DCDA* process)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>(b) Sulfuric acid production (SCSA* process)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>(* DCDA: Double Conversion, Double Absorption; SCSA: Single Conversion, Single Absorption.)</td>
<td></td>
</tr>
</tbody>
</table>

Lowest height of stack for dispersion of sulfuric acid (in meter).

(a) Coal based power plant

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>500 Megawatt or above</td>
<td>275</td>
</tr>
<tr>
<td>(2)</td>
<td>200 to 500 Megawatt</td>
<td>220</td>
</tr>
<tr>
<td>(3)</td>
<td>Less than 200 Megawatt</td>
<td>$14(Q)^{0.3}$</td>
</tr>
</tbody>
</table>

(b) Boiler

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Steam per hour up to 15 tons</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>(2) Steam per hour more than 15 tons</td>
<td>$14(Q)^{0.3}$</td>
<td></td>
</tr>
</tbody>
</table>

$[Q = \text{Emission of Sulfur dioxide (kg/hour)}]$.
<table>
<thead>
<tr>
<th></th>
<th>Oxides of Nitrogen</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td></td>
<td>(a) Nitric acid production</td>
<td>3 kg/ton acid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Gas Fuel based Power Plant</td>
<td>50 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1) 500 Megawatt or above</td>
<td>50 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) 200 to 500 Megawatt</td>
<td>40 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Below 200 Megawatt</td>
<td>30 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c) Metallurgical oven</td>
<td>200 ppm</td>
</tr>
<tr>
<td>10.</td>
<td>Kiln soot and dust</td>
<td></td>
<td>mg/Nm³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(a) Blast Furnace</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b) Brick Kiln</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c) Coke oven</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(d) Lime Kiln</td>
<td>250</td>
</tr>
</tbody>
</table>
Standards for Industrial Effluent or Emission

Boiler of Industrial unit

Gaseous Emission

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Standards for presence in a unit of mg/Nm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soot and particulate (fuel based)</td>
<td></td>
</tr>
<tr>
<td>(a) Coal</td>
<td>500</td>
</tr>
<tr>
<td>(b) Gas</td>
<td>100</td>
</tr>
<tr>
<td>(c) Oil</td>
<td>300</td>
</tr>
<tr>
<td>2. Oxides of Nitrogen (fuel based)</td>
<td></td>
</tr>
<tr>
<td>(a) Coal</td>
<td>600</td>
</tr>
<tr>
<td>(b) Gas</td>
<td>150</td>
</tr>
<tr>
<td>(c) Oil</td>
<td>300</td>
</tr>
</tbody>
</table>
Annexure-4

Seismic Zoning Map of Bangladesh
Annexure-5

Basic Wind Speed Map of Bangladesh
NOTE: 
a) Isobars at a region boundary have the same value as that of the region.
b) Basic wind speed for a particular location shall be obtained as follows:
   i) When a location is listed in Table 3.4.1, the value of basic wind speed shall be taken from that table.
   ii) When the location lies within any region (shown coloured in the map), the value marked for that region shall be taken.
   iii) For a location lying on any isobars as shown in this map, the value of that isobars shall be taken.
   iv) For a location lying outside the positions (i) through (iii) above, linear interpolation shall be made between the adjacent isobars to obtain the basic wind speed.
Annexure-6

Indicative Single Line Diagram