BANGLADESH POWER DEVELOPMENT BOARD

BIDDING DOCUMENT
Single-Stage, Two-Envelope System

FOR
PROCUREMENT OF

DESIGN, SUPPLY AND INSTALL FOR

PACKAGE-1-CONVERSION OF 100 MW BAGHABARI GAS TURBINE POWER PLANT TO 150 MW COMBINED CYCLE POWER PLANT AND THE CONVERSION OF 2X35 MW SHAHJIBAZAR GAS TURBINE POWER PLANT TO 105 MW COMBINED CYCLE POWER PLANT ON TURNKEY BASIS

LOT-1: CONVERSION OF 100 MW BAGHABARI GAS TURBINE POWER PLANT TO 150 MW COMBINED CYCLE POWER PLANT

VOLUME 2 of 3

December 2016
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
CONVERSION OF 100 MW BAGHABARI GAS TURBINE POWER PLANT TO 150 MW COMBINED CYCLE POWER PLANT ON TURNKEY BASIS

VOLUME 2 - TECHNICAL REQUIREMENTS

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Section 1

Description of the Project
1.1 DESCRIPTION OF THE PROJECT:

A simple cycle 100 MW Gas Turbine (Machine Model GE- PG9171E) Power Plant was installed in Baghabari, Sirajgonj. Now BPDB is intend to convert 100 MW existing Gas Turbine Power Plant to 150 MW Combined Cycle Power Station at site conditions (35°C, 1.013 bar, 98% R.H.) at the specified space within existing Baghabari Power Station, Baghabari, Sirajgonj. At present Total plant area is 28 acre where 100 MW GT & 71 MW GT situated. Another adjacent approx. 12.25 acre land acquisition is in under process for Combined Cycle Plant.

The project defined herein covers the installation of a Steam Power Plant (SPP) utilising the exhaust heat of the Gas Turbine.

In case of discrepancies between the Technical Specification and the General Technical requirements, the Technical Specification shall have higher priority than the General Technical Requirements.

Wherever in the various parts of the Technical Specification limits of supply may be mentioned, these shall only be understood to show the area covered by the relevant portion the Technical Specification and is in no case meant to limit or exclude equipment, supplies or services required to form a complete, safe and modern power plant.

The proposed Plant consisting of 1:1:1 (One Existing GT, One HRSG and One ST) units will be installed in the vacant space adjacent to the existing power station, as Shown at the site layout. The Project will be implemented on turnkey basis Under Bidder’s financing.

The Power Station will be connected with the existing Baghabari 132 kV Grid Sub-Station through underground cable and other electrical equipment as per enclosed Dwg. No. TE-009249-BAG-D-EL-0001 – Key Electrical Single Line Diagram.

Fault Levels of existing Baghabari Grid Sub-station’s 132 kV Busbar are

\[
\text{MVA}_{\text{BASE}} : \text{MVA}_{\text{PHASE}} : \text{MVA}_{\text{PHASE-GND}}
\]

\[
\text{BAGHABARI} : 100 : 2,869 : 2,709
\]

Climatic Conditions: Sub-Tropical Monsoon

[To be considered in Temperature: 5°C to 45°C

Plant design] Relative Humidity: 36% to 100%

- Annual Rainfall: 120 cm to 345 cm
- Wind Velocity: 195 km/hr
- Seismic Horizontal Ground Acceleration: 0.28g

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, landscaping of the proposed site.
2. Modification/Renovation/Inspection/Overhaul/Shifting of Existing equipment

3. The supply and construction of the required power plant equipment for conversion of existing 1X100 MW GTG to Combined cycle power plant.

4. The supply of 132 KV material / equipment at the Grid Sub-Station premises as per enclosed Electrical Single Line Diagram.

5. The supply and installation of Electrical equipment/ materials as per enclosed Electrical Single Line Diagram.

6. Supply and Construction of all civil work including control room, administrative building, residential building, internal roads, boundary etc.

7. Supply and Construction of Chemical Water Treatment plant, etc.

1.2 Design Philosophy:

The existing Gas Turbine is generating 100 MW at site condition. The GT is operated on natural gas only. The Bidders are to ensure that safety and interlocking systems as well as controls for GT, HRSG and ST are perfectly matching and permit the operation of GT and ST as specified in the relevant parts of this specification.

AS it is the intension of every Bidder offers his optimum, the choice of live steam parameters, condenser vacuum and feedwater temperature is left to the Bidder.

The ST shall be designed to generate full capacity when GT is operated at 100% base load under all weather conditions.

All parts of the plant shall be suitable in every respect for continuous operation at maximum output as well as part loads, & under the anticipated transient operations as well as the climatic conditions peculiar to the site & environmental restrictions.

The Combined Cycle plant shall be designed for the following two kinds of start-up modes. The normal mode of start-up is that GT & related HRSG are started commonly & the Exhaust Gas is led through the steam generator even during start-up to GT. The equipment shall, however, also be designed for cold start-up of the HRSG while the related GT is operating under full load.

The CCCP control system shall be designed for automatic start-up & shut down operation.

The remote controls, monitoring & information facilities are to be installed in the new central control building.
Section 2

Scope of Work
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single-Stage: Two-Envelope
2. **Scope of Work**

2.0 Scope of work

2.1 Combined Cycle Power Plant

2.1.1 General

2.2 Existing Gas Turbine Generating unit (Simple Cycle)

2.2.1 General Description

2.2.2 Renovation of Existing Gas Turbine Generating unit (Simple Cycle)

2.3 Mechanical System

2.4 Electrical System

2.5 Heat Recovery Steam Generators

2.6 Steam Turbine Generating Units

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 Booster Compressors

2.8 132 kV Switchgear, equipment and Transformers (CC)

2.8.1 132 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 Defect liability Period
2.21 First Inspection, CI & HGPI
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 Simulator for Power Plant Operation Training
2.0 General

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 service of operation & maintenance for the first twenty four (24) months after satisfactory performance tests of 150 MW Combined Cycle Generating Unit in Baghabari, Sirajgonj, Bangladesh on full turnkey basis.

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 150 MW consists of 1:1:1 configuration.

Plant Configuration: (1:1:1 Configuration)

One (1) of existing heavy duty industrial type gas turbine generator (without any ancillary equipment, such as water/steam injection, evaporator, chiller etc. for increasing power output), One (1) of heat recovery steam generator and one (1) unit of steam turbine generator unit.

The quantities and number of equipment mentioned in the scope of work and price schedule is based on the requirement of 1 i.e. One existing GTG, One HRSG & One STG.

The Bidders will have to Supply Main (132 KV & 11KV ) and Auxiliary (6.6 KV & 0.415 KV) Equipment, Materials & Systems including Supply, Installation, Testing, Commissioning of Equipment and Control system (including pre-close check systems & inter-lock systems, Protection system, Metering System etc. accordingly. Bidders shall also fill the Price Schedule of Vol. 1 of 2, accordingly.

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.

Each Bidder before submitting tender shall carefully examine the Tender Documents and shall visit the Site to acquaint himself with, and determine the existing conditions and limitations. The Bidder shall thoroughly inform himself of all conditions and factors which would affect the prosecution and completion of the Work, including, but not be limited to, GTG & its auxiliaries, electrical system, space available for civil construction, condition of the land, soil condition, water quality, the availability and cost of labour, applicable laws and regulations and facilities for transportation, handling and storage of materials and equipment and limitation of working days due to monsoon.

It must be understood and agreed that such factors have been properly investigated and considered in the preparation of the Proposal submitted. No claims for financial and time adjustment to the Contract awarded for the Work under these Specifications and Documents will be permitted by BPDB/Engineer which are based on the lack of such prior information or its affect on the cost of the work and its completion time.
Modification of GT Exhaust gas system:

The existing GT Exhaust system has to be modified in such a manner that the connection of the new HRSG can be carried out.

The whole exhaust system shall be designed to withstand the allowable back pressure.

The exhaust duct system shall be designed to avoid drumming, vibration & any resonance under all operating conditions.

High temperature resistant quality steel is to be applied for the exhaust gas ducts & diverter flaps, combined with duct expansion joint & duct insulation. The diverter dampers shall be operated hydraulically with motor driven pumps & a hand pump. At ST trip, the diverter flap shall operate automatically to open the exhaust to the bypass chimney, without interference of the GT operation. The diverter flap is to be provided with a seal air system.

The main items to be supplied, modified or replaced are specified but not limited to the following measure items:

i) Modification or replacement of the existing lower chimney part by a T-box with diverter damper.

ii) Modification & reinstallation of the existing exhaust chimney as bypass chimney.

iii) Installation of a new guillotine type isolation damper at the outlet side of the T-box to the HRSG.

iv) Supply & installation of an interconnection duct of the exhaust system with the HRSG with removable blind plate.

v) Relocation of existing piping (if any).

Diverter Damper:

The gas Diverter Damper shall meet the following characteristics:

i) One automatic outside hydraulic & direct driving system with additional hand operated drive for emergency cases & for correcting the sealing effect shall have to be provided.

ii) In case of power failure the hydraulic driving system shall be fully operable.

iii) There shall be only one diverter blade for the duct cross section, it must be of high stiffness & be heat insulated to the cold side to avoid heat losses.

iv) For easy maintenance during operation, all bearing shall be outside the frame & no lubrication shall be needed.

v) For safety reasons the diverter blade must be lockable in the position for open cycle.
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): 150 MW

(2) Number of units

a. Existing Gas turbine unit: One(1)
b. Heat recovery steam generator: One(1)
c. Steam turbine unit: One(1)

(3) Main Fuel: Natural Gas

(4) Operation mode

a. Gas turbine unit: Base load as well as peak load.
b. Combined cycle unit: Base load.

2.2 Existing Gas Turbine Generating Unit (Simple Cycle) Description:

2.2.1 Renovation/ Inspection/ Overhaul of Existing Gas Turbine Generating Unit & its Auxiliaries:

At present existing one 100 MW Open Cycle, Single Shaft, Heavy Duty Industrial Package type Gas Turbine unit was used as a combined cycle operation.

Bidder have to renovate/ inspect the existing Gas turbine & its Auxiliaries (i.e Gas Turbine Generating Unit, Transformers, Gas Booster Compressors (3 nos), electrical system including AVR & Excitation System, all electrical equipment, Protection and Control system, EDG, UPS, Battery charger system etc.) and capable the existing Gas Turbine to 100 MW capacity for using as a Gas turbine of combined cycle operation.

Plant History of 100 MW GT Unit.

<table>
<thead>
<tr>
<th>Gas turbine Model Series (GE Design)</th>
<th>: PG9171E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Manufacturer</td>
<td>: GEEP, France</td>
</tr>
<tr>
<td>No. of turbine stages</td>
<td>: 3</td>
</tr>
<tr>
<td>No. of Compressor stages</td>
<td>: 17 (Axial)</td>
</tr>
<tr>
<td>Base Output</td>
<td>: 106.88 MW (At 35°C, 1.013 bar &amp; 98% Relative Humidity)</td>
</tr>
<tr>
<td>Type of Operation</td>
<td>: Continuous</td>
</tr>
<tr>
<td>Compressor Inlet Temperature</td>
<td>: 35°C</td>
</tr>
</tbody>
</table>
Turbine Exhaust Temperature : 558 °C
Design Heat Rate : 10660 Kj/Kwh
Control : Mark V

<table>
<thead>
<tr>
<th>Date of Commissioning</th>
<th>Combustion Inspection(CI)</th>
<th>Hot Gas Path Inspection(HGPI)</th>
<th>Major Inspection(MI)</th>
<th>Total Running Hours</th>
<th>No. of Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>November, 25, 2001</td>
<td>02(Two) Nos. 24/04/2003 - 30/04/2003 = 7 days 16/12/2008 - 20/12/2008 = 4 days</td>
<td>01(ONE) No. 09/01/2006 - 25/03/2006 = 76 days (Including Accessory Coupling Shaft Maintenance)</td>
<td>01(One) No. 02/07/2009 - 09/12/2009 = 161 days (Including Accessory Coupling Shaft)</td>
<td>70,000</td>
<td>1280</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Load</td>
<td>21.4 2 10.9 1</td>
<td>47 8.16 98.35</td>
<td>10.26 364 84°</td>
<td>562</td>
<td>562</td>
<td>6.4</td>
<td>100 13</td>
<td>100 8</td>
</tr>
<tr>
<td>75% Load</td>
<td>21.9 9 20.8 8</td>
<td>47 6.33 55.4</td>
<td>9.60 350 84°</td>
<td>571</td>
<td>486</td>
<td>6.1</td>
<td>75 16</td>
<td>75 11</td>
</tr>
<tr>
<td>50% Load</td>
<td>22.3 4 21.1 0</td>
<td>47 4.85 40.8</td>
<td>9.16 344 84°</td>
<td>577</td>
<td>411</td>
<td>6.0</td>
<td>50 10</td>
<td>50 5</td>
</tr>
</tbody>
</table>

Performance guarantee Test procedures, Result and sample calculation:

Ambient Temperature is 32°C and RH is 98%

2.2.1 Upgradation:

Bidder have to renovate/inspect the existing Gas turbine & its Auxiliaries (i.e Gas Turbine Generating Unit, Transformers, Gas Booster Compressors (3 nos), electrical system, EDG, UPS, Battery charger system, protection and control system etc.) and capable the existing Gas Turbine to 100 MW capacity for using as a Gas turbine of combined cycle operation. However, Bidder can enhance rated capacity by renovation or retrofitting of GT.

Upgradation / Rehabilitation comprise (with supply of all spares):

i) Dry Low NOx combustion system for the existing GT.

ii) NOx abatement of existing GT emissions.
iii) Rehabilitation of the existing Plant Auxiliary systems & BOP.

iv) Overhauling of accessory gear

v) New central control room common for GTG, STG & their associates.

vi) Overhauling and Rehabilitation / MI (major inspection) of existing GTG along with auxiliaries (Replacement of Exhaust Diffuser and Exhaust Assembly) with supply of all necessary new and unused spare parts and consumables by the EPC contractor.

vii) Rehabilitation of VIGV with Rack & pinion have to be done

viii) Upgrade of existing gas turbine control system Mark V to Mark Vle, along with associated accessories like control cables along with other cables etc.

Since the plant is 10-15 years old, the need for any upgradation with respect to existing I&C System shall be suggested / recommended in consultation with Owner/Owner’s Engineer.

2.2.2 Present simple cycle gas Turbine & its Auxiliaries description:

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td><strong>Gas Turbine</strong></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>IEC -34 &amp; IS -5422</td>
</tr>
<tr>
<td>Type</td>
<td>Open Cycle, Single Shaft, Heavy Duty Industrial Package type Gas Turbine</td>
</tr>
<tr>
<td>Model</td>
<td>PG9171E</td>
</tr>
<tr>
<td>Compressor Type</td>
<td>Multistage axial flow heavy duty corrosion protected</td>
</tr>
<tr>
<td>Inlet Guide Vane</td>
<td>Modulated</td>
</tr>
<tr>
<td>Casing Split</td>
<td>Horizontal Flange</td>
</tr>
<tr>
<td>Number of Stages</td>
<td>17</td>
</tr>
<tr>
<td>Combustor Type</td>
<td>Can Annular (Multiple Combustors, reverse flow)</td>
</tr>
<tr>
<td>Fuel Nozzle</td>
<td>One Per combustion Chamber</td>
</tr>
<tr>
<td>No of Chambers</td>
<td>14</td>
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<tr>
<td>Turbine Type</td>
<td>Axial Flow, Reaction Type</td>
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<tr>
<td>No of Stages</td>
<td>3</td>
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<tr>
<td>Shaft speed</td>
<td>3000 rpm</td>
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<tr>
<td>Overspeed</td>
<td>110%</td>
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<tr>
<td><strong>Generator</strong></td>
<td></td>
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<tr>
<td>Type</td>
<td>TARI 1080 -36F</td>
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<tr>
<td>Drive</td>
<td>Gas Turbine</td>
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<tr>
<td>KVA</td>
<td>134250</td>
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<tr>
<td>Volts</td>
<td>11000</td>
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<td>Description</td>
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<td>-----------------------------------</td>
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</tr>
<tr>
<td>KW</td>
<td>107400</td>
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<td>P.F Log</td>
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<td>Frequency</td>
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<tr>
<td>Rpm</td>
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<td>Phase</td>
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<td>Connection</td>
<td>Y</td>
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<td>Volts(Stator)</td>
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<tr>
<td>Volts(Rotor)</td>
<td>350</td>
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<tr>
<td>Amps (Rotor)</td>
<td>811</td>
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<tr>
<td>Cooling</td>
<td>Open Air</td>
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<td>Duty Cycle</td>
<td>Continuous</td>
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<tr>
<td>Altitude</td>
<td>&lt; 1000 m.</td>
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<tr>
<td>Winding Insulation Class</td>
<td>Class F</td>
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<tr>
<td>Protection</td>
<td>IP-54</td>
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<td>Year</td>
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**Excitation System (With all Auxiliaries)**

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<tbody>
<tr>
<td>Type</td>
<td>EAR 54/34 -30/6-4</td>
</tr>
<tr>
<td>Volts</td>
<td>385 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>892 A</td>
</tr>
<tr>
<td>KW</td>
<td>344 Continuous</td>
</tr>
<tr>
<td>Rpm</td>
<td>3000</td>
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<tr>
<td>Duty Cycle</td>
<td>Continuous</td>
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<tr>
<td>Insulation Class</td>
<td>Class F</td>
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<tr>
<td>Excitation</td>
<td>869 W, 69.92 Volts, 12.42 A</td>
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**Permanent magnet generator**

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<tr>
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<tr>
<td>Type</td>
<td>EAP 39/12-30/6</td>
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<tr>
<td>KVA</td>
<td>8</td>
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<tr>
<td>Voltage</td>
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<tr>
<td>Ampere</td>
<td>26</td>
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<tr>
<td>Hz</td>
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**Starting System**

**A. Starting Motor**

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<tbody>
<tr>
<td>Type</td>
<td>3 - Phase Induction Motor</td>
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<tr>
<td>Capacity</td>
<td>1750 HP (1305 KW)</td>
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<tr>
<td>Volts</td>
<td>6.6 KV</td>
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<tr>
<td>Freq.</td>
<td>50 Hz</td>
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<tr>
<td>Sync. Speed</td>
<td>1480 rpm</td>
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<td>Duty</td>
<td>Continuous</td>
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**B. Torque Converter**

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<th>Description</th>
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<td>Type</td>
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<tr>
<td>Model</td>
<td>4-LUG2620</td>
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<tr>
<td>Specific Torque</td>
<td>475</td>
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<tr>
<td>Lube Oil Pump &amp; Motor</td>
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<td>Motor</td>
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<tr>
<td>Capacity</td>
<td>75 HP</td>
</tr>
<tr>
<td>Service Factor</td>
<td>1.15</td>
</tr>
<tr>
<td>Description</td>
<td>Data</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Rpm</td>
<td>2965</td>
</tr>
<tr>
<td>Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>102A</td>
</tr>
<tr>
<td>Made</td>
<td>USA</td>
</tr>
<tr>
<td>PF</td>
<td>0.81</td>
</tr>
<tr>
<td>Max. kVAR</td>
<td>28855</td>
</tr>
<tr>
<td>Pump</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>288 m</td>
</tr>
<tr>
<td>Capacity</td>
<td>650 GPM</td>
</tr>
<tr>
<td>Sp</td>
<td>2900 rpm</td>
</tr>
<tr>
<td>Model</td>
<td>VCRE</td>
</tr>
<tr>
<td>Made In</td>
<td>USA</td>
</tr>
<tr>
<td>Impeller Diameter</td>
<td>10-5/8</td>
</tr>
<tr>
<td>Emergency Lube Oil Pump</td>
<td></td>
</tr>
<tr>
<td>DC MOTOR</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>10 HP</td>
</tr>
<tr>
<td>Speed</td>
<td>1750 rpm</td>
</tr>
<tr>
<td>Volts</td>
<td>120 V</td>
</tr>
<tr>
<td>Duty</td>
<td>Continuous</td>
</tr>
<tr>
<td>Type</td>
<td>CD258 APY</td>
</tr>
<tr>
<td>Made in</td>
<td>USA</td>
</tr>
<tr>
<td>Pump</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>54m</td>
</tr>
<tr>
<td>Capacity</td>
<td>420 GPM</td>
</tr>
<tr>
<td>Model</td>
<td>VCRE</td>
</tr>
<tr>
<td>Impeller Diameter</td>
<td>8-3/8</td>
</tr>
<tr>
<td>Made in</td>
<td>USA</td>
</tr>
<tr>
<td>Turbine Cooling Exhaust Frame Blower</td>
<td></td>
</tr>
<tr>
<td>Blower</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>2 (Two)</td>
</tr>
<tr>
<td>Vibration Level</td>
<td>10 in/Sec</td>
</tr>
<tr>
<td>Service Factor</td>
<td>1.00</td>
</tr>
<tr>
<td>Model</td>
<td>5.3HPRB</td>
</tr>
<tr>
<td>P.F</td>
<td>0.93</td>
</tr>
<tr>
<td>Motor</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>2 (Two)</td>
</tr>
<tr>
<td>Capacity</td>
<td>100HP</td>
</tr>
<tr>
<td>Volts</td>
<td>380</td>
</tr>
<tr>
<td>Frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>Speed</td>
<td>2950 rpm</td>
</tr>
<tr>
<td>Made in</td>
<td>USA</td>
</tr>
<tr>
<td>Lube Oil System</td>
<td></td>
</tr>
<tr>
<td>Main Lube Oil Pump Capacity</td>
<td>2460 Lit/Min</td>
</tr>
<tr>
<td>Auxiliary Oil Pump Capacity</td>
<td>2460 Lit/Min</td>
</tr>
<tr>
<td>Emergency Lube oil Pump Capacity</td>
<td>1590 Lit/Min</td>
</tr>
<tr>
<td>Total Quantity of Oil In the System</td>
<td>15000 Liter</td>
</tr>
<tr>
<td>Type of Filter</td>
<td>Pleated paper</td>
</tr>
<tr>
<td>Degree of Filtration</td>
<td>5 Micron</td>
</tr>
<tr>
<td>Lube Oil Grade</td>
<td>ISO VG-32</td>
</tr>
<tr>
<td>A. Lube Oil Reservoir</td>
<td>12492 Liter</td>
</tr>
</tbody>
</table>

LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan: December, 2016

Single – Stage: Two-Envelope
<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B. Lube oil Mist Separator Motor</strong></td>
<td>Voltage: 415 V</td>
</tr>
<tr>
<td></td>
<td>Speed: 3000 rpm</td>
</tr>
<tr>
<td></td>
<td>Phase, Freq.: 03, 50Hz</td>
</tr>
<tr>
<td><strong>C. Jacking Oil Pump Motor</strong></td>
<td>Capacity: 11 KW</td>
</tr>
<tr>
<td></td>
<td>Volts: 415</td>
</tr>
<tr>
<td></td>
<td>Frequency: 50 Hz</td>
</tr>
<tr>
<td><strong>Compressor Water wash Pump</strong></td>
<td>Model: CC 40 x 32-250</td>
</tr>
<tr>
<td></td>
<td>Head: 7.7 m</td>
</tr>
<tr>
<td></td>
<td>Speed: 2900</td>
</tr>
<tr>
<td></td>
<td>Discharge: 16.38 M3/m</td>
</tr>
<tr>
<td></td>
<td>Made: Sulger, Pump, India</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td>Capacity: 11 KW</td>
</tr>
<tr>
<td></td>
<td>Speed: 2890 rpm</td>
</tr>
<tr>
<td></td>
<td>Made: KIRLOSKAR, India</td>
</tr>
<tr>
<td><strong>Atomizing Air Booster Comp.</strong></td>
<td>Type: Motor Driven Cyclo-Blower</td>
</tr>
<tr>
<td></td>
<td>Model: 351A9239P003</td>
</tr>
<tr>
<td></td>
<td>Speed: 4000 Rpm</td>
</tr>
<tr>
<td></td>
<td>Made in: GARDNER DENVER, USA</td>
</tr>
<tr>
<td><strong>Cooling Water Module</strong></td>
<td>Type: 1 MJ 3181-4, 3-Phase induction motor</td>
</tr>
<tr>
<td></td>
<td>Motor Capacity: 15 Kw</td>
</tr>
<tr>
<td></td>
<td>Voltage: 415</td>
</tr>
<tr>
<td></td>
<td>Speed: 1460 rpm</td>
</tr>
<tr>
<td></td>
<td>Made in: India</td>
</tr>
<tr>
<td><strong>Fan</strong></td>
<td>Fan Dia: 9 feet</td>
</tr>
<tr>
<td></td>
<td>Power absorbed: 11.1 KW</td>
</tr>
<tr>
<td></td>
<td>Pressure: 15 mm WG</td>
</tr>
<tr>
<td></td>
<td>Air flow: 193406 Kg/hr</td>
</tr>
<tr>
<td></td>
<td>Speed: 368 rpm</td>
</tr>
<tr>
<td></td>
<td>No. of Blade: 4</td>
</tr>
<tr>
<td></td>
<td>Quantity: 6</td>
</tr>
<tr>
<td><strong>Cooling Air Fan Motor (Turbine Compartment)</strong></td>
<td>Capacity: 55 KW</td>
</tr>
<tr>
<td></td>
<td>Voltage: 415</td>
</tr>
<tr>
<td></td>
<td>Speed: 1500 rpm</td>
</tr>
<tr>
<td><strong>Turning Gear (AC)</strong></td>
<td>Type: Worm Gear</td>
</tr>
<tr>
<td></td>
<td>Model: DSMBM 170-54</td>
</tr>
<tr>
<td></td>
<td>Ratio: 238.9</td>
</tr>
<tr>
<td><strong>Turning Gear (DC)</strong></td>
<td>Type: Worm Gear</td>
</tr>
<tr>
<td></td>
<td>Model: VM 35-57</td>
</tr>
<tr>
<td></td>
<td>Ratio: 30</td>
</tr>
<tr>
<td><strong>Cooling Water Module</strong></td>
<td>Design Pressure: 7 Kg/cm2</td>
</tr>
</tbody>
</table>

LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan: December, 2016

Single - Stage: Two-Envelope
<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Fluid</td>
<td>DM water</td>
</tr>
<tr>
<td>Duty /Surface</td>
<td>2633 m²</td>
</tr>
<tr>
<td>Full nof Water</td>
<td>8292 Kg</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>VHELL, INDIA</td>
</tr>
<tr>
<td><strong>Cooling Water Pump</strong></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>7E 100-2200</td>
</tr>
<tr>
<td>Head</td>
<td>45 M</td>
</tr>
<tr>
<td>Motor Capacity</td>
<td>22.59 KW</td>
</tr>
<tr>
<td>Pump Made in</td>
<td>Sulger India</td>
</tr>
<tr>
<td>Discharge</td>
<td>140 m³/hr</td>
</tr>
<tr>
<td><strong>Air Intake System for Turbine</strong></td>
<td></td>
</tr>
<tr>
<td>Material of Intake Duct</td>
<td>Carbon Steel</td>
</tr>
<tr>
<td>Type of air Filter</td>
<td>Self Cleaning (5 micron)</td>
</tr>
<tr>
<td>Material of filter medium</td>
<td>Synthetic - Cellulose fiber</td>
</tr>
<tr>
<td>Max. Intake Velocity</td>
<td>1 M/Min.</td>
</tr>
<tr>
<td>Amount of Air required for GT at ISO</td>
<td>1,13000 m³/hr</td>
</tr>
<tr>
<td>Type of Silencer</td>
<td>Baffle</td>
</tr>
<tr>
<td>Material of Absorber</td>
<td>Mineral Wool.</td>
</tr>
<tr>
<td>Total Air Flow throw air Filter</td>
<td>7,71,100 ft³/min</td>
</tr>
<tr>
<td>Maximum pressure loss</td>
<td>89 mm H2O Column</td>
</tr>
<tr>
<td><strong>Inlet Air Filter</strong></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Donalson Company, Inc, USA</td>
</tr>
<tr>
<td>Model No</td>
<td>OSM-AD</td>
</tr>
<tr>
<td>Total Air Flow throw air Filter</td>
<td>7,71,100 ft³/min</td>
</tr>
<tr>
<td>Filter P/N</td>
<td>P19-1033/P19-1107</td>
</tr>
<tr>
<td><strong>11 KV Generator Circuit Breaker</strong></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>ALSTOM, France</td>
</tr>
<tr>
<td>Year of Manufacture</td>
<td>2001</td>
</tr>
<tr>
<td>Rated Maximum Voltage</td>
<td>12 KV</td>
</tr>
<tr>
<td>Rated Frequency</td>
<td>50</td>
</tr>
<tr>
<td>Rated Continuous Current at 35 C</td>
<td>10 KA</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td>SF6 gas, 7.5 Bar</td>
</tr>
<tr>
<td>Rated full-wave impulse with stand voltage (peak)</td>
<td>125 KV</td>
</tr>
<tr>
<td>Rated short circuit duty cycle</td>
<td>CO-30 min-CO</td>
</tr>
<tr>
<td>Rated short circuit current, symmetrical</td>
<td>100KA</td>
</tr>
<tr>
<td>Max asymmetrical short circuit peak current</td>
<td>274 KA</td>
</tr>
<tr>
<td>Short time current</td>
<td>100 KA, 1s</td>
</tr>
<tr>
<td>Interrupting time</td>
<td>3.5 cycles</td>
</tr>
<tr>
<td><strong>Step up - Transformer</strong></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Single phase, outdoor type</td>
</tr>
<tr>
<td>Standard</td>
<td>IEC-76 (To Indian 2026-1977)</td>
</tr>
<tr>
<td>Type of cooling</td>
<td>ONAF/ONAN</td>
</tr>
<tr>
<td>Rating H.V. (MVA) (ONAF/ONAN)</td>
<td>50.00/41.25</td>
</tr>
<tr>
<td>No load Voltage H.V. (kV)</td>
<td>132/√3</td>
</tr>
<tr>
<td>No load Voltage L.V. (kV)</td>
<td>11</td>
</tr>
<tr>
<td>Line Current (HV)(Amps) (ONAN/ONAF)</td>
<td>656.08/541.27</td>
</tr>
<tr>
<td>Line Current (LV)(Amps) (ONAN/ONAF)</td>
<td>4545.45/3750</td>
</tr>
<tr>
<td>Connection Symbol</td>
<td>bYNd11 (In- three phase Bank)</td>
</tr>
</tbody>
</table>
Guaranteed Impedance at Normal Tap Voltage % HV –LV: 16.5±10 % (at 50 MVA)

Unit Auxiliary Transformer #2

Connection Symbol : Dyn11
MVA : 5
Volts Ratio : 11/6.9 KV
Amps. at HV Side : 262.44
Amps. at LV Side : 418.38
Phase HV/LV : 3
Type of Cooling : ONAN

Station Service Transformer

KVA/MVA : 1600/1.6
Volts Ratio : 6600 / 415V
Amps HV : 140A
Amps. LV : 2226A
Phase HV/LV : 3
Type of Cooling : ONAN

Maintenance Facilities

a) 30 Ton Capacity truck mounted mobile crane
b) 4 Ton truck with 3 T Jib Crane
c) Overhead Electric Crane
Maximum safe working load : 60 Tons/ 10 Tons

Existing Gas Booster Compressor Description:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Gas Booster No A</th>
<th>Gas Booster No B</th>
<th>Gas Booster No C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installed Capacity</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
</tr>
<tr>
<td>2</td>
<td>Ambient Air Temperature</td>
<td>+4 ..... +42 °C</td>
<td>+4 ..... +42 °C</td>
<td>+4 ..... +42 °C</td>
</tr>
<tr>
<td>3</td>
<td>Relative humidity</td>
<td>80% (Av.)</td>
<td>80% (Av.)</td>
<td>80% (Av.)</td>
</tr>
<tr>
<td>4</td>
<td>Ambient Air Pressure.</td>
<td>1.013 mbar(g)</td>
<td>1.013 mbar(g)</td>
<td>1.013 mbar(g)</td>
</tr>
<tr>
<td>5</td>
<td>Minimum Inlet Pressure</td>
<td>10.34 bar(g)</td>
<td>10.34 bar(g)</td>
<td>10.34 bar(g)</td>
</tr>
<tr>
<td>6</td>
<td>Maximum Inlet Pressure</td>
<td>15.00 bar(g)</td>
<td>15.00 bar(g)</td>
<td>15.00 bar(g)</td>
</tr>
<tr>
<td>7</td>
<td>Minimum Gas Temperature</td>
<td>20 °C</td>
<td>20 °C</td>
<td>20 °C</td>
</tr>
<tr>
<td>8</td>
<td>Maximum Gas Temperature</td>
<td>35 °C</td>
<td>35 °C</td>
<td>35 °C</td>
</tr>
<tr>
<td>9</td>
<td>Maximum Volume flow</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
</tr>
<tr>
<td>10</td>
<td>Minimum Volume flow</td>
<td>40,000 Nm³/Hour</td>
<td>40,000 Nm³/Hour</td>
<td>40,000 Nm³/Hour</td>
</tr>
<tr>
<td>11</td>
<td>Outlet/Service Pressure</td>
<td>25.50 bar(g)</td>
<td>25.50 bar(g)</td>
<td>25.50 bar(g)</td>
</tr>
<tr>
<td>12</td>
<td>Outlet/Service Temperature</td>
<td>52 °C</td>
<td>52 °C</td>
<td>52 °C</td>
</tr>
</tbody>
</table>
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single – Stage: Two- Envelope

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Gas Booster No A</th>
<th>Gas Booster No B</th>
<th>Gas Booster No C</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Motor Rated Capacity</td>
<td>2,200 KW</td>
<td>2,200 KW</td>
<td>2,200 KW</td>
</tr>
<tr>
<td>14</td>
<td>Name of the Manufacturer</td>
<td>MAN TURBO, GERMANY.</td>
<td>MAN TURBO, GERMANY.</td>
<td>MAN TURBO, GERMANY.</td>
</tr>
<tr>
<td>16</td>
<td>Total running hours since installation (Upto December 2010)</td>
<td>2,593.63 Hours</td>
<td>2,537.21 Hours</td>
<td>1,184.20 Hours</td>
</tr>
<tr>
<td>17</td>
<td>First Running</td>
<td>01/03/2004, 14:57</td>
<td>01/03/2004, 15:15</td>
<td>06/03/2004, 09:25</td>
</tr>
</tbody>
</table>

**Existing Diesel Engine Description (3 MW)**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>SACM Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>France</td>
</tr>
<tr>
<td>Capacity</td>
<td>3 MW</td>
</tr>
<tr>
<td>Year of Manufacturer</td>
<td>1990</td>
</tr>
<tr>
<td>Voltage</td>
<td>6.6 KV</td>
</tr>
<tr>
<td>RPM</td>
<td>1500</td>
</tr>
</tbody>
</table>

**Existing Diesel Engine Description (125 KW)**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Alsthom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>France</td>
</tr>
<tr>
<td>Capacity</td>
<td>125 KW</td>
</tr>
<tr>
<td>Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>RPM</td>
<td>1500</td>
</tr>
</tbody>
</table>

### 2.3 Mechanical System

The scope shall include design, engineering, manufacture, supply, inspection and testing at manufacturer's works, packing and shipment and delivery at site, insurance, erection/installation, spares, consumables, unloading, storage and handling at site, site testing, commissioning, obtaining clearances from all statutory authorities, trial run, performance & guarantee tests, initial commercial operation, handing over, services for defect liability period and other services including co-ordination, engineering and project management related to the complete the works for the following systems:

- Upgraded exiting Gas Turbine and Ancillary Equipment systems
- Main Steam system
- Feed Water system
- Condensate system
- Closed Circuit Cooling Water system
- Closed Circuit Cooling system for Auxiliary cooling
• Chemical Feed system
• Instrument Air system
• Steam Turbine Drains
• Condenser Air Removal system
• Boiler Drains and Sample Coolers
• Fire Protection System
• Potable Water system

Scope of works shall include as well:

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 gas turbine generating plant.

e. Lubrication oil for flushing and for the initial filling.

f. All lubricant and chemical additives.

g.

h. Overhead crane of proper capacity for heaviest piece with 20% margin of STG unit.

i. Closed loop cooling system and open loop cooling system.

2.4 Electrical System

Scope of work shall include, but not limited to, design, engineering, manufacture, supply, inspection and testing at manufacturer's works, packing and shipment and delivery at site, insurance, erection/installation, spares, consumables, unloading, storage and handling at site, site testing, commissioning, obtaining clearances from all statutory authorities, trial run, performance & guarantee tests, initial commercial operation, handing over, services for defect liability period and other services including co-ordination, engineering and project management related to following plants and equipment in general. For specific requirement individual equipment/ system specification shall be referred.

a) Steam Turbine Generator & Accessories – One (1) no.

b) 11kV Generator Switchgear - One (1) no.

c) Isolated Phase Bus duct – One (1) set
d) Generator Step-up Transformer – One (1) no.
e) Unit Auxiliary Transformer – One (1) no.
f) Station Service Transformer – Two (2) nos.
g) 132kV equipments (Circuit Breaker, Isolator with Earth Switches, CT, PT, LA, Cable Termination Ends & XLPE Power Cables) – As required
h) Neutral Grounding Resistor – One (1) no.
i) Non-phase Segregated 400V Bus duct – As required
j) 6.6kV Switchgear – One (1) no.
k) 400V Switchgear – One (1) no.
l) 400V MCC, DB & DC Starter Panel – As required
m) Plant DC & UPS System – As required
n) Protection & Metering Systems – As required
o) 11kV and 6.6kV XLPE Power Cable – As required
p) Control & Instrumentation Cables – As required
q) Electric Motors & Actuators – As required
r) Plant Illumination System – As required
s) Plant Grounding & Lightning Protection Systems – As required
t) Miscellaneous Electrical Items (Race way materials etc.) – As required
u) Solar system capacity of 2 KW at roof of the buildings listed in cl.no.14.7.
v) Modification / renovation / inspection / major overhaul of following existing equipments
   a) Gas Turbine Generating Unit & it’s Auxiliaries (i.e Gas Turbine Generating Unit, 5MVA, 11/6.9kV Unit Transformer, Gas Booster Compressors (3 nos), electrical system including AVR & Excitation System, all electrical equipment, Protection, EDG, UPS, Battery charger system etc.)
   b) Extension of existing 6.6kV Switchgear to connect with the proposed 6.6kV Switchgear with new 6.6kV cable as shown in enclosed Electrical Single Line Diagram.
   c) Existing 132kV Bays (Dia #3 & #8) for Gas Turbine Unit & Steam Turbine Unit shall be under Bidder’s scope.
   d) Existing Station Service Transformers (2X1600 kVA, 6.9/0.415 kV)
   e) Existing GTG Step-up Transformer #2 (11/132 kV, 3 x 37.5/50MVA Banks)
2.5 Heat Recovery Steam Generator

One (1) unit of heat recovery steam generator of dual pressure steam cycle suitable to utilise exhaust gas from the existing 100 MW 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. 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.

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

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

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

g. Complete control, protection and monitoring systems for the heat recovery steam generator (HRSG) and auxiliaries including feed-water temperature control, HP/LP feed water flow/drum level control, superheated steam temperature control and reheated steam temperature control (if applicable), HP/LP by-pass control system, HRSG safety system, BPS, HRSG stress monitoring and drum level gauge systems, etc.

h. The feed-water control valve system.

i. Flow nozzles for water and steam.

j. De-aerator system complete in all respect

k. Feed water & preservation Tanks

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

m. Insulation and lagging.

n. Foundation plates and bolts.

o. HRSG roof deck & wall panels for the top area

p. Sun shades for local instrumentation & control equipment, enclosure/ protection for sensitive equipment

q. Special tools for operation, maintenance & repair (1 set)

r. Lifting devices

s. Consumables

t. Boiling out chemicals & equipment, all provision for blowing out
u. Spare parts

Header shall be fabricated from seamless steel pipes. Special provision shall be made for chemical cleaning i.e. flushing of Boiler heaters.

Aviation warning equipment (flushing lights) shall be provided in accordance with the requirements of the local aviation authority.

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

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

Note: Supplementary firing for HRSG shall not be considered.

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.

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 C&I system, associated man- machine interface system including servers/OWS and primary sensing devices required for steam turbine C&I system. Steam turbine control system including digital electronic governor systems, automatic run-up and loading system, turbine stress evaluator, turbine supervisory system, turbine trip system, generator control and monitoring system, generator cooling gas system, local control station and all auxiliary equipment & steam turbine protection system

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 main lube oil pump, AC auxiliary lube oil pump, DC emergency pump, Jacking oil 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 Bidder) 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.
s. Oil purification plant with storage tanks for new & waste oil.
t. Special Lifting tackles.
The maximum overspeed shall be limited by two (2) independent electronic & mechanical overspeed trip devices in order to prevent any harmful vibration & /or distortion of any part of the equipment.

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 sets of motor driven condensate pumps, 60% size each.
c. 3 sets of motor driven boiler feed pumps, 60% size each.
d. 2 sets of motor driven vacuum pumps 100% size each.
e. 3 sets of circulating water pumps, 60% size each.
f. 3 sets of closed cooling water pumps, 60% each
g. 1 lot of circulating water / closed cooling water pipework and associated valves.
h. 1 lot of pipework, associated valves, tanks, pumps, heat exchangers, etc.
i. 1 lot of compressed air equipment (two compressor of 100% capacity each) with dryers
j. 1 lot of chemical dosing equipment.
k. 1 set of de-aerator.
l. 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. Electrical overhead travelling crane and supporting structures for S/T unit.
c. Painting including finished coat and special paints required for corrosion protection and high temperature resistance.
d. Design operation and maintenance manuals, including drawings.
e. All other works necessary for the proper operation and maintenance of the combined cycle plant.
f. Lubrication oil for flushing and for the initial operation.
g. Workshop equipment.

2.6.4 One (1) lot of other electrical system

a. One (1) lot of 400 V switchgear.
b. Cables and wiring for interconnection between the equipment.

2.6.5 Emergency Diesel Generating Set

At present 2 emergency Diesel generators are present at Baghabari Power Station. One is 3 MW capacity and one is 125 KW capacity. 3 MW Diesel Generator is used for Black Start and safe shut down of the power plant. existing 125kW,400V D.G set is used to charge the compressor of this 3MW D.G set. Bidder have to renovate the existing Emergency Diesel Generating Sets (Both 3 MW & 125 KW Units) to use it at it’s full capacity for Combined Cycle Power Plants (Existing GT + Proposed ST).

If there is no remote control from DCS for the existing EDG, then EDG should be interfaced with Plant DCS for monitoring and control. Modbus interface to Plant DCS to be provided for monitoring and control of the EDG. The Start/Stop Commands/Feedbacks and Group Alarms must be hardwired.

2.7 Natural Gas Booster Compressors

3 (Three) GBC (Manufacturer: MAN TURBO, Germany) for Baghabari 100 MW & 71 MW GT Power Station already exist.

Bidder have to renovate the existing Gas Booster Compressors (3 Nos) for using its full capacity of Combined Cycle plant requirement. The each Gas Booster
Compressor is capable to provide 100% of 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 were centrifugal type, 6.6 KV motor driven. Appropriate sealing & cooling system shall have to be provided including all necessary ancillaries and auxiliaries.

2.8 **132 kV Switchgear Equipment And Transformers (ST)**

At present existing 100 MW Gas Turbine Unit is connected to 132 kV Bay of Baghabari Grid. For STG Unit, extra outgoing bay (Dia #8) is present for power transmission. Construction of new bay is not under scope of the Bidder. However, renovation of existing 132kV system of Dia #3 & #8 shall be under Bidder’s scope.

2.8.1 **132 KV Switchgear Equipment & Transformers (ST)**

*(Equipment to be provided as per configuration of the plant)*

1) 1 (one) Lot of 132 kV circuit breaker with the following features:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>SF6, Dead Tank [3 phase trip]</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>145 kV (Max)</td>
</tr>
<tr>
<td>Rated insulation level</td>
<td></td>
</tr>
<tr>
<td>Lighting impulse withstand voltage</td>
<td>650 kV (Peak) (1.2/50 micro sec.)</td>
</tr>
<tr>
<td>Power frequency withstand voltage</td>
<td>275 kV (for 1 mm.)</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Rated nominal current</td>
<td>1250 A</td>
</tr>
<tr>
<td>Rated Interrupting current</td>
<td>40 kA rms-3 sec</td>
</tr>
<tr>
<td>Thermal Rating</td>
<td>100 kA -1 sec</td>
</tr>
<tr>
<td>Operating duty (&lt;2.5 cycle)</td>
<td>0-0.3 sec-CO-3min-CO</td>
</tr>
<tr>
<td>Interrupting time</td>
<td>50 msec (max.)</td>
</tr>
<tr>
<td>Operating mechanism</td>
<td>Hydraulic &amp; Spring latch</td>
</tr>
<tr>
<td>Protection Class</td>
<td>IP55</td>
</tr>
</tbody>
</table>

2) One (1) Lot 132 KV Current Transformers

3) One (1) Lot 132 KV Voltage Transformers

4) One (1) Lot 132 KV Lightning Arresters

5) One (1) Lot of steel structures for supporting the switchgear, equipment, posts and beams and gantry structures.

6) One (1) Lot of 132 kV XLPE (Single-Core) cable including supply, installation, testing and commissioning with Two end Termination and One spare core (3+1) with necessary hardware between outdoor type Cable Termination Ends at both ends [underground cable with RCC slab on three...
sides].

**XLPE Cable Size:**
- **Copper Conductor:** Minimum 300 mm²
- **Screen:** 95 mm²

**Rated Voltage:** 132 kv

**Maximum Permissible Voltage:** 145 kv

**Current Rating:**
- As required at any site condition or 770+10% Amps at 65°C
- 935+10% Amps at 90°C

**Short Circuit Current:** 98.7kA for 1 s.

**Length of the Cable:**
- \([3 + 1] = 4 \) No. Single Core Cable, As Requirement.

Cable should be single point bonding at source end but provision should be made for both ends with Link Box & Protective Device (Surge Voltage Limiter) for open end.

7) Outdoor bushing suitable for connection of minimum 850 mm² hard drawn aluminium stranded Overhead Conductor. The conductors shall comply with the requirements of IEC.

8) One (1) lot of suspension/post insulator string sets, tension insulator string sets and station post supporting insulator set with necessary hardware, if required.

9) One (1) lot of shield wire connectors and necessary hardware.

10) The Tenderer shall prepare the layout of the proposed 132kV Switchyard in conjunction with the power plant layout. Bidder shall consider all technical aspects of the power plant in re-routing the existing OHL, if required.

### 2.8.2 Step-Up Transformers and Associated Equipment (For STG)

Please note that, Single Line Diagrams are included with the tender document is for reference only. Bidder shall design their plant and S/S equipment on the basis of the requirement with the following voltage rating of the transformers.

1) 1 (One) Lot Single phase step-up transformers including One(1) spare Bank for ST having required capacity and associated equipment with the following features.
   - **Type:** Oil immersed Single phase, outdoor power transformer
- Rating: To meet the required of the specification as stated above & Clause-8
- Voltage ratio of single phase transformer at full load: 11 / 132 \(\sqrt{3}\) KV
- Connection: Ynd\(_{11}\) as shown in single line diagram.
  - HV winding
  - LV winding
- Rated insulation level
- Lighting impulse Withstand Voltage (1.2/50 micro sec.): 650 kV (Peak) 75 kV Peak
- Power frequency withstand Voltage (for 1 min.): 275kV 28kV
- Impedance voltage including positive and negative tolerances: 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 High tension side: Outdoor bushing suitable to terminate overhead conductor
- Low tension side: Insulated and Isolated phase copper bus duct.

2) One (1) lot of associated equipment.

2.8.3 **Unit Auxiliary Transformer, Station Service Transformers and Associated Equipment (ST)**

1) One (1) no. Unit Auxiliary Transformer and associated equipment with the following features:
   - Type: Oil immerse, three phase and two windings, outdoor power transformer.
   - Rating: To meet the requirement of the specification
- Rated high voltage : 11 kV
- Rated low voltage : 6.9 kV
- Connection : DYn11
- Rated insulation level : HV Winding LV Winding
- Lighting impulse
  - Withstand voltage
    - (1.2/50 micro sec) : 75 kV (Peak) 60 kV (Peak)
- Power frequency
  - Withstand voltage
    - (For 1 mm) : 28 kV 22 kV
- Impedance voltage : shall be within the range of 5% and 7.5%
  including positive and negative tolerance
- Tap changer : Off-current on high tension winding ±5% @ 2.5%
- Neutral grounded : Resistively grounded through 10A, 30 Sec.Resistor.

2) One (1) Lot of Station Service Transformer and associated equipment with the following features:

- Type : Oil immersed, three phase and two windings, outdoor power transformer
- Rating : To meet the requirement of the Specification
- Rated high voltage : 6.6 kV
- Rated low voltage : 415 V
- Connection : Dyn11
- Rated insulation : HV Winding LV Winding
- Lighting impulse : 60 kV(peak)
  - Withstand voltage
    - (1.2/50 micro sec.) : 22 kV(peak) 4kV
Withstand voltage
(for 1 mm).

- **Impedance voltage**: Not less than 5 %, but not more than 7.5 % including positive and negative tolerance.
- **Tap changer**: Off Load on high tension winding ±5% @ 2.5%
- **Neutral grounded**: Solidly grounded

### 2.8.4 Step-Up Transformers and Associated Equipment (For GTG #2)

1) **One(1) no. spare 1-Ph. Bank for GT having required capacity and associated equipment with the following features.**

- **Type**: Oil immersed Single phase, outdoor power transformer
- **Rating**: To meet the required of the specification as stated above & Clause-8
- **Voltage ratio of single phase transformer at full load**: 11 / 132√3 KV
- **Connection**: Ynd₁₁ as shown in single line diagram.
  
  : HV winding / LV winding / HV-N

- **Rated insulation level**
- **Lighting impulse Withstand (peak):** 650kV / 75 kV / 95kV Voltage (1.2/50 micro sec.)
- **Power frequency withstand**: 275kV / 28kV / 38kV Voltage (for 1 min). (r.m.s)
- **Impedance voltage**: 16.44%
- **Tap changer**: On load at high tension winding +8 x 1.25% to -8x1.25%.
Termination High tension side : Outdoor Cable Termination End

- Low tension side : Insulated and Isolated phase copper bus duct.

2) One (1) lot of associated equipment

2.9 Instrumentation and Control

I&C scope of work shall include, but not limited to the following:

a. One (1) latest version DCS system of ABB (Germany, USA, Singapore), Foxboro (USA, Singapore), Siemens (Germany), Alstom (France), GE (USA) for control, monitoring of CCGT, Common Plant Auxiliaries /offsite system (common for the plant) including all hardware, software, operating licenses and associated equipment to provide integrated control and monitoring of the overall plant from the existing Central Control Room (CCR) in addition to any local control facilities

b. Softlink and hardwired (including critical/protection signals) interface of OEM control system of STG with DCS to allow control, monitoring and operation

c. Interfaces between the DCS, field equipment, packaged control systems, instrumentation, actuators, motor control centres and all associated equipment and devices

d. Offered DCS shall be interfaced with existing plant DCS. It shall be possible to monitor and control all turbine and Gas Turbine, generator & it's auxiliaries from the Distributed Control System. All the necessary hardware & software required for interfacing the existing Gas turbines & Generator Control System with new plant DCS. Hardwire (including critical/protection signals) and softlink signal exchange from the existing GTG control system is in bidder’s scope

e. HMIs for HRSG at CCR and one (1) at Local control room (if Local control room is proposed for HRSG), HMI for steam turbine at CCR and one (1) at Local control room. Human Machine Interface (HMI) of latest design (not be more two year old system) and should have proven track record and shall be subject to Owner’s approval.

f. Large Video Screens (LVS) (Optional), Master Clock System, and Information management system

g. Alarm annunciator systems.

h. Condition monitoring system (of vibration and temperature) for HV drives like Boiler Feed Pump, Condensate Extraction Pump, CW, Air Compressor etc. shall be also included.

i. Emergency shutdown systems for plant safety, shut-down and protection for Add-On CCGT including interface/integration with the existing control system

j. Continuous Emission monitoring system for By-pass stack and main stack

k. Steam and Water analysis system

l. Field Instrument, final control element, erection hardware
m. I&C cables, interface cables, laying and termination of the cables

n. I&C earthing/shield systems

o. Black Boxes for off-site/auxiliaries systems. Interface of the black boxes with main plant DCS, through serial link interface. Accepted soft link interfaces can be: Modbus TCP/IP, OPC, and Ethernet TCP/IP

p. Control room equipment, furniture, consoles and panels.

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

q. One (1) Lot Step-up transformer control and protection panels for Combined Cycle plant.

r. 6.6 kv common switchgear and emergency diesel generator control boards as per requirement.

s. Auxiliary power supply control boards for combined cycle plant as per requirement.

t. Synchroniser panel / HMI [Auto & Manual system].

u. One Simulator with 5 (five) work stations for operational training of Combined Cycle Power Plant.

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.

b. Lubricating oil for flushing and for the initial filling.

e. All lubricant and chemical additives.

2.11 Other Electrical System

a. One (1) 415V power Centre.

b. One (1) 41 5 V common power Centre.

c. One (1) Lot 11 kV XLPE power cables & isolated (Insulated) phase (solid) copper bus duct.

d. One (1) Lot 6.6 kV XLPE power cables
2.11.1 Construction Power

The Bidder shall be provided construction power supply at one point only by the Owner till the completion of the project. The Bidder shall make its own further distribution arrangement with step down transformer/s, if required, and arrangement for lighting and other facilities needed for construction activities, subject to Owner’s approval. The Bidder shall bear all cost of Electricity consumption for construction use at Site according to prevailing tariff rate including government duty.

2.12 Maintenance Facilities

a. One (1) lot Overhead electric cranes (ST & CW Pump House) As required for lifting the heaviest single piece with 20% margin complete with gantry structure, weather protection shed, control, power supply etc.)

b. One (1) lot Special tools etc.

2.13 Fire Fighting Facilities

At present Fire Fighting pump house and fire fighting reservoir for 100 MW & 71 MW GTG(s) Unit was present in the plant area. The Bidder shall have to renovate/modify the pump house including its equipment to capable the pumps for 150 MW CCPP Power plant & 71 MW power plant.

a. One (1) lot Auto-Release CO₂ fire fighting facilities for ST (if appropriate).

b. One (1) lot Hydrant system including (motor driven and diesel engine driven fire-fighting pumps, jockey pump- if required) water main, hydrant stands, hoses, water sprinkle system in the control room, water pool etc.
c. One (1)lot Portable fire fighting equipment.

2.14 Building and Civil Works

The work to be performed under this specification shall also include Dismantling & demolitions works, Topographical and contour survey, soil investigation, hydrological investigation of source of water, design, engineering and providing all labour, materials, plant and equipment for construction, consumables, construction facilities and all incidental items though not specifically mentioned but necessary for completion and proper functioning of the plant, systems and facilities in strict accordance with the Specification. All materials required for works under the Bidder’s scope shall be arranged and supplied by the Bidder. The Bidder’s work shall comply with relevant American Standards, British Standards & Codes, requirements of various statutory bodies, National Building Code of Bangladesh, best prevailing practices and to the complete satisfaction of the Owner.

The work shall be carried out according to the approved design and drawings, to be developed by the Bidder and approved by the Owner. For all plant, systems, facilities, structures, etc., necessary layout and details are to be developed by the Bidder keeping in view the statutory and functional requirements and providing enough space and access for operation, use and maintenance. The short description of works are given below.

The design and construction of the power house, control room building (for Combined Cycle Control), Steam Turbine Engine house, 2 storied store building, workshop building, Officers Quarters, Staff Quarters, 2 KW Solar system, guard rooms, rest house, Studio type dormitory building, CW pump house, Water Treatment plant, Water intake system, permanent Jetty construction (up to 225 ton load), fencing, boundary wall etc. The design and construction of all major foundations and buildings shall include piling.

- 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 work as per section 20 and 21

Jetty Construction:

The Bidder shall have to install a complete permanent Jetty adjacent to the river Boral. The capacity of the Jetty will be 225 ton load.
The Bidder shall also build at his own cost a suitable temporary site office for Owner at the approved location. Office shall be of single storey Structure steel frame with metal sheet roofing, side cladding and false ceiling. Minimum floor area of the office shall be of 1000 m² and shall contain reception area, conference hall, Toilet, Pantry & Office etc.

2.15 Training

The training at the Manufacturer's factory by the Bidder including:

- 10 (Ten) round trip air fares from Dhaka, Bangladesh to the Bidder's factory.
- 10 (Ten) person-months of training.
- Local transportation, meals, lodging costs etc. will be born by the Bidder. In addition, pocket expenses of US $ 100 per day will be provided by the Bidder.

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 Bidder 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.

i. If different data/values/rating etc. for a particular item is given in various sections of the offer, the stringent one will be considered as offer.

ii. Nos., ratings and types of all equipment / systems will be approved / accepted during detail engineering stage, not during evaluation stage. Bidder shall submit all design calculations during detail engineering stage to substantiate nos., ratings and types for all equipment / systems which will be subject to approval of the Owner. No price escalation on positive side will be accepted for changes in nos., ratings and types of all equipment / systems due to respective approved calculations.

iii. In case, Bidder fills up any data/information in Volume - 3, as ‘Later / DDE / to be informed later on equivalent word ’ or left blank,, , it will be presumed that their offer is strictly in compliance with Tender Specification, except for accepted deviation/s, if any,

iv. Makes of all equipment / systems will be approved / accepted during contract finalization stage.

v. Other than the deviations mentioned in ‘Deviation List’, Bidder shall confirm that their offer is in compliance with Tender Specification. Deviations taken / mentioned in any other pages / sections / lists etc. of their offer will not be accepted during contract execution stage.
2.17 Manufacturer's Field Training Supervisor

From the date of commencement of initial operation of the major equipment, the Bidder 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. Total No of Trainee will be 40. 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 Bidder shall be responsible to all testing of equipment and systems supplied under this contract. The Bidder 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 Bidder 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.

For start up and test Board will supply operating staff who will operate the equipment as directed by the Bidder under the Bidder's responsibility.

All routine & acceptance tests, as listed in IEC/ANSI Standards or Tender Specification shall be carried out by the successful Bidder on all equipment, charges for which shall be deemed to be included in the bid price.

Unless specifically asked for in Tender Specification to carry out the type tests, reports of the same, as listed in IEC/ANSI Standards or Tender Specification, already carried out on identical/similar equipment shall be furnished during detail engineering stage. Such type tests should have been carried out within last five years with respect to date of bid opening. In absence of such type test reports or in case such reports are not found to meet the requirement of Tender Specification, all such tests shall be carried out free of cost to the Owner and reports shall be submitted for their approval. This is applicable for all equipment/items to be supplied by the Bidder.

2.19 Commissioning

The Bidder 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 Bidder 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 Defect liability Period

The Bidder 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.) & I&C, one (1) Engineer Mechanical Maintenance (BOP), Gas Turbine Maintenance, Steam Turbine maintenance & HRSG Maintenance during 24 months defect liability period for smooth maintenance and operation of the Plant. The Bidder has to provide all the spares and service needed for maintenance requirement during the defect liability period and will engage required manpower in addition to the above stated personnel.

During defect liability 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 First Inspection, CI, HGPI of Gas Turbine and Overhauling of other equipment.

The Bidder shall provide necessary spares and expert service for execution of first inspection, CI of the Gas Turbine Unit or any other required maintenance of Steam Turbine, Generators, HRSG and BOP during the Defect liability period. During the defect liability period the Bidder have to conduct (providing all required spare parts and service) at least 1(One) CI for Gas Turbine and at least one inspection for other equipment and any other maintenance work for force outage. 1 (One) HGPI Spare is also included.

2.22 Transport:

i) 2 Nos. Double Cabinet Pick-up (Not less than 2400 CC each) including catalytic converter

ii) 1 No. Car (Not less than 1800 CC)

iii) 4 Nos. Motor Cycle

iv) 1 No. Truck (5 Tons)

v) 1 No. Microbus (Not less than 1800 CC, for 9 person)
2.23 **Spare Parts and consumables**

The Bidder shall submit a list & supply accordingly Essential spare parts with OEM part No. (as per Vol. 2, Schedule-F) to be necessary for maintenance of Gas Turbine Generating Unit, Steam Turbine Generating unit, HRSG and other plant equipment inclusive of routine, scheduled as well as emergency use that takes place in the course of operation of the plant during defect liability period (24 months) which are mandatory. It may be mentioned that Bidder must quote in Schedule-F in full quantity and also additional items & quantity necessary as stated in Tender Document, otherwise Tender shall be rejected. During the defect liability period of 24 months, the Bidder shall supply all necessary equipment, spare parts, materials/consumables etc. at his own cost and whether it is listed or not in Schedule-F, Vol. 2 of 2 Part B Tender Documents. In preparation of the list the Bidder have to consider plant factor as 80%. During the defect liability period the Bidder have to conduct (providing all required spare parts and service) at least 1 (One) CI for Gas Turbine and at least one Inspection for other equipment and any other maintenance work for force outage. 1 (One) HGPI Spare is also included. Spare parts & consumables to be supplied for defect liability period under the Contract must be made available at site before start of testing.

2.24 **Special Maintenance Tools**

The Bidder shall provide all special tools including a boroscope set required for maintenance of the unit and hand them over in good condition to the BOARD. A list of all such tools shall be incorporated with tender. Bidder shall not be permitted to use any equipment/ machinery/ tools, which are to be supplied under the Contract.

2.25 **Electrical workshop tools**

The Bidder shall have to provide Electrical Workshop tools which shall include but are not limited to the followings:

Current injection test set, Megger(HV: 2.5 to 6 KV, LV: 250V,500V,1000V), Multimeter, Level Gauge(600mm), Mega Ohmer (ZC-25B), Portable Millammeter (BMA-1), Mimmivoltmeter (BMV-1), Wire Buffing Machine, Hand Shares, Hydraulic Press(5 Ton), Pneumatic, Grease Gun, High Pressure Water Cleaener, Bearing Puller Kit, Bearing heater, Pistol Drill(medium), Temperature Probe, Power Meter Set(Inclued: 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**

The Bidder shall have to provide Machine Shop equipments & tools which shall include but are not limited to the followings:

**Laboratory Equipment (Testing Bench):**

The Bidder shall have to provide Laboratory equipments (Testing Bench) for measurement and calibration of pressure, temperature, measuring equipment.

### 2.27 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 analyse 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(O₂)
• iron
• sodium
• silicate (SiO₂)
• 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 100°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.

Chemicals
The types and quantities of chemicals supplied shall be calculated in such a way that all necessary analyses can be carried out to permit uninterrupted laboratory operation.

Normal solutions for titrimetric analysis to be in the form of prefabricated vials for later dilution (type; Merck Titrico or equivalent).

The quantities of all chemicals must be sufficient for the analytical supervision of the power plant during a period of 1 year. The purity of the chemical substances must be in accordance with the requirements of the various analytical methods to be performed.

General glassware and tools
This scope of supply comprises the complete furnishing of the laboratory glassware e.g. beakers. Erlenmeyer flasks funnel graduated cylinders volumetric
flasks normal and automatic burettes pipettes porcelain dishes. exsiccator roundbottom flasks, coolers, crucibles, thermometers, filter crucibles, vibrating funnels, etc. of various sizes rubber tubing ejector pumps, crucible tongs, desiccators, bunsen burners, stands, cork drillers, and other accessories; also small laboratory test filters made from acrylic resin for filling ion exchanger material.

**Laboratory furniture**

The following laboratory equipment shall be included in the scope of supplies as a minimum:

- work places for wet-chemical work working surfaces proof against chemicals and heat. doors and cabinets in the floor-mounted units with integrated sinks at one end with a swivel-type mixing faucet for cold and warm water and splash wall electrical connection outlets compressed air supply gas supply and water supply

- closed laboratory ventilation hood working surfaces proof against chemicals and heat drawers and cabinets in the floor-mounted unit electrical connections outlets compressed air supply. gas and water supply

- weighing table for the precision analysis balances

- work benches with artificial resin surface for titrimetric analysis. proof against chemicals and heat with drawers and cabinets in the floor-mounted units

- potable water stainless steel connection from existing potable water distribution network to places where water is required.

- complete compressed air distribution network in the laboratory rooms. made of galvanized carbon steel piping from the compressed air system

- complete compressed air reducing and filtering device for oil-free and dust-free

- demineralized water system

When furnishing the laboratory, there may he no gaps left in the working surfaces. Adequate numbers or control elements for water, electricity, compressed air supplies etc. shall he provided and so arranged that they can be easily operated.

Adequate provision shall be made for storage space liter glass equipment chemicals, etc. and likewise there shall he adequate working surfaces and stowage surfaces for analysis equipment.

**Spare parts.**

All spare parts and commissioning spares shall be supplied. Spare parts for the defect liability time are to be included in the component price. Spare parts after the defect liability time shall be included and specified according to spare part price sheets.

**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 **Simulator for Power Plant operation Training**

The Bidder have to provide One Simulator with 5 (five) work stations for operational training of Combined Cycle Power Plant. Refer Vol 2, Section 11.14 for details.
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

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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
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single Stage: Two Envelope
3.0 Power Plant Arrangement

3.1 General

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

The Combined Cycle (existing GT+ST) Power Plant with a continuous total generating capacity at site conditions (35°C, 1.013 bar, 98% relative humidity) of 150MW shall be accommodated in the location proposed with required number of auxiliary system as per drawing attached. The power plant general arrangement shall be as per attached drawing.

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 150 MW at site conditions (35°C, 1.013 bar, 98% relative humidity) in one (1) unit of existing gas turbine generating plants and one (1) unit of steam turbine generating plant.

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

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

The plant arrangement shall be in multi-shaft type i.e. existing gas turbine drives its own generator and exhausts into a heat recovery steam generator. The steam output from the heat recovery steam generator shall be combined in a header system and directed to a steam turbine. 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 generator shall be supplied for indoor installation in the powerhouse. An overhead electrical crane shall be supplied for maintenance of the steam turbine generator.

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 for combined cycle unit 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 132 kV switch-gear controls shall be accommodated in the central control room.

The Site is located at Baghabari, District of Sirajgonj in Bangladesh.

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 Bidder 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 Bidder at the following conditions:

a. Ambient temperature : 95°F (35°C)
b. Site elevation : less than 1000 ft (msl)
c. Relative humidity : 98%
d. Barometric pressure : 1.013 bar
e. Generation voltage : Manufacturer’s standard voltage rating
f. Power factor : 0.8 lagging
g. Frequency : 50 Hz
h. Cooling water temperature : 90°F (32.2°C)

The Bidder 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(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 (see Tender)

(1) Guaranteed net total base load capability at site Condition (35°C, 1,013 bar, 98% relative humidity) 150 MW for CC

(2) Minimum KVA rating of generators:
   The generator KVA rating at 0.80 power factor shall match or exceed gas/steam turbine drive output under all load operating conditions.

3.3 Combined Cycle and Ancillary Equipment

3.3.1 Basic Equipment Requirements

The Steam Turbine generating unit shall be of well-proven design. The following
equipment shall have satisfactory operating experience outside manufacturer's country for at least 2 (two) years.

- Offered or higher capacity HRSG manufactured by proposed manufacturer;
- Offered or higher capacity Steam Turbine manufactured by proposed manufacturer;
- Offered or higher capacity Steam Turbine Generator manufactured by proposed manufacturer;
- Offered or higher capacity Steam Turbine Generator Circuit Breaker manufactured by proposed manufacturer;
- Offered or higher capacity Unit Transformer for Steam Turbine manufactured by proposed manufacturer.

Bidder shall have to submit separate certificates 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 existing 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 150 MW.

No proposal which offers less than 150 MW CC capacity (Net output at site conditions) of Power Plant as specified in Technical Requirements will be evaluated and accepted.

(2) Number of generating units: One (1) existing units of gas turbines and One (1) unit of steam turbine

(3) Operating pattern
- Simple cycle mode: Base load as well as peak load.
- 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 generators.

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 DCS in 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 from 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 DCS at centre control room (CCR).

The motorized drains shall be level actuated for automatic condensate draining
during start-up and shutdown. The control of Drain and Vents to be such that
single measurement failure shall not contribute to loss of function.

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

All instrumentation, monitoring and control equipment shall be in accordance with
the requirements of Vol 2, Section 11

All controls, monitoring of main steam system shall be envisaged in the Plant DCS
in CCR.

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.

The regulation system of the bypass station shall be equipped with all the
equipment and accessories necessary for connection to the control equipment.

In the safety mode the bypass shall operate independently from the regulating
mode and open rapidly on a turbine trip signal or over pressure of the main steam
line. For this safety critical function three independent pressure transmitters
operating under a two out of three voting system will provide the initiating signal

3.3.3 Feed water System

Steam generator feed water shall be supplied with condensate from a surface
condenser, de-aerated in the De-aerator. 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 three (3) 60% duty motor driven pumps.

Each pump shall be horizontal, multi-stage, centrifugal type capable of supplying
two times of heat recovery steam generator MCR flow plus a margin to cover
boiler swing and eventual reduction in effective capacity from water. 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 condenser.

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.

All instrumentation, monitoring and control equipment shall be in accordance with the requirements of Vol 2, Section 11

All controls, monitoring of feedwater system shall be envisaged in the Plant DCS in CCR

In the main header, a redundant 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 three level transmitters. A level transmitter shall send a signal to the level controller.

A two(2) element and three (3) element control schemes based on drum level and steam/feed water flow shall be provided. Automatic changeover between two(2) element and three (3) elements control in accordance with the steam flow shall be provided in addition to a manual changeover facility

### 3.3.4 Condensate System

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

The three (3) 60% 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.
- Condenser ball cleaning (tube cleaning) system.

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.

Monitoring and control equipment shall be in accordance with the requirements of Section 11.

All controls, monitoring of condensate system shall be envisaged in the Plant DCS in CCR

3.3.5 Cooling System

The Boral river is perennial river having water throughout the year. Hence, the river water shall be used for condenser cooling with once through system.

The cooling water shall be drawn through pipe line and hot water shall be discharge through discharge channel to river.

However, an auxiliary cooling tower shall be used for cooling of close circuit cooling water for auxiliary equipment cooling. For Condenser no closed circuit cooling system with cooling tower is required.

Circulating Cooling Water System:

Condenser cooling water is required to be supplied by three (3) 60% capacity circulating water pumps located in the pump house adjacent to River Boral. Also required pipe line from pump house to main engine hall have to be constructed. Auto Changeover system among the pumps shall be provided.

The circulating water pumps shall take suction from the River and feed the cooling water to the Condenser.

The pumps shall be installed in the pit below minimum water level of the basin. A circulating water pump house shall be provided.
A manual operated butterfly valve with position switch shall be provided at each circulating water pump discharge and suction.

Cooling water configuration and valve arrangement incl. mechanical reverse rotation locks to protect the pumps from any surge effect, shall be subject to E/E’s approval

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

A motor operated reversing valve shall be provided for condenser backwash purpose. A chain hoist is provided in circulating water pump house.

All instrumentation, monitoring and control equipment in accordance with the requirements of Section 11.

All controls, monitoring of cooling water system shall be envisaged in the Plant DCS in CCR

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 three (3) 60% capacity cooling water pumps. Cooling water head tank, two 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.

All instrumentation, monitoring and control equipment in accordance with the requirements of Vol 2, Section 11.

All controls, monitoring of Closed circuit cooling water system shall be envisaged in the Plant DCS in CCR
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 System

One instrument air system shall be provided consisting of two (2) full-capacity reciprocating / Screw type air compressors each with necessary air filters, after cooler and receiver. One dual tower, desiccant type air dryer shall be furnished with the system. Each compressor shall be furnished with automatic controls locally mounted. Control system can be PLC/Proprietary Control System based on the redundancy requirement spelled out in the Tender Vol 2, section 11.

1x100% full-capacity reciprocating / Screw type air compressor with necessary accessories and spares for service and maintenance purpose shall have to be provided.

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 and one full capacity 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 blow-down 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 and controls and proper water hydrant system shall also be provided for other equipment and facilities. Appropriate foam based fire fighting system for liquid fuel facilities to be provided.

Interface to fire protection panel and detection panel to DCS shall be provided.

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 Bidder is mandatory for detailed design of Water Treatment Plant.

Demineralisation is the 3rd step of this process. There are two basic steps of demineralisation system: roughing demineralisation and polishing demineralisation. Roughing removes a bulk of mineral contamination including desalination 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. Rough polish
water or desalinated water will be used for cooling water make up and other industrial purpose. After passing through active carbon filters this water will also used for further polishing for demineralised water and may be used for potable water system.

The demineralizer shall be sized to handle the steam cycle make-up. The demineralizer 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.

For the water treatment & Demi Water system, the equipment to be included but not limited to the following:

**Intake Water Pump House:**
- Clarifier: 2 Units
- Multimedia Pressure filter
- Active Carbon filter
- Sand filters
- Filtered water reservoir: 500 M³
- Micro filter
- Single bed Cation-exchange filter
- Single bed ion-exchange filter
- De-salined water reservoir: 500 M³
- De-Carbonizer
- Mixed Bed polishers
- RO (Reverse Osmosis) Plant

Demineralization Plant: storage tank (3000 ton capacity), 1 degasser unit, 1 single bed anion exchange, 1 mixed bed unit, semi demin and demin, water reservoirs including its all necessary pumps, equipment, instrumentations, automation, accessories/ auxiliaries and all other relevant work, etc.
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.

Important Indications, Alarms and control functions to be interfaced with Plant DCS 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 and Demi water Tank capacity shall be for 72 hrs continuous operation (full load) of Steam Turbine.

3.3.14 Potable Water system

Extension of the existing potable water system to the new plant area and other extension area should be included with the Tender.

3.4 Electrical System

The electrical system shall consist of apparatus required to operate the heat recovery steam generators, steam turbine generating set, associated equipment, and step-up transformer and 132 kv switchgear equipment necessary to delivery power to the 132 kv 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:

- 132 kv switchgear : 40 kA, 3 Sec.
- Generator switchgear : Minimum 63 kA for ST, 3 Sec.
- 6.6kV switchgear : Minimum 40 kA, 3 Sec.
- 400 V switchgear : Minimum 40 kA, 1 Sec.
- 125V DC : Minimum 10 kA, 1 Sec.

The voltage variation at 132kV system shall be considered as -20% to +10% of rated voltage.

3.4.2 Generators

The Gas Turbine generator is of open circuit air cooling type and Steam Turbine Generator shall be of TEWAC type.

Steam Turbine 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.

The generation voltage is considered as 11kV. Bidder may propose for other generation voltage. According to the generation voltage, the design parameter for all other equipment shall be changed.
The Generator to Generator Switchgear and Generator Switchgear to low voltage terminals of the Generator Step-Up Transformer shall be connected to through copper IPBD. Generator Switchgear shall be connected to the high voltage terminals of Unit Auxiliary Transformer by 11kV cables.

3.4.3 6.6 kV Switchgear

The 6.6 kV common switchgear will consist of metalclad circuit breakers and fed through Unit Auxiliary Transformer as shown in enclosed Electrical Single Line Diagram. The 6.6 kV switchgear shall supply auxiliaries and common auxiliary power through Station Service Transformers.

3.4.4 Balance of Plant

The auxiliary for the existing 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 generator voltage down to 6.6 kV to feed the auxiliary equipment. The station transformers shall step the medium voltage of 6.6 kV down to 415/230 to feed gas turbine generator unit MCC and the heat recovery steam generator unit 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/ANSI standard.

3.4.5 Motor

a) A.C Motor

i) Motors shall be general purpose, constant speed, squirrel cage, three/single phase, and induction type.

ii) All motors shall be rated for continuous duty. They shall also be suitable for long period of inactivity.

iii) Motor name plate rating shall be at 45 Deg. C. The motor rating shall be arrived at considering 15% margin over the rated duty point or 10% over the maximum demand of the driven equipment,
whichever is higher under entire operating range including voltage and frequency variations unless otherwise specified.

iv) Power supply for AC motors shall be as follows:

- Below 0.2 KW: 230V, 1 Phase, 50Hz
- From 0.2 KW to 200 KW: 400V, 3 Phase, 50Hz
- Above 200KW: 6.6 KV 3 Phase, 50Hz

v) All AC motors shall be suitable for following voltage & frequency variations:

- Voltage Variation: (±) 10%
- Frequency Variation: (+)5% to (-)5%
- Combined Variation of: 10% (absolute sum)

vi) Motor shall be designed for direct on line starting at full voltage. Starting current shall not exceed 6 times full load current subject to IEC tolerance.

vii) The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

viii) Motor shall start with rated load and accelerate to full speed with 80% rated voltage at motor terminals.

ix) Motors shall be suitable for 3 nos. consecutive cold starts up and 2 nos. consecutive hot starts up.

x) The motor shall be suitable to withstand stress during bus transfer

b) D.C Motor

i) D.C. motor provided for emergency service shall be shunt/compound wound type.

ii) Motor starter shall be sized for operation with fixed resistance starter for maximum reliability.

iii) DC motors shall be rated for 125V DC with supply voltage variation of -15% to +10%.

c) Actuator Motor

i) For isolating service, the actuator shall be rated for three successive open-close operation of the valve/damper or 15 minutes, whichever is longer.

ii) For regulating service, the actuator shall be suitably time-rated for the duty cycle involved with necessary number of starts per hour, but in no case less than 150 starts per hour.
iii) The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high torque and reversing service

iv) The actuator shall have integral starters along with overload relays and built in single phase preventer.

v) Each actuator shall be provided with necessary Torque / Travel limit switches. Each actuator shall be provided with a hand wheel for emergency manual operation.

vi) One built in local position indicator for 0 – 100% travel and one position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with 24V DC

vii) A space heater shall be provided for each Actuator.

### 3.4.5.1 Specific Requirements of Motors

i) All motor enclosures shall conform to the degree of protection of IP-54 or IP-55 depending upon area of installation unless otherwise specified. Motor for outdoor or semi-outdoor service shall be of weather-proof construction.

ii) For motors located in outdoor & corrosive locations, FRP canopy or epoxy painted steel canopy shall be provided. Motors located in hazardous areas shall have flame proof enclosures conforming to IEC/International standard.

iii) The motor shall be self ventilated type, either totally enclosed fan cooled (TEFC) or closed air circuit air cooled (CACA).

iv) All insulated winding shall be of copper.

v) 6600V motors shall have class F insulation but limited to class B temperature rise.

vi) All motors shall have class F insulation but limited to class B insulation or better.

vii) Windings shall be impregnated to make them non-hygroscopic and oil resistant. Winding shall be flame resistant.

viii) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.

ix) All fittings and hardware shall be corrosion resistant.

x) The noise level shall not exceed 85 db (A) at 1.5 meters from the motor.

xi) The peak amplitude of the vibration shall be within IEC/International standard specified limits.
xii) Motor terminal box shall be detachable type and located in accordance with International standards clearing the motor base-plate/foundation

xiii) The terminal box shall be capable of withstanding maximum system fault current for duration of 0.25 sec.

xiv) For H.T motors, the terminal box shall be phase-segregated type. The neutral leads shall be brought out in a separate terminal box with shorting links for star connection.

 xv) Separate terminal boxes shall be provided for space heaters and RTDs.

xvi) All outdoor motors and Indoor Motor of rating 30 KW and above shall be provided with space heaters, suitably located for easy removal or replacement.

xvii) The space heater shall be rated 230 V, 1 phase 50 Hz and sized to maintain the motor internal temperature above dew point when the motor is idle.

xviii) All H.T motors shall be provided with six (6) simplex type winding temperature detectors, two (2) per phase.

xix) H.T motor bearing shall be provided with duplex type temperature detectors and shall be resistance type, 3 wire, platinum wound, 100 Ohms at 0 Deg.C.

xx) Leads of all duplex type motor winding RTDS and motor bearing RTDS shall be wired up to respective switchgear metering & protection compartment. From which one set of RTDS will be connected to numerical protection relay and another set shall be kept free for DCS connectivity.

xxi) Motor above 1000 KW shall be provided with three differential current transformers mounted over the neutral leads within the enclosure. The arrangement shall be such as to permit easy access for C.T. testing and replacement. Current transformer characteristics shall match Owner's requirements to be intimated later.

xxii) Vibration monitoring System for Motors for Boiler Feed Pumps, CW Pumps, Condensate Pump and other H.T motors, if any, shall be provided.

3.5 Functional Requirements

3.5.1 General

Combined cycle shall be designed for operation as a base load generating unit. The existing gas turbine unit are also be suitable for peak load operation as well as base load plant.

3.5.2 Controls
Fully automatic start-up sequences shall also be provided for the generator synchronisation and loading of the ST, the HRSG’s, and all auxiliary equipment from the Central Control Room (CCR) using all the main full automatic start-up sequence step and automatic programs based on function group control using a single push-button start from the CCR.

Semi-automatic and manual modes shall also be provided for operator selection.

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 open circuit air cooling system.

3.5.4 Noise Levels

The Noise level shall be as per Annexure-23.7.

3.5.5 Vibration Severity

Vibration severity of the units shall not exceed 10.0 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.

3.5.6 Spare Parts & Consumables

The Bidder shall submit a list & supply accordingly Essential spare parts with OEM part No. (as per Vol. 2, Schedule-F) to be necessary for maintenance of Gas Turbine Generating Unit, Steam Turbine Generating unit, HRSG and other plant equipment inclusive of routine, scheduled as well as emergency use that takes place in the course of operation of the plant during defect liability period (24 months) which are mandatory. It may be mentioned that Bidder must quote in Schedule-F in full quantity and also additional items & quantity necessary as stated in Tender Document, otherwise Tender shall be rejected. During the defect liability period of 24 months, the Bidder shall supply all necessary equipment, spare parts, materials/consumables etc. at his own cost and whether it is listed or not in in Schedule-F, Vol. 2 of 2 Part B Tender Documents. In preparation of the list the Bidder have to consider plant factor as 80%. During the defect liability period the Bidder have to conduct (providing all required spare parts and service) at least 1 (One) CI for Gas Turbine and at least one Inspection for other equipment and any other maintenance work for force outage. 1 (One) HGPI Spare is also included. Spare parts & consumables to be supplied for defect liability period under the Contract must be made available at site before start of testing.

All spare parts shall be subject to the same specification, tests and conditions as
similar material supplied under the inter-changeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and number for identification and prepared for storage by greasing or painting to prevent deterioration.

All spare parts shall be delivered in cases or containers suitable for storing such parts over a period of years without deterioration under the atmospheric conditions existing in Bangladesh. The cases shall remain the property of the Board.

Each case or container shall be marked with the appropriate contract details and a list of the parts contained therein with identification references given of the outside of the enclosure.

3.5.7 Special Maintenance Tools

The Bidder shall provide all special tools including a boroscope set 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.

3.6 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable relevant Bangladesh/IEC/ANSI Standards except where modified and/or supplemented by this specification. In case of conflict among Codes & Standards and Tender Specification, the stipulation of later shall prevail.

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Bangladesh Electricity Rules as amended up to date and relevant IEC/ANSI Standards.
Section-4

Existing Gas Turbine Generating Set, Gas Booster Compressors, EDG and Ancillary Equipment
4.0 Existing Gas Turbine Generator Set and Ancillary Equipment

4.1 General

4.2 Plant History of existing GT Unit

4.3 Operational data of Existing Gas Turbine Generating Unit

4.4 Present Gas Turbine Set & its auxiliary's description

4.5 Existing Gas Booster Compressors Description
4.0 Existing Gas Turbine Generator Set and Ancillary Equipment

4.1 General

At present existing one 1x100 MW GE (PG9171E) Open Cycle, Single Shaft, Heavy Duty Industrial Package type Gas Turbine unit shall be converted to combined cycle operation.

Bidder have to renovate/ inspect the existing Gas turbine & its Auxiliaries (i.e Gas Turbine Generator Set, Transformers, Gas Booster Compressors (3 nos), electrical system, UPS/ Battery System, EDG etc.) and capable the existing Gas Turbine Generator to its full capacity for using as a Gas turbine of combined cycle operation and the capacity of Combined Cycle Unit will be 150 MW.

Details of existing GTG unit & major auxiliaries are given below. Bidder are requested to verify and collect required date of existing plant during site visit.

4.2 Plant History of Existing GT Unit.

| Gas turbine Model Series (GE Design) | : PG9171E |
| Name of Manufacturer | : GEEP, France |
| No. of turbine stages | : 3 |
| No. of Compressor stages | : 17 (Axial) |
| Base Output | : 106.88 MW (At 35ºC, 1.013 bar & 98% Relative Humidity) |
| Type of Operation | : Continuous |
| Compressor Inlet Temperature | : 35ºC |
| Turbine Exhaust Temperature | : 558 ºC |
| Control | : Mark V |

4.3 Operational Data of Existing Gas Turbine Generating Unit:

<table>
<thead>
<tr>
<th>Date of Commissioning</th>
<th>Combustion Inspection(CI)</th>
<th>Hot Gas Path Inspection(HGPI)</th>
<th>Major Inspection(MI)</th>
<th>Total Running Hours</th>
<th>No. of Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>November, 25, 2001</td>
<td>02(Two) Nos. 24/04/2003 - 30/04/2003 = 7 days 16/12/2008 - 20/12/2008 = 4 days</td>
<td>01(ONE) No. 09/01/2006 - 25/03/2006 = 76 days (Including Accessory Coupling Shaft Maintenance)</td>
<td>01(One) No. 02/07/2009 - 09/12/2009 = 161 days (Including Accessory Coupling Shaft</td>
<td>70,000</td>
<td>1280</td>
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<table>
<thead>
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<th></th>
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<td></td>
</tr>
</tbody>
</table>
### LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

#### Procurement of Plan

**December, 2016**

**Single Stage: Two-Envelope**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Base Load</td>
<td>Before SRV</td>
<td>21.42</td>
<td>20.91</td>
<td>47</td>
<td>10.26</td>
<td>364</td>
<td>84°</td>
<td>562</td>
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<tr>
<td></td>
<td>After SRV</td>
<td>21.99</td>
<td>20.88</td>
<td>47</td>
<td>9.60</td>
<td>350</td>
<td>84°</td>
<td>571</td>
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<td></td>
<td></td>
<td>22.34</td>
<td>21.10</td>
<td>47</td>
<td>9.16</td>
<td>344</td>
<td>84°</td>
<td>577</td>
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**Ambient Temperature is 32°C and RH is 98%**

### 4.4 Present Gas Turbine Set & its auxiliary's description:

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
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<tbody>
<tr>
<td>Gas Turbine</td>
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<tr>
<td>Standard</td>
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<tr>
<td>Type</td>
<td>Open Cycle, Single Shaft, Heavy Duty Industrial Package type Gas Turbine</td>
</tr>
<tr>
<td>Model</td>
<td>PG9171E</td>
</tr>
<tr>
<td>Compressor Type</td>
<td>Multistage axial flow heavy duty corrosion protected</td>
</tr>
<tr>
<td>Inlet Guide Vane</td>
<td>Modulated</td>
</tr>
<tr>
<td>Casing Split</td>
<td>Horizontal Flange</td>
</tr>
<tr>
<td>Combustor Type</td>
<td>Can Annular (Multiple Combustors, reverse flow)</td>
</tr>
<tr>
<td>Fuel Nozzle</td>
<td>One Per combustion Chamber</td>
</tr>
<tr>
<td>No of Chambers</td>
<td>14</td>
</tr>
<tr>
<td>Turbine Type</td>
<td>Axial Flow, Reaction Type</td>
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<tr>
<td>No of Stages</td>
<td>3</td>
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<tr>
<td>Shaft speed</td>
<td>3000 rpm</td>
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<tr>
<td>Generator</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>TARI 1080 -36F</td>
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<tr>
<td>Drive</td>
<td>Gas Turbine</td>
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<td>KVA</td>
<td>134250</td>
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<tr>
<td>Volts</td>
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<tr>
<td>KW</td>
<td>107400</td>
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<tr>
<td>Description</td>
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<td>P.F Log</td>
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<td>Frequency</td>
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<td>Rpm</td>
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<td>Phase</td>
<td>3</td>
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<td>Connection</td>
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</tr>
<tr>
<td>Volts (Stator)</td>
<td>11000</td>
</tr>
<tr>
<td>Volts (Rotor)</td>
<td>350</td>
</tr>
<tr>
<td>Amps (Rotor)</td>
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<tr>
<td>Altitude</td>
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<tr>
<td>Winding Insulation Class</td>
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<td>Protection</td>
<td>IP-54</td>
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**Excitation System (With all Auxiliaries)**

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<tr>
<td>Type</td>
<td>EAR 54/34 -30/6-4</td>
</tr>
<tr>
<td>Volts</td>
<td>385 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>892 A</td>
</tr>
<tr>
<td>KW</td>
<td>344 Continuous</td>
</tr>
<tr>
<td>Rpm</td>
<td>3000</td>
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<td>Duty Cycle</td>
<td>Continuous</td>
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<tr>
<td>Insulation Class</td>
<td>Class F</td>
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<tr>
<td>Excitation</td>
<td>869 W, 69.92 Volts, 12.42 A</td>
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**Permanent magnet generator**

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<tr>
<td>Type</td>
<td>EAP 39/12-30/6</td>
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<tr>
<td>KVA</td>
<td>8</td>
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<td>Voltage</td>
<td>22</td>
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<tr>
<td>Ampere</td>
<td>26</td>
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<tr>
<td>Hz</td>
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**Starting System**

**A. Starting Motor**

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<tr>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Type</td>
<td>3 - Phase Induction Motor</td>
</tr>
<tr>
<td>Capacity</td>
<td>1750 HP (1305 KW)</td>
</tr>
<tr>
<td>Volts</td>
<td>6.6 KV</td>
</tr>
<tr>
<td>Freq.</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Sync. Speed</td>
<td>1480 rpm</td>
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<tr>
<td>Duty</td>
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**B. Torque Converter**

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<tr>
<td>Type</td>
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<td>Specific Torque</td>
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**Lube Oil Pump & Motor**

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<th>Description</th>
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<tr>
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<tr>
<td>Capacity</td>
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<td>Service Factor</td>
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<td>Rpm</td>
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<td>Voltage</td>
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<td>----------</td>
</tr>
<tr>
<td>Ampere</td>
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<td>Made</td>
<td>USA</td>
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<tr>
<td>PF</td>
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<tr>
<td><strong>Pump</strong></td>
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<tr>
<td>Head</td>
<td>288 m</td>
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<tr>
<td>Capacity</td>
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<td>Speed</td>
<td>2900 rpm</td>
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<td>Model</td>
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<td>Made In</td>
<td>USA</td>
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<tr>
<td>Impeller Diameter</td>
<td>10-5/8</td>
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<tr>
<td><strong>Emergency Lube Oil Pump</strong></td>
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<tr>
<td><strong>DC MOTOR</strong></td>
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<td>Capacity</td>
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<td>Speed</td>
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<tr>
<td>Volts</td>
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<td>Type</td>
<td>CD258 APY</td>
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<td>Made in</td>
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<tr>
<td><strong>Turbine Cooling Exhaust Frame Blower</strong></td>
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<td><strong>Blower</strong></td>
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<td>100HP</td>
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<tr>
<td>Volts</td>
<td>380</td>
</tr>
<tr>
<td>Frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>Speed</td>
<td>2950 rpm</td>
</tr>
<tr>
<td>Made in</td>
<td>USA</td>
</tr>
<tr>
<td><strong>Lube Oil System</strong></td>
<td></td>
</tr>
<tr>
<td>Main Lube Oil Pump Capacity</td>
<td>2460 Lit/ Min</td>
</tr>
<tr>
<td>Auxiliary Oil Pump Capacity</td>
<td>2460 Lit/Min</td>
</tr>
<tr>
<td>Emergency Lube Oil Pump Capacity</td>
<td>1590 Lit/Min</td>
</tr>
<tr>
<td>Total Quantity of Oil In the System</td>
<td>15000 Liter</td>
</tr>
<tr>
<td>Type of Filter</td>
<td>Pleated paper</td>
</tr>
<tr>
<td>Degree of Filtration</td>
<td>5 Micron</td>
</tr>
<tr>
<td>Lube Oil Grade</td>
<td>ISO VG-32</td>
</tr>
<tr>
<td>A. Lube Oil Reservoir</td>
<td>12492 Liter</td>
</tr>
<tr>
<td>B. Lube Oil Mist Separator Motor</td>
<td>15 KW</td>
</tr>
<tr>
<td>Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>Speed</td>
<td>3000 rpm</td>
</tr>
<tr>
<td>Phase, Freq.</td>
<td>03, 50Hz</td>
</tr>
<tr>
<td>Description</td>
<td>Data</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>C. Jacking Oil Pump Motor</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>11 KW</td>
</tr>
<tr>
<td>Volts</td>
<td>415</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Compressor Water wash Pump</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>CC 40 x 32-250</td>
</tr>
<tr>
<td>Head</td>
<td>7.7 m</td>
</tr>
<tr>
<td>Speed</td>
<td>2900</td>
</tr>
<tr>
<td>Discharge</td>
<td>16.38 M3/m</td>
</tr>
<tr>
<td>Made</td>
<td>Sulger, Pump, India</td>
</tr>
<tr>
<td>Motor</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>11 KW</td>
</tr>
<tr>
<td>Speed</td>
<td>2890 rpm</td>
</tr>
<tr>
<td>Made</td>
<td>KIRLOSKAR, India</td>
</tr>
<tr>
<td>Atomizing Air Booster Comp.</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Motor Driven Cyclo- Blower</td>
</tr>
<tr>
<td>Model</td>
<td>351A9239P003</td>
</tr>
<tr>
<td>Speed</td>
<td>4000 Rpm</td>
</tr>
<tr>
<td>Made in</td>
<td>GARDNER DENVER, USA</td>
</tr>
<tr>
<td>Cooling Water Module</td>
<td></td>
</tr>
<tr>
<td>Motor Capacity</td>
<td>15 Kw</td>
</tr>
<tr>
<td>Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>Made in</td>
<td>India</td>
</tr>
<tr>
<td>Fan</td>
<td></td>
</tr>
<tr>
<td>Fan Dia</td>
<td>9 feet</td>
</tr>
<tr>
<td>Speed</td>
<td>368rpm</td>
</tr>
<tr>
<td>No. of Blade</td>
<td>4</td>
</tr>
<tr>
<td>Quantity</td>
<td>6</td>
</tr>
<tr>
<td>Cooling Air Fan Motor (Turbine Compartment)</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>55 KW</td>
</tr>
<tr>
<td>Voltage</td>
<td>415</td>
</tr>
<tr>
<td>Speed</td>
<td>1500 rpm</td>
</tr>
<tr>
<td>Turning Gear (AC)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Worm Gear</td>
</tr>
<tr>
<td>Model</td>
<td>DSMBM 170-54</td>
</tr>
<tr>
<td>Ratio</td>
<td>238.9</td>
</tr>
<tr>
<td>Turning Gear (DC)</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Worm Gear</td>
</tr>
<tr>
<td>Model</td>
<td>VM 35-57</td>
</tr>
<tr>
<td>Ratio</td>
<td>30</td>
</tr>
<tr>
<td>Cooling Water Module</td>
<td></td>
</tr>
<tr>
<td>Design Pressure</td>
<td>7 Kg/ cm2</td>
</tr>
<tr>
<td>Operating Fluid</td>
<td>DM water</td>
</tr>
<tr>
<td>Dyty /Surface</td>
<td>2633 m2</td>
</tr>
<tr>
<td>Full nof Water</td>
<td>8292 Kg</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>VHELL, INDIA</td>
</tr>
<tr>
<td>Cooling Water Pump</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>7E 100-2200</td>
</tr>
<tr>
<td>Head</td>
<td>45 M</td>
</tr>
<tr>
<td>Motor Capacity</td>
<td>22.59 KW</td>
</tr>
<tr>
<td>Pump Made in</td>
<td>Sulger India</td>
</tr>
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</table>
### Air Intake System for Turbine

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>140 m3/hr</td>
</tr>
<tr>
<td><strong>Air Intake System for Turbine</strong></td>
<td></td>
</tr>
<tr>
<td>Material of Intake Duct</td>
<td>Carbon Steel</td>
</tr>
<tr>
<td>Type of air Filter</td>
<td>Self Cleaning (5 micron)</td>
</tr>
<tr>
<td>Material of filter medium</td>
<td>Synthetic - Cellulose fiber</td>
</tr>
<tr>
<td>Max. Intake Velocity</td>
<td>1 M/ Min.</td>
</tr>
<tr>
<td>Amount of Air required for GT at ISO</td>
<td>1,13000 m3/hr</td>
</tr>
<tr>
<td>Type of Silencer</td>
<td>Baffle</td>
</tr>
<tr>
<td>Material of Absorber</td>
<td>Mineral Wool.</td>
</tr>
<tr>
<td>Total Air Flow throw air Filter</td>
<td>7,71,100 ft³/min</td>
</tr>
<tr>
<td>Maximum pressure loss</td>
<td>89 mm H2O Column</td>
</tr>
</tbody>
</table>

### Inlet Air Filter

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Donalson Company, Inc, USA</td>
</tr>
<tr>
<td>Model No</td>
<td>OSM-AD</td>
</tr>
<tr>
<td>Filter P/N</td>
<td>P19-1033/P19-1107</td>
</tr>
</tbody>
</table>

### 4.5 Existing Gas Booster Compressors Description:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Gas Booster No A</th>
<th>Gas Booster No B</th>
<th>Gas Booster No C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installed Capacity</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
</tr>
<tr>
<td>2</td>
<td>Ambient Air Temperature</td>
<td>+4 ..... +42 °C</td>
<td>+4 ..... +42 °C</td>
<td>+4 ..... +42 °C</td>
</tr>
<tr>
<td>3</td>
<td>Relative Humidity</td>
<td>80% (Av.)</td>
<td>80% (Av.)</td>
<td>80% (Av.)</td>
</tr>
<tr>
<td>4</td>
<td>Ambient Air Pressure</td>
<td>1.013 mbar(g)</td>
<td>1.013 mbar(g)</td>
<td>1.013 mbar(g)</td>
</tr>
<tr>
<td>5</td>
<td>Minimum Inlet Pressure</td>
<td>10.34 bar(g)</td>
<td>10.34 bar(g)</td>
<td>10.34 bar(g)</td>
</tr>
<tr>
<td>6</td>
<td>Maximum Inlet Pressure</td>
<td>15.00 bar(g)</td>
<td>15.00 bar(g)</td>
<td>15.00 bar(g)</td>
</tr>
<tr>
<td>7</td>
<td>Minimum Gas Temperature</td>
<td>20 °C</td>
<td>20 °C</td>
<td>20 °C</td>
</tr>
<tr>
<td>8</td>
<td>Maximum Gas Temperature</td>
<td>35 °C</td>
<td>35 °C</td>
<td>35 °C</td>
</tr>
<tr>
<td>9</td>
<td>Maximum Volume Flow</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
<td>45,000 Nm³/Hour</td>
</tr>
<tr>
<td>10</td>
<td>Minimum Volume Flow</td>
<td>40,000 Nm³/Hour</td>
<td>40,000 Nm³/Hour</td>
<td>40,000 Nm³/Hour</td>
</tr>
<tr>
<td>11</td>
<td>Outlet/Service Pressure</td>
<td>25.50 bar(g)</td>
<td>25.50 bar(g)</td>
<td>25.50 bar(g)</td>
</tr>
<tr>
<td>12</td>
<td>Outlet/Service Temperature</td>
<td>52 °C</td>
<td>52 °C</td>
<td>52 °C</td>
</tr>
<tr>
<td>13</td>
<td>Motor Rated Capacity</td>
<td>2,200 KW</td>
<td>2,200 KW</td>
<td>2,200 KW</td>
</tr>
<tr>
<td>14</td>
<td>Name of the Manufacturer</td>
<td>MAN TURBO, GERMANY.</td>
<td>MAN TURBO, GERMANY.</td>
<td>MAN TURBO, GERMANY.</td>
</tr>
<tr>
<td>16</td>
<td>Total running hours since install (Upto December 2010)</td>
<td>2,593.63 Hours</td>
<td>2,537.21 Hours</td>
<td>1,184.20 Hours</td>
</tr>
<tr>
<td>Sl. No</td>
<td>Description</td>
<td>Gas Booster No A</td>
<td>Gas Booster No B</td>
<td>Gas Booster No C</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>17</td>
<td>First Running</td>
<td>01/03/2004, 14:57</td>
<td>01/03/2004, 15:15</td>
<td>06/03/2004, 09:25</td>
</tr>
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</table>

**Existing Diesel Engine Description (3 MW)**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>SACM Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>France</td>
</tr>
<tr>
<td>Capacity</td>
<td>3 MW</td>
</tr>
<tr>
<td>Year of Manufacturer</td>
<td>1990</td>
</tr>
<tr>
<td>Voltage</td>
<td>6.6 KV</td>
</tr>
<tr>
<td>RPM</td>
<td>1500</td>
</tr>
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</table>

**Existing Diesel Engine Description (125 KW)**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Alsthom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>France</td>
</tr>
<tr>
<td>Capacity</td>
<td>125 KW</td>
</tr>
<tr>
<td>Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>RPM</td>
<td>1500</td>
</tr>
</tbody>
</table>

**Existing DC 125 V Description**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>AMARAJA, INDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>125 V</td>
</tr>
<tr>
<td>No of Cell</td>
<td>64</td>
</tr>
<tr>
<td>Description</td>
<td>Maintenance free lead acid battery</td>
</tr>
<tr>
<td>Output</td>
<td>995 AH</td>
</tr>
</tbody>
</table>
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

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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

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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

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5.3 Special Tools and Spare Sprats
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single – Stage: Two-Envelope
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 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.

k. Instrumentation, control and monitoring equipments according to requirements in Vol 2, section 11

l. Emission monitoring system for By pass stack and main stack in line with local environmental laws

m. HRSG Water and Steam Sampling accordance with the applicable standards

#### 5.1.2 Steam Conditions

The steam conditions shall be determined by the Bidder and be clearly indicated
in the "GUARANTEE SCHEDULE" and "BIDDER'S DATA SHEET" (Vol. 3 of 3).

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 extended 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 Bidder 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 "BIDDER'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 Steam Temperature Control

Steam temperature at the superheater outlet shall be automatically controlled to $+10^\circ\text{C}$ with adequate cooling method such as feedwater spray.

The Bidder 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 Bidder.

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

The forced 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 Bidder 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 Bidder. All necessary chemicals for the process shall be recommended and provided by the Bidder.

5.1.9 Steam Purging

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

The Bidder shall provide details of connections for temporary steam purge pipework and valves, which shall be provided by the Bidder and which include suitable blanks for the protection of the turbo-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/ LP super heater
- Complete Lot of heat transfer surfaces for the HP/ LP evaporator
- Complete Lot of heat transfer surfaces for the HP/ 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 Bidder.

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 Bidder 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 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 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**

Level Measurement of boiler drum shall be in line with ASME Boiler code.

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 of 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.

Three water level transmitters, two at one side and rest on the at other side of the
drum for remote level indication and control purposes, shall be provided by the Bidder.

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

(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 reality 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 sapling nozzle shall be installed at the inlet and outlet to the superheater. Steam sampling especially between the drum and super-heater 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.

Please refer to Vol2, Section 11 for technical requirement on sampling system.

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 Bidder 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 Bidder 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 Bidder 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 doors 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 fixing 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 Bidder shall in this Tender thickness of each layer of heat insulating material to be applied to the various parts of the unit.

The Bidder 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 pipe works 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 Bidder shall furnish the following fittings, valves and mountings.

Pressure and temperature ratings of all items 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 starting 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 ± 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 shall be no danger personnel who may be in the vicinity of the outlets.

(2) **Feed Water 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) **Feed Water 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 Bidder shall provide one motorised valve with motorised by pass valve at the inlet. For the 25% duty feedwater regulator, the Bidder 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 Bidder.

(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 siphon breaker.

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 Bidder 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

The Bidder 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 Bidder 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 Pipe work

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 Bidder. The Bidder 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 Shiite 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 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 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 Bidder.

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. Eyebolts 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 are 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 400 volt 50 Hz supply.

5.2.11 Instrumentation and Control

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

Control of the steam generators and associated auxiliary plant shall be from DCS.

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 HMI in the central control room.

Stress evaluation and Lifetime expenditure of HRSG shall be provided. If not integral part of DCS, this system must also be interfaced with the Plant DCS in 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 Bidder 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 he 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.

For Instrumentation and control requirements refer Vol 2, Section 11

5.2.11.1 HRSG controls

The basic HRSG control loops are stated below. The bidder is responsible for ensuring all necessary signals, control philosophies, equipment, etc. that are required to provide a complete operational system are provided.

The HRSG systems shall allow operation of the HRSG in all automatic control modes between full range of thermodynamic output of GTs.

• Superheater steam temperature control
• Drum level control
• Feed water flow control
• HRSG safety system (As applicable)
• HRSG thermal stress monitoring
• HRSG drains

During start-up, the rate of change of drum pressure/temperature and HRSG stress shall be monitored. The starting sequence shall take these values into account to achieve minimum run up and loading times consistent with preset thermal stress limits.

During and subsequent to all the Plant operating modes including Plant trips, the drum levels shall be maintained at their desired settings.

The water level in the HRSG drum shall be controlled by a feed water control valves capable of maintaining the water level at a safe distance above the entry to any down coming tubes, under any condition of design load change.

The superheated steam temperature control shall be achieved by feed water injection into the superheated steam between first and final stage of superheating.

A temperature closed loop control comprising of either a cascade control or a two (2) loops control shall be provided.

To improve the control loop accuracy the steam flow shall be used as a feed forward signal.

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 shall be 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 Diverter Damper

Diverter damper can be either DCS controlled or Black Box system. It shall have signal exchange with the GT control system.

In case of black box controlled system, it shall be interfaced with main plant DCS in CCR. Diverter damper shall also be interfaced with plant protection system an emergency shut down system.

The diverter at the exhaust stack/boiler inlet shall be operated automatically for emergency reasons, and manually from the central control room with continuous position indication.

HRSG shall be shut down on the exhaust side by switching the exhaust gas diverter damper from HRSG operation to gas turbine operation using the bypass-stack.

The time taken (duration) to empty the drum from its low level trip shall be minimum twice time taken by diverter damper to close on its fast closing sequence to prevent HRSG surface overheating resulting from drying up.

A shaft-mounted position indicator shall be included which is clearly visible. Damper shaft drives shall be capable of transmitting at least 110% of the maximum motor torque.

The maximum blade travel in both directions shall be controlled by limit switches. The mounting brackets of the limit switches shall be adjustable so as to allow the optimum closing positions of the damper blade to be set. All switches indicating the position shall be of the proximity type.

In case of any failure the damper shall traverse to a safe position.

All necessary instrumentation like limit switches, positioners etc shall be provided.

5.2.13 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.

5.2.12 Off - load Cleaning Equipment

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

5.2.13 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 Bidder 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 Bidder 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.

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

5.3 **Special Tools and Spare Parts.**

Two complete sets of all special spanners and tools necessary for maintaining the whole of the steam generator plant, 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
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant
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
6.2.15 Instrumentation and Control
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LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
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 Bidder shall state limitations, if any, as to frequency, load, or duration for this mode or 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 and also ESD. 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 full closure while the turbine is on load. The Bidder 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 Bidder 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 Bidder 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.

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 this 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 Bidder shall provide the following minimum supervisory measurements. The Bidder 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. Emergency stop and Control valves position
i. Turbine main steam valves position.
j. Absoloute as well as relative shaft vibration measurement, of each bearing in both X-Y direction
k. Axial shaft of rotor
l. Turbine speed
m. Main steam inlet and outlet pressure

All measurements shall include local indication and provision for plugging in portable recorders on the turbine supervisory panel and outputs suitable for remote indication and data logging which are to be provided in the central control room.
A dedicated event recorder shall be provided for dedicated measurements for diagnostic purposes. The scan time of inputs should be less than 10ms. The system shall be independent of the Turbine Control System. The event recording shall have archiving and backup facility with the software to analyse and trend the live as well as historic data.

The lubricating oil level in the main storage tank shall be supervised by two level switches 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 Bidder 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 Bidder 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 provided. 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.

Four speed sensors including one spare speed sensor shall be provided for speed measurement. In case of working speed sensor failure, the spare sensor shall be utilized immediately for vital signal of speed/ frequency. The three (3) probes shall be used for over speed protection system and for steam turbine controller. All the three (3) speed probes and channels shall be continuously supervised and any fault shall be alarmed and the faulty signal shall be excluded from the protection logic/selection gate. High deviation between the signals shall also be supervised and shall be alarmed. High-high deviation shall be considered as a fault and the faulty signal shall be excluded with an alarm message.

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 Turbine stress evaluator system shall monitor and control the thermal stress of the steam turbine during auto run-up. The system shall determine the loading rate under rolling and loading conditions respectively so the stressed do not exceed the predetermined limits. Appropriate indications and alarms shall be provided in the DCS.

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 Bidder 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 provided 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 indicating 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 Bidder 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 earthing 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 5 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 Bidder 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 prevent 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 Bidder shall put forward in his proposal a recommended scheme for automatic traps with the appropriate instrumentation.
6.2.15 Instrumentation and Control

All necessary control, monitoring, interlocking and protecting functions shall be in accordance to Vol 2, Section 11.

Steam turbine shall have its own proven control and protection systems as hardware and software. The control system shall include all necessary control functions such as governor control, start-up/shut-down sequence control, etc.

A sufficient number of field instrumentation and local/remote indicators shall be provided to secure a reliable and safe operation, monitoring and protection of the ST and its auxiliaries. Wherever possible, field signal junction boxes, local indicators and transmitters shall be mounted in groups to allow easy operation, monitoring and maintenance.

All the necessary operations for turbine start-up and shut down together with operation of its associated auxiliaries shall be carried out automatically. It shall also be possible to start and stop the Steam Turbine by manual operation from CCR or locally.

Both the start-up and shut-down procedures and normal operation shall be initiated and supervised continuously from the operator stations of the DCS within the CCR.

The regulation equipment supplied shall successfully control rapid changes in load. Operation in the frequency support mode, constant electrical power output mode and speed control mode shall be possible.

The exhaust pressure shall be controlled for all these conditions or modes of operation.

The protection system shall protect the ST in every phase of operation from overload and damage. It shall be continually ready for operation and capable of being checked even during operation and shall not be capable of being switched off even accidentally.

The protection system of the ST shall be provided in a fail-safe, fault tolerant design. It shall be configured in triple redundant protection channels with the 2 out of 3 voting concept

**Major Steam Turbine Controls**

b. Steam Turbine Governor Controls (EHGC)

c. Turbine Bypass control

d. Turbine Stress Evaluator and Lifetime Counter (TSE)

e. Automatic Turbine Run System

f. Automatic Turbine Testing

g. Turbine supervisory Instrumentation

h. Turbine protection system (based on 2oo3 voting)
Interfacing with DCS

The interfacing for non-time critical signals shall be via redundant serial link and for time critical signals (operator commands, command check-back signals, protection signals, etc.) hardwired signals shall be provided, however, protection signals shall be triple redundant hard-wired.

The Human Machine Interface (HMI) for steam turbine shall also be provided in the Central Control Room (CCR).

6.2.16 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 machine, 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 quality.

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 river 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 Bidder in 'BIDDER’S DATA SHEET’ shall be obtainable with a condenser cleanliness factor of 0.8 with circulation water inlet temperature of 28°C and with heat duty as established for the turbo generator at guaranteed gross output in accordance with specified parameters as stated in "BIDDER’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 Bidder 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.

Condenser hot-well level measurement shall be provided.

The hotwell outlet to the condensate pump suction shall be arranged to avoid dead define 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 Bidder shall supply 3 (three) 60% 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 capacity of each condensate pump shall be 60% of the condensate flow at maximum output. 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 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 Bidder 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 additional the time allowed for raising vacuum shall be determined by the hot start up time specified by the Bidder.

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 Bidder 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 blowdown operations to be carried out when the turbo-generator unit is at full load.
6.3.5 De-aerator and Auxiliaries

The Bidder 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 de-aerator 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 Bidder 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 liners.

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

The Bidder may propose an alternative means to the de-aerator.

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 electrical conduits and piping furnished by the Bidder, such as bearing oil, gland steam, drains, etc. The Bidder 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 maximum steam generator super heater safety valve blow off pressure and temperature.

To enable regular creep measurements to be made under service conditions the Bidder 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 otherwise 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 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 form 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 spindles 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 Bidder.

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.

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 Bidder shall give a full list in "BIDDER'S DATA" valves fitted with extended
spindles, indicators shall be fitted both to the extended spindle.
Valves shall not be 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 Bidder 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 exceed 70°C. All lagging material shall be asbestos free.

All lagging on de-aerator, 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.
6.6 WATER TREATMENT & DE-MINERALIZATION 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 Bidder is mandatory for detailed design of Water Treatment Plant.

Demineralisation is the 3rd step of this process. There are two basic steps of demineralisation system: roughing demineralisation and polishing demineralisation. Roughing removes a bulk of mineral contamination including desalination 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. Rough polish water or desalinated water will be used for cooling water make up and other industrial purpose. After passing through active carbon filters this water will also used for further polishing for demineralised water and may be used for potable water system.

The demineralizer shall be sized to handle the steam cycle make-up. The dimineralizer 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.

For the water treatment & Demi Water system, the equipment to be included but not limited to the following:

**Intake Water Pump House:**

Clarifier: 2 Units
Multimedia Pressure filter
Active Carbon filter
Sand filters
Filtered water reservoir: 500 M³
Micro filter
Single bed Cation-exchange filter
Single bed ion-exchange filter
De-salined water reservoir: 500 M³
De-Carbonizer
Mixed Bed polishers

RO (Reverse Osmosis) Plant

Demineralization Plant: storage tank (3000 ton capacity), 1 degasser unit, 1 single bed anion exchange, 1 mixed bed unit, semi demin and demin, water reservoirs including its all necessary pumps, equipment, instrumentations, automation, accessories/auxiliaries and all other relevant work, etc.

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 and Demi water Tank capacity shall be for 72 hrs continuous operation (full load) of Steam Turbine.

**Potable Water system**

Extension of the existing potable water system to the new plant area and other extension area should be included with the Tender.
Section 7

Generator and Ancillary Equipment
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan          December, 2016          Single - Stage: Two- Envelope
7.  Generator and Ancillary Equipment

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7.1.1  Steam Turbine Generator - General Requirements

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 (AVR)

7.3  Neutral Grounding Cubicle

7.4  Isolated / Insulated Phase Bus Duct (IPBD)

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7.5.1  General

7.5.2  Type and Rating

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7.5.4  Circuit Breaker

7.5.5  Current Transformer
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7.5.7 Surge Absorbing Equipment
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7.4 6.6 kV Proposed Switchgear

7.4.1 General
7.4.2 Type and Rating
7.4.3 Construction and Fittings
7.4.4 Circuit Breaker
7.4.5 Composition of Cubicles
7. **GENERATOR AND ANCILLARY EQUIPMENT**

7.1 **GENERATOR**

7.1.0 **EXISTING GAS TURBINE GENERATOR**

The Plant is now equipped with 100 MW Generator with GE- PG9171E Machine.

Details Description of Existing Gas Turbine Generator is given below:

<table>
<thead>
<tr>
<th>GENERATOR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>TARI 1080 -36F</td>
</tr>
<tr>
<td>Drive</td>
<td>Gas Turbine</td>
</tr>
<tr>
<td>KVA</td>
<td>134250</td>
</tr>
<tr>
<td>Volts</td>
<td>11000</td>
</tr>
<tr>
<td>KW</td>
<td>107400</td>
</tr>
<tr>
<td>P.F Log</td>
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<tr>
<td>Frequency</td>
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</tr>
<tr>
<td>Rpm</td>
<td>3000</td>
</tr>
<tr>
<td>Phase</td>
<td>3</td>
</tr>
<tr>
<td>Connection</td>
<td>Y</td>
</tr>
<tr>
<td>Volts(Stator)</td>
<td>11000</td>
</tr>
<tr>
<td>Volts(Rotor)</td>
<td>350</td>
</tr>
<tr>
<td>Amps (Rotor)</td>
<td>811</td>
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<tr>
<td>Cooling</td>
<td>Open Air</td>
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<tr>
<td>Duty Cycle</td>
<td>Continuous</td>
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<tr>
<td>Altitude</td>
<td>&lt; 1000 m.</td>
</tr>
<tr>
<td>Winding Insulation Class</td>
<td>Class F</td>
</tr>
<tr>
<td>Protection</td>
<td>IP-54</td>
</tr>
<tr>
<td>Year</td>
<td>2001</td>
</tr>
</tbody>
</table>

7.1.1 **Steam Turbine Generator:**

**General Requirements**

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

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 : Generator for ST unit having capacity of 70 MVA (approx.) To match steam turbine peak output/MCR of ST at any ambient temperature

b. Power factor : 0.80 (lagging)

c. Frequency : 50 Hz ±5% Continuous (For ST)

d. Rated rotating speed : 3000 rpm

e. Rated voltage : 11 kV

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 47.5 to 52.5 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. 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 according to 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>at Base</th>
<th>at Peak / MCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Stator winding by resistance temperature detectors method</td>
<td>95°C</td>
<td>100°C</td>
</tr>
<tr>
<td>b. Field winding by resistance method</td>
<td>100°C</td>
<td>105°C</td>
</tr>
<tr>
<td>c. Cores and mechanical parts in contact with or adjacent to insulated winding by thermometer</td>
<td>95°C</td>
<td>100°C</td>
</tr>
<tr>
<td>d. Bearing when measured on the surface</td>
<td>40°C</td>
<td>40°C</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, but temperature rise shall be limited to class B.

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 11 kV generator switchgear & Generator Switchgear and Generator Step Up transformers shall be of copper 11 kV 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 Bidder 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 Bidder.

7.1.10 Temperature Detectors

Total 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 : 6 (six)
   - spare : 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 shall 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.

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 preset level in a response time of less than 50 milliseconds. The accuracy of controlling the AVR shall maintain the generator terminal voltage within plus 1 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 Neutral Grounding Cubicle

One (1) no. Generator Neutral Grounding (N.G.) cubicle containing disconnect link, neutral grounding transformer, loading resistors and current transformers.

(1) Neutral Earthing Transformer

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

The voltage ratio of transformer shall be 11,000/ 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 Bidder.

Insulation level of primary winding shall be of BIL 75 KV.

(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.

The transient over voltage on un-faulted phase during line to ground fault is to be kept minimum by selecting the value of secondary loading resistor so that, the resistive losses during line to ground fault is equal to or more than capacitive KVA to ground. For determining capacitive KVA to ground, capacitances of Generator, Generator Bus Duct, Generator Step-up Transformer and, surge capacitor are to be considered.

7.4 Isolated / Insulated Phase Bus Duct (IPBD)

7.4.1 General

The IPBD will serve as interconnection between the Generator and its associated Generator Transformer.

Following accessories shall be provided,

i. All supporting steel structures, fasteners and necessary hardware for complete Bus Duct, 11kV Switchgear & NG cubicle installation.

ii. One (1) set of bus bar shorting pieces with all nuts, bolts and special washers for heat run/short circuit/stability tests.

iii. One set of hot air blowing equipment.

iv. Silica Gel Breathers for Bus ducts.

v. Maintenance tools and tackles

Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.

For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be limited to the site permissible values stipulated in relevant standards and/or this specification. The maximum allowable temperature at 45 deg C ambient, under maximum continuous load operation shall be limited to:

i. Main Conductor Temp: 90°C end Temp
ii. Bus Connections for silver plated joints: 105°C end Temp

iii. Bus Enclosures & support enclosure: 70°C

The bus ducts shall be natural air cooled type and shall not be equipped with blower or any other type of forced ventilation.

Wall frame assembly for IPB if required and floor frame assembly for IPB tapping wherever it penetrates the floor shall be provided.

Required supporting galvanized steel structures and necessary hardware need to be provided.

Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the short-circuit currents without any damage or deterioration of material.

For generator bus duct adapter box of aluminium sheets with seal-off bushing near Generator ends (both Phase and Neutral) and wherever required shall be provided. All contact surfaces shall be silver-plated to ensure an efficient and trouble free connection.

7.4.2 Sizing of Equipment

Equipment sizing shall be carried out by the successful bidder as per following criteria.

i. For calculating the continuous rating it is to be considered that the Generator is loaded to 105% of rated MVA with rated p.f. with 95% of the rated voltage at its terminal and rounded off to the next Standard rating. The generator bus duct shall be such that the continuous rating can be delivered at site ambient conditions without exceeding the allowable temperatures rise considering site ambient and duly considering the effect of solar radiation.

ii. For calculating the short time rating the following are to be considered:

System fault level : Minimum 63kA, 3 Sec at 11kV.
System voltage : 110% of 11kV.

Negative tolerance on Generator sub-transient reactance shall be considered as per Generator data sheet.

While deriving short time rating, 3-phase solid fault is to be considered.

The bus duct shall be designed for the higher value of the fault current to be contributed by the Generator or 132kV system plus the contribution from unit auxiliary motors through Unit Auxiliary Transformer.

7.4.3 Type And Rating

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service</td>
<td>Indoor / Outdoor</td>
</tr>
<tr>
<td>Particulars</td>
<td>Specified</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cooling System</td>
<td>Air Natural</td>
</tr>
<tr>
<td>System Nominal Voltage</td>
<td>To match with Generation Voltage ± 5%</td>
</tr>
<tr>
<td>System Maximum Voltage</td>
<td>To be approved by the Owner</td>
</tr>
<tr>
<td>Continuous Current Rating</td>
<td>Shall be as per calculation. Bidder to furnish.</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz ±5%</td>
</tr>
<tr>
<td>Short Circuit Current Rating for 3 Sec withstand</td>
<td></td>
</tr>
<tr>
<td>a) Main Run</td>
<td>Shall be as per approved system study report.</td>
</tr>
<tr>
<td>b) Tap-off</td>
<td>Shall be as per approved system study report.</td>
</tr>
<tr>
<td>Short Circuit Current (Peak)</td>
<td>As per approved system study report</td>
</tr>
<tr>
<td>Insulation Level</td>
<td></td>
</tr>
<tr>
<td>a) 1-Min. Dry Power Frequency Withstand</td>
<td>To be decided as per selected Generator voltage level</td>
</tr>
<tr>
<td>b) 10-Sec. Wet Power Frequency Withstand.</td>
<td>To be decided as per selected Generator voltage level</td>
</tr>
<tr>
<td>c) Impulse Withstand</td>
<td>To be decided as per selected Generator voltage level</td>
</tr>
<tr>
<td>Service Voltage</td>
<td></td>
</tr>
<tr>
<td>a) Hot Air Blowing</td>
<td>400V ± 10%, 3ph., 50 Hz ± 5%, 4 wire</td>
</tr>
<tr>
<td>b) Space Heating, Cubicle Lighting etc.</td>
<td>230V ± 10%, 1ph. 50 Hz, ± 5%, 2 wire</td>
</tr>
<tr>
<td>Degree of Protection</td>
<td>IP 54(Indoor) / IP 55 (Outdoor)</td>
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<tr>
<td>1 min Dry Power Frequency Withstand Voltage of Auxiliary Circuit</td>
<td>3 kV (rms)</td>
</tr>
<tr>
<td>Material of Busbar</td>
<td>Copper</td>
</tr>
<tr>
<td>Shape</td>
<td>Rectangular / Circular Bar</td>
</tr>
<tr>
<td>Type of Joints</td>
<td>Bolted/Welded</td>
</tr>
<tr>
<td>Material of Insulator</td>
<td>Porcelain</td>
</tr>
<tr>
<td>Paint Shade</td>
<td>RAL7035</td>
</tr>
</tbody>
</table>

7.4.4 Construction and Fittings

Each phase shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminium alloy) enclosure. The enclosure shall be minimum flux type to permit not more than five (5) per cent of total conductor flux outside enclosure.
The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion/contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

Inspection opening/split covers shall be provided to allow easy access for installation, inspection, replacement or repairs of the insulators, disconnects, bus connections and terminations. The inspection/split covers shall have reliable sealing arrangements with neoprene/rubber gaskets in grooves.

Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent exchange of air between indoor and outdoor portions of the bus duct.

Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct.

Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.

Space heaters shall also be provided.

### 7.5 11 KV GENERATOR SWITCHGEAR

**Existing 11 KV Generator Circuit Breaker of 100 MW GT Unit:**

Bidder have to renovate/modify/overhaul existing 11 KV CB(s), CT(s), PT(s) and capable them to handle for full capacity.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>ALSTOM, France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of manufacture</td>
<td>2001</td>
</tr>
<tr>
<td>Rated Max. Voltage</td>
<td>12 KV</td>
</tr>
<tr>
<td>Rated Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Rated Continous Current at 35C</td>
<td>10 KA</td>
</tr>
<tr>
<td>Type</td>
<td>SF₆ Gas,</td>
</tr>
<tr>
<td>Pressure</td>
<td>7.5 Bar</td>
</tr>
<tr>
<td>Rated full-wave impulse with standard voltage</td>
<td>125 KV</td>
</tr>
<tr>
<td>Rated Short Circuit duty cycle</td>
<td>CO-30 min-CO</td>
</tr>
<tr>
<td>Rated Short Circuit Current symmetric</td>
<td>100KA</td>
</tr>
<tr>
<td>Max. asymmetrical short circuit peak</td>
<td>274 KA</td>
</tr>
<tr>
<td>Short Time Current</td>
<td>100 KA, 1s</td>
</tr>
</tbody>
</table>
7.5.1 **General**

The generator circuit breaker for Steam Turbine Unit shall be provided, and it shall be accommodated in metal clad switchgear cubicle arranged for local and remote control.

The switchgear and the associated equipment shall be fully metal clad and shall comprise:

- Switchgear bus bar
- Voltage transformers
- Current transformers
- Surge protective equipment
- Generator circuit breaker (drawout type)
- Circuit Breaker for station transformers
- Cable termination facilities for 15 KV or 11 KV circuit
- Secondary wiring including cable termination facilities
- Earthing facilities.

7.5.2 **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.

   IEC 298   AC metal-enclosed switchgear
   IEC 85    Insulating materials
   IEC 51    Electrical indicating instruments

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

   System highest voltage : 12 KV
   Withstand voltage
   Lighting (impulse) : 75 KV (peak)
   (11.2/50micro sec.)
   Power Frequency (rms.) : 28 KV
(For 1 mm.)

3) The rated service voltage shall be of 11 KV

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 Bidder.

(5) The short time three phase fault level rating for three second of the switchgear shall be of 63 KA (rms) for ST. The Bidder shall check the system fault current level.

7.5.3 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, 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.

7.5.4 Circuit Breaker

ST Generator unit Circuit Breaker shall be of SF₆ gas and other Circuit Breaker(s) shall be of SF₆ gas or vacuum type. Circuit Breakers shall be draw out type.

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

- Rated Voltage: 11 KV
- Rated Current: As per IEC Standard and not less than generator
- Interrupting Current: Minimum 63 KA for (rms), 3 Sec.

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.

7.5.5 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: 0.2, Protection: X/5P30) of current transformers shall conform to IEC185 or IEC 60044-1.

7.5.6 Voltage Transformer

The voltage transformers shall be of the horizontally with draw-out type and shall be located at bottom parts of each unit switchgear for easy maintenance. 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.

7.5.7 Surge Absorbing Equipment

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

The configuration of this Switchgear has been envisaged as follows:

a. Incoming Cubicle
   - Generator Circuit breaker : One (1) X KA, 63 KA (rms)
   - Current transformer : Three (3) units XXXX/ 5A, 40 VA,
   - Voltage transformer : One three phase unit
   - End terminal : One (1) lot
   - Ammeter (with selector switch) : One (1) set
   - Voltmeter (with selector switch) : One (1) set
   - Protective relays : One (1) set
   - Control switch, etc. : One (1) lot
   - Lightning Arrester : One (1) lot
   along with Surge Capacitor
   - Earth switch at Generator side : One (1) lot

b. Voltage Transformer cubicle
   - Voltage Transformer : One (1) three phase unit
   - Under Voltage Relay wi : One (1) lot
   - Voltmeter (with selector switch) : One (1) set

c. Cubicle for Generator Step Up Transformer
   - Current Transformer (for Protection) : One (1) lot

d. Cubicle for Unit Auxiliary Transformer Feeder
   - Circuit breaker : One (1) X KA, 63 KA (rms)
   - Current transformer (Protection & Metering for H.V side of Unit Auxiliary Transformer) : Three (3) units XXXX/ 5A, 40 VA,
   - Earth Switch : One (1) lot
   - End terminal : One (1) lot
   - Ammeter (with selector switch) : One (1) set
- Protective relays : One (1) set
- Control switch, etc. : One (1) lot

Moreover, each Current Transformer shall have at least one spare core.

7.6 6.6 KV PROPOSED SWITCHGEAR

7.6.1 General

The proposed 6.6kV 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 transformer.
- Outgoing circuit breaker cubicle to station transformers.
- Voltage transformer cubicle.
- Outgoing circuit breaker cubicles to starting motor, DG set, GBC 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 Specification.

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

7.6.2 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) The Switchgear Busbar and associated connection shall have the insulation level as given below:

   System highest voltage : 7.2
   Withstand voltage
   Lighting (impulse) : 60 KV (peak)
   (11.2/50micro sec.)
   Power Frequency (rms.) : 22 KV
   (For 1 mm.)
3) The rated service voltage shall be of 6.6 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 Bidder.

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

7.6.3 Construction and Fittings

The 6.6 KV proposed switchgear shall be designed and constructed as same as those for 15 KV generator switchgear specified in Section 7.3.

7.6.4 Circuit Breaker

The circuit breaker shall be of SF₆ gas or vacuum type with draw out feature.

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
- Rated Current : 1250A
- Interrupting Current : Minimum 40 KA (rms), 3 Sec.

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.

7.6.5 Composition of Cubicles

(1) Incoming Circuit Breaker Cubicle for unit(s)

- Circuit breaker : One (1) for each feeder
  1250 A, 50 KA (rms)
- Current transformer (Protection and Metering for 6.6kV Incomer) : One (1) lot
  600/300- 5A, 40 VA
- End terminal : One (1) lot
- Ammeter : One (1) set
- Protective relays : One (1) set
- Control switch, etc. : One (1) lot
3) Voltage Transformer Cubicle
   - Voltage transformer : One (1) three phase unit
   - Under voltage relay : One (1) unit
   - Voltmeter with selector switch : One (1) lot
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
Section 8

Transformers
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement Plan: December, 2016

Single Stage: Two Envelope
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 Accessories
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan
December, 2016

Single - Stage: Two-Envelope
8. TRANSFORMERS

8.1 GENERAL

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

(1) Generator Step-up Transformer (GT #2)

Specification of Existing Gas Turbine Generator Step up Transformer: (Single Phase Transformer)

<table>
<thead>
<tr>
<th>Step up - Transformer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Single phase, outdoor type</td>
</tr>
<tr>
<td>Standard</td>
<td>IEC-76(To Indian 2026-1977)</td>
</tr>
<tr>
<td>Type of cooling</td>
<td>ONAF/ONAN</td>
</tr>
<tr>
<td>Rating H.V.(MVA) (ONAF/ONAN)</td>
<td>50.00/41.25</td>
</tr>
<tr>
<td>No load Voltage H.V.(kV)</td>
<td>132/√3</td>
</tr>
<tr>
<td>No load Voltage L.V.(kV)</td>
<td>11</td>
</tr>
<tr>
<td>Line Current (HV)(Amps)(ONAN/ONAF)</td>
<td>656.08/541.27</td>
</tr>
<tr>
<td>Line Current (LV)(Amps)(ONAN/ONAF)</td>
<td>4545.45/3750</td>
</tr>
<tr>
<td>Connection Symbol</td>
<td>YNd11 (In- three phase Bank)</td>
</tr>
<tr>
<td>Guaranteed Impedance at Normal Tap Voltage % HV – LV</td>
<td>16.5 ±10 % (at 50 MVA)</td>
</tr>
</tbody>
</table>

Bidder have to supply new 1(One) Lot (3 nos) single phase step-up transformer and 1(One) spare (Total 3+1= 4 nos) for power evacuation of existing GT no. 2. Single phase oil immersed self cooled/forced air cooled (ONAN/ONAF) outdoor use type for stepping up the voltage from 11 to 132 kV with OLTC having uniform insulation. The maximum continuous rating of the transformer (Three phase and Vector Group = Ynd11) shall be 120% (one hundred and twenty per cent) of the corresponding MVA (pf=0.8) of the Guaranteed Net Generator output at Site condition.

General Requirements for Steam Turbine Step –up Transformer:

Single phase oil immersed self cooled/forced air cooled (ONAN/ONAF) outdoor use type for stepping up the voltage from 11 to 132 kV with OLTC having uniform insulation. The maximum continuous rating of the transformer shall meet at any taps with the output of the Generator, which is connected with the transformer in series as shown enclosed Electrical Single Line Diagram. The maximum continuous rating of the transformer (Three phase and Vector Group = Ynd11) shall be 120% (one hundred and twenty per cent) of the corresponding MVA (pf=0.8) of the Guaranteed Net Generator output at Site condition of 35°C, 1.013 bar and 98% RH. Detailed specification is mentioned in clause [2.8.2] page 31, 32 of this volume.
The self cooled capacity shall not be less than 75% of forced air cooled capacity.

(2) **Station Transformer (#02 & #03)**

**Existing Gas Turbine Station Transformer:**

Bidder have to renovate/modify/overhaul existing Station Transformer and capable to handle for its full capacity

<table>
<thead>
<tr>
<th>Station Service Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>KVA/MVA</td>
</tr>
<tr>
<td>Volts at HV</td>
</tr>
<tr>
<td>Amps HV</td>
</tr>
<tr>
<td>Amps. LV</td>
</tr>
<tr>
<td>Phase HV/LV</td>
</tr>
<tr>
<td>Type of Cooling</td>
</tr>
</tbody>
</table>

**General Requirements for Steam Turbine Station Transformer**

Three phase, oil immersed type, self air cooled (ONAN) for stepping down the voltage from 6.6 kV to 415 V with off load tap changer. The capacity of each auxiliary transformer shall enable to supply 120% of the required power for the unit(s) 400 V system.

(3) **Unit Auxiliary Transformer #02**

**Existing Gas Turbine Unit Auxiliary Transformer:**

Bidder have to renovate/modify/overhaul existing Unit Aux. Transformer and capable to handle for its full capacity

<table>
<thead>
<tr>
<th>Unit Auxiliary Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection Symbol</td>
</tr>
<tr>
<td>MVA</td>
</tr>
<tr>
<td>Volts at HV</td>
</tr>
<tr>
<td>Amps. at HV Side</td>
</tr>
<tr>
<td>Amps. at LV Side</td>
</tr>
<tr>
<td>Phase HV/LV</td>
</tr>
<tr>
<td>Type of Cooling</td>
</tr>
</tbody>
</table>
General Requirements for Steam Turbine Unit Auxiliary Transformer

Three phase, oil immersed type, self air-cooled (ONAN) for stepping down the voltage from 11 kV to 6.6 kV with off circuit tap changer. The capacity of station transformer shall enable to supply start-up power, medium voltage loads and common station load for both GT & ST individually.

8.1.1 REQUIREMENT FOR CHARACTERISTICS

(1) Efficiency

The transformers shall be of highest efficiency that the Bidder 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 50°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. 132 kV CIRCUIT
   - lightning impulse withstand test voltage : 650 KV (peak)
     (1.2/ 50 micro sec.)
   - Power frequency test voltage : 275 kV for one minute.

b. 11kKV circuit
   - lightning impulse withstand test voltage : 75 KV (peak)
     (1.2/ 50 micro sec.)
   - Power frequency test voltage : 28 kV for one minute.

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
- lighting impulse withstand test voltage : Not applicable
  (1.2 I 50 micro sec.)
- Power frequency test voltage : 4.0 KV for one minute

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.
  c. The sealed joint part of the tank shall be designed to prevent oil and
     gas leakage and shall be water light 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 tile 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 $132\sqrt{3}$ 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 Bidder 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. 132 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 15 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.

- 132 KV line bushings : $650 \text{ kV}_{\text{peak}}$
- 132 KV line neutral bushing : $650 \text{ kV}_{\text{peak}}$
- 11 KV bushings : $75 \text{ kV}_{\text{peak}}$

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 400 V, 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 TRANSFORMERS

8.2.1 TYPE AND RATIO

The transformer shall be of single phase, oil immersed, self cooled / forced air cooled (ONAN/ONAF) by cooling fans, outdoor use type. Ratio of delta star connection shall be 11 KV to 132 KV on full load condition.

The connection of the single phase transformer shall be arranged in vector symbol Ynd11 (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:

132KV (+ 8 x 1.25% to -12x 1.25%)

8.2.2 OUTPUT AND REQUIRED NUMBERS

The maximum continuous rating of the transformer shall met at any taps a total output of the generator which is connected with the transformer in series as shown in the attached single line diagram (Annexure -23.1).

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

8.2.3 IMPEDENCE VOLTAGE

Impedance voltage (+ve Seq.) shall be within the range of 15% to 18% (including positive and negative tolerances) on the forced air cooled rating on the rated tapping (11 KV /132 KV ) and shall be guaranteed by the Bidder.

8.2.4 WINDING AND INSULATION

The full (uniform) insulation shall be applied on both 132 KV (phase & neutral) and
11 KV windings and neutral point of 132 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 132 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 **Termination Arrangement**

The connection between Generator terminal and Generator Switchgear & Generator Switchgear and Generator Step Up transformers shall be of 11 kV copper isolated (insulated) phase bus duct.

At 132 kV side, the transformer shall be suitable for connection of minimum 850 mm$^2$ hard drawn stranded ACSR conductor of suitable rating and subsequently connected to new 132kV Lightning Arresters. The conductors shall comply with the requirements of IEC.

Generator Switchgear shall also be connected to the high voltage terminals of Unit Auxiliary Transformer by 11kV cables.

8.2.7 **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 Inter-posing current transformers may be used.

1) **Use** : Protection

2) **Ratings**

   Rated primary current : 400 - 800 A
   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 UNIT AUXILIARY TRANSFORMER (ST)

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 11 kV to 6.9 kV.

The connection shall be arrangement in vector symbol Dyn11, 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,

11 kV (Tap: ± 5% @ 2.5%)/ 6.9 kV Output

8.3.2 OUTPUT

The Unit Auxiliary Transformer for ST unit shall be suitable to cater the starting/Running/Shut down loads for CCPP Configuration including 100% station loads. In addition to the above requirement, each transformer shall have minimum 20% spare margin over the total calculated load. However, the rating of the transformer shall be minimum 5MVA.

8.3.3 IMPEDENCE VOLTAGE

The impedance voltage shall not less than 5 %, but not more than 7.5 % (including positive and negative tolerances) on the rated tapping (6.9KV) and shall be guaranteed by the Bidder.

8.3.4 WINDING AND INSULATION

The requirements shall be in accordance with section 8.2.4 for HV side.

8.3.5 OFF LOAD TAP CHANGER

The off load tap changer shall be provided on 11 kV winding and shall be designed to meet the requirements of IEC 76. as follows.

- Central tap : 11kV
- 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 detachable type cable boxes shall be provided on both high tension and low tension sides to terminate Copper power cables. Proper cable supports and cable cleats shall also be provided.

8.4 STATION TRANSFORMERS (ST)

8.4.1 TYPE AND RATIO

The Station transformers shall be of 3 (three) phase, oil immersed type. Nominal no load ratio of delta star connection shall be 6.6/0.415 KV (ONAN).

The connection shall be arrangement in vector symbol Dyn11 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 6.6 kV (Tap: ± 5% @2.5%) /415V -240 V

8.4.2 Output

Each auxiliary transformer shall enable to supply 120% of required power on unit 415 V for the unit gas and steam turbine generating set.

8.4.3 IMPEDENCE VOLTAGE

The impedance voltage shall not less than 5%, but not more than 7.5% (including positive and negative tolerances) on the rated tapping (6.6 KV /415V) and shall be guaranteed by the Bidder.

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 off load tap changer shall be provided on 6.6kV 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.

8.4.6 CABLE BOX

The detachable type cable boxes shall be provided on high tension terminals to terminate XLPE insulated copper cables. Proper cable supports and cable cleats shall also be provided.

Non Segregated Phase Bus Duct (NSPBD) between 415V terminals of Station Service Transformer and 400V Switchgear terminals shall be provided.

8.5 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. Connecting bus ducts including flexible connectors among the single phase transformer to compose three phase bank (for Step-up transformer only).
o. Rail track in the transformer yard.
Section 9

132 kV Switchgear Equipment
9. **132 kV OUTDOOR SWITCHGEAR, EQUIPMENT**

9.1 **General**

9.1.1 Design Requirement

9.2 **132 kV Switchgear, Equipment**

9.2.1 132 kV Circuit Breakers
9.2.2 132 kV Disconnecting switches
9.2.3 132 kV Voltage Transformer
9.2.4 132 kV Current transformer
9.2.5 132 kV Lightning Arresters
9.2.6 132 kV Outdoor type cable termination end

9.3 **Steel Structure**

9.3.1 Type

9.3.2 Design Criteria

9.3.3 Requirements 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 Fittings
9.4.3 Standard Conductor for Over Head Line
9.4.4 Miscellaneous Material
9. **132 kV OUTDOOR SWITCHGEAR, EQUIPMENT**

At present existing 100 MW Gas Turbine Unit is connected to 132 KV Bay of Baghabari Grid. For combined cycle Unit extra outgoing bay (Dia #8) is present for power transmission. Construction of new bay is not under scope of the Bidder. However, renovation of existing 132kV system of Dia #3 & #8 shall be under Bidder’s scope.

9.1 **GENERAL**

The Bidder shall furnish the 132 kV outdoor switchyard equipment which shall comply with relevant IEC as listed below and the 132 kV equipment shall be arranged in the outdoor as shown on the attached drawings or as directed by the Board.

9.1.1 **DESIGN REQUIREMENT**

(1) **System Voltage**

The system shall be as follows:

- Nominal system voltage : 132 kV
- Highest system voltage : 145 kV

(2) **Insulation level**

The insulation level of the switchgear, equipment shall be as follows:

- Lighting impulse withstand test : 650 kV(Peak) Voltage (1.2 / 50 micro sec.)
- Power frequency insulation level (for 1 mm.): 275 kV

(3) **Outdoor Conductor Clearance**

- Phase to phase, standard : 3000 mm
- Phase to phase, minimum : 2100 mm
- Phase to ground, Standard : 1900 mm
- Phase to ground, Standard : 1500 mm

(4) **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 **132 kV SWITCHGEAR, EQUIPMENT**
9.2.1 132 kV CIRCUIT BREAKERS

(1) Type

Three (3) pole, porcelain type, high speed, outdoor, trip free in any position, spring operated SF₆ gas puffer, single flow type complete with, conduit, wiring, and all other necessary accessories.

(2) Use

For paralleling, control and protection.

(3) Ratings

a. Rated voltage : 132 kV

b. Rated insulation level

- Lighting impulse withstand test voltage : 650 kV (peak)
  (1.2/50 micro sec.)
- Power frequency withstand voltage : 275 kV
  (for 1 mm.)

c. Rated frequency : 50 Hz

d. Rated nominal current : 1,250 A

e. Rated short circuit breaking current : 40 kA [rms, 3 sec]

d. Rated transient recovery voltage for terminal faults and rated characteristics for short line faults shall be in accordance with IEC 56.

g. Rated short circuit making current : 100 kA

h. Rated duration of short circuit : 1 sec

i. Rated operating time : Less than 40 m sec

j. Rated operating sequence (<2.5 cycles): O-0.3sec-CO-3min-CO

4) Control System

The rated supply voltages of closing and opening devices shall be 125 V DC, and the operation of circuit breaker shall be performed safely under the following conditions:

For tripping operation (-30% to +10%) : 88 V to 137 V DC

For closing operation (-15% to +10%) : 106 V to 137 V DC

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 (applicable for only single pole breaker)

d. The arcing contact shall be of an arc proof metal and the main contact shall be covered with silver electroplated. Five (5) pairs of “a-b “spare contacts shall be equipped with the auxiliary switches.

e. The tripping current of the trip coil shall not be more than 2 A per phase (applicable for only single pole breaker).

f. 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.

g. 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.

h. 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.

i. 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.

j. The circuit breakers shall be provided with an emergency push button switch with cover to prevent inadvertent switching.

k. The circuit breakers shall be provided with an electrical anti pumping relay.

l. The supporting structure shall be free from mechanical vibration and loosening under long term use.

m. The circuit breakers shall be designed to facilitate inspection, especially for those parts which need inspection frequently.

n. The circuit breakers shall be filled with sufficient SF₆ gas.

o. SF₆ gas leak detector shall be furnished.
p. The circuit breakers shall be driven by spring operated mechanism. The operating mechanism shall be designed to meet the requirements of IEC 56.

q. Temperature limitation shall be in accordance with IEC 56.

r. The Contractor shall furnish all control cables, pipes or ducts and fittings between each phase and control box.

s. 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) Dielectric Test Voltage

a. Power frequency withstand voltage : 275 kV for one minute

b. Lighting impulse withstand voltage : 650 kV_{PEAK}

Full wave (1.2 / 50 micro sec.)

c. Test voltage on control circuit : 2.0 kV for one min.

(7) 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, 132 V, 10 A in control box

o. Conduit pipes

p. Communication facilities between switchgear and control room
q. Other necessary accessories, if any

9.2.2 132 kV DISCONNECTING SWITCHES

(1) Type
For buses

Outdoor, three (3) pole, single throw, group operated, horizontal break, rotating insulator, remote controlled motor operated type.

(2) Ratings

a. Rated voltage : 132 kV
b. Rated insulation level
   lighting impulse withstand test voltage : 650 kV (peak)
   (1.2 /50 micro sec.)
   - Power frequency withstand voltage (for 1 mm.) : 275 kV

c. Rated frequency : 50Hz
d. Rated nominal current : 1250A
e. Rated duration of short circuit current : 1 sec
f. Rated short circuit withstand current : 40 kA, 3 Sec.
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 129.
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) Dielectric Test Voltage
a. Power frequency withstand voltage : 275 kV for one minute
b. Lighting impulse withstand voltage
   Full wave (1.2/ 50 micro sec.) : 650 kV<sub>peak</sub>
c. Test voltage on control circuit : 2.0 kV for one min.

(5) Accessories
a. Nameplate
b. Control box with locking device
c. Grounding terminal
d. Auxiliary switches
e. Steel supporting structure with anchor bolts and nuts
f. Manual operation handle
g. Motor operating mechanism with manual operation inter-lock
h. Conduit pipes
i. Other necessary accessories, if any

9.2.3 132 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 : 132√3 kV
   - Secondary : 110√3 V
   - Tertiary : 110/3KV
b. Rated insulation level
   - Lighting impulse withstand voltage : 650 kV<sub>peak</sub>
     Full wave (1.2 / 50 micro sec.)
   - Power frequency withstand voltage : 275 kV
     for one minute
c. Rated frequency : 50 Hz
d. Rated burden
   - Secondary : 200 VA
   - Tertiary : 25 VA

e. Accuracy class : 1.0 (secondary)
                 : 3 P (tertiary)

(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. Voltage Transformer will be used for Synchronising, Protection & Metering purposes for proposed Generator Transformer for ST with 132 kV Ring main System.

Unless otherwise specified, the characteristic and others shall comply with the requirements of IEC 186.

(5) Dielectric Test Voltages
a. Power frequency withstand voltage for one minute on primary windings : 275 kV
b. Lighting impulse withstand voltage : 650 kV_{\text{PEAK}}
   Full wave (1.2 / 50 micro Sec.)
c. Power frequency withstand voltage for one minute on secondary windings : 2.0 kV

(6) Accessories
The following accessories shall be provided for each voltage transformer.
a. Nameplates
b. Grounding terminals
c. Lifting lugs
d. Steel supporting structure with anchor bolts and nuts
e. Junction boxes
f. Conduit pipes
g. Other necessary accessories, if any
9.2.4 132 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 : [to be at actual requirement]
   - Secondary : 5-5-5-5 A
b. Rated insulation level
   - Lighting impulse withstand voltage
     Full wave (1.2 / 50 micro sec.) : 650 kV$_{PEAK}$
     - Power frequency withstand voltage : 275 KV for one min.
c. Rated frequency : 50 Hz
d. Rated burden and
   - 60 VA for protection
   - 30 VA for measuring.
e. Rated continuous thermal current : 120%
f. Short time current ratings
   - Thermal rating (r.m.s. for three sec.) : 40 KA
   - Dynamic rating (peak) ratings : 2.5 times the thermal ratings
g. Accuracy classes
   - For metering : 0.2, n<5
   - For protection : X / 5P30

(4) Requirements for Design and Construction
a. The current transformer shall be of oil immersed hermetically sealed structure type.
b. Internal conductor shall be adequately reinforced taking into account over current intensity.
c. The junction box with terminals shall be provided for the secondary circuit connections.

d. Each current transformer shall be equipped with terminal block of short circuiting type.

e. Creepage distance of bushing shall not less than 25 mm / kV of phase to phase voltage. The glazing colour shall be of brown.

f. Unless otherwise specified, the characteristics and others shall comply with IEC 185.

(5) Dielectric Test Voltages

a. Power frequency withstand voltage on primary windings : 275 kV for one minute

b. Lighting impulse withstand voltage

Full wave (1.2/ 50 micro sec.) : 650 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.

a. Nameplates

b. Grounding terminals

c. Lifting lugs

d. Steel supporting structure with anchor bolts and nuts

e. Junction boxes

f. Conduit pipes

g. Other necessary accessories, if any

9.2.5 132 kV LIGHTNING ARRESTERS

(1) Type

Outdoor, single phase, self standing, Metal-Oxide type with surge operating counter.

(2) Use

For protection of 132 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 : 117 kV
b. Rated frequency : 50 Hz
c. Nominal discharge current : 10 KA
d. Type of duty discharge : Heavy, Long duration discharge
e. Pressure relief class : C
f. Lighting impulse insulation level : $650 \text{ KV}_{\text{peak}}$
   (1.2 / 50 micro sec.)
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 99-1

(7) Dielectric Test Voltage

a. Power frequency withstand voltage : 275 kV for one
b. Lighting impulse withstand voltage : $650 \text{ KV (peak)}$
   (1.2 / 50 micro sec.)
(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

9.2.6 132kV Outdoor Type Cable Termination End

a) Supply of 132kV Outdoor type Cable Termination End.
Each termination end shall be suitable to terminate overhead conductor at top end and 132kV XLPE Cable at bottom end.
b) Construction of foundation including all materials for above mentioned Cable Termination End.
c) Supply & installation including all materials of supporting steel structure for above mentioned Cable Termination End.
d) Complete Installation including earthing system of above mentioned Cable Termination End.
e) Commissioning of above mentioned Cable Termination End.

9.3 STEEL STRUCTURE

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.

- 132 kV bus and outgoing conductor : 900 kg per conductor
- Overhead grounding wire : 450 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
120 kg at the centre of the beam.

(4) Wind loads
Wind loads shall be calculated with wind speed of 100 miles / hr, 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) : 0.27 g

(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 Bidder 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:
- a. Formed steel : not less than 45 x 45 x 4 mm
- b. 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.
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 clippings, 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 Bidder shall submit to the Board 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 AND WIRING MATERIALS

9.4.1 INSULATORS

(1) Type and requirements

a. The insulator assemblies shall consist of suspension insulator discs, hardware, strain or suspension clamps as required.

b. The suspension insulators shall be of ball and socket type and shall conform to the requirement of IEC 120.

c. The insulator unit shall be standard 254 mm porcelain disc type or fog type 254 mm porcelain disc type, and have a spacing of 146 mm between discs.

d. Total creepage distance of the insulator assemblies shall not be less than 3300 mm.

e. The insulators shall be wet-process porcelain of the highest glade, dense and homogeneous. The glaze shall be smooth, hard, dense and uniform and shall not be effected by weather or sudden change in temperature, salty atmosphere and lighting during certain periods of the year. Colour of porcelain surface shall be brown. All ferrous metals shall be galvanised except for female thread and stainless steel. Each insulator shall bear symbols identifying the manufacturer and indicating the year of manufacturer and tension proof test load.

(2) Characteristics of Suspension Insulators

a. Porcelain disc diameter : 254 mm

b. Unit spacing : 146 mm

c. Minimum electromechanical failing load : 21000 Kg

d. Dimension of ball socket and pin : Conform to IEC

(3) Characteristic of Insulator Assemblies

a. Nominal system voltage : 132kV

b. Highest system voltage : 145 kV

c. Creepage distance not less than : 3300 mm

d. Breaking strength of complete set : 1200kg
e. System insulation level
   - Basic impulse insulation level
     (1.2120 micro sec.) \( : 650 \text{ kV}_{\text{peak}} \)
   - Power frequency withstands voltage
     (For 1 mm.) \( : 275 \text{ kV} \)

9.4.2 FITTINGS

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 hardwire 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 clamps shall not be occurred in excessive heating by magnetising or other causes.

9.4.3 STANDARD CONDUCTORS FOR OVER HEAD LINES

(1) 850 mm\(^2\), hard drawn aluminium conductor

The hard down aluminium stranded conductor of 850 mm\(^2\) shall be used for 132 kV bus bars and for outgoing feeder circuit. The conductors shall comply with the requirements of IEC .

(2) Galvanised Steel Wire

The galvanised steel wire of 55 mm\(^2\) shall be used as overhead grounding wire.

(3) Spools for Conductors

The spools for conductors shall be made of steel and treated against corrosion and rust, and the following marking shall be indicated on an appropriate side of the spool.

- Conductor number
- Kind and cross sectional area of conductor
- Conductor length
- Spool weight
- Name of manufacturer or abbreviation
- Date of production
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 Bidder.
Section 10

6.6kV Switchgear and Low Tension Switchgear
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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**

10.3 **NON SEGREGATED PHASE BUS DUCT (NSPBD)**
10. **6.6 kV SWITCHGEAR AND LOW TENSION SWITCHGEAR**

As shown in the Auxiliary One Line Diagram, 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

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: Minimum 40 kA (rms.), 3 Sec.
    - Rated short circuit making current: 100 kA (peak)
    - Number of circuit: Determined by the Bidder but two spare feeders shall be included.

(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 1000A
b. Branch bus, more than 600 A

(8) Control Power Bus

2-wires DC 125 volt insulated wire.

Branched circuit shall consist of two circuits of closing and tripping for every circuit breaker.

(9) Neutral Grounding Resistor

Neutral point of 6.6kV winding of the Unit Auxiliary Transformer shall be grounded through neutral grounding resistor which shall preferably be located near the Transformer. Necessary neutral side CTs for Unit Auxiliary Transformer shall be provided within the Neutral Grounding Resistor Cubicle. 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) Bus Transfer Scheme

i) Switchgear shall be provided with bus transfer facility which could come into operation either manually (Planned operation) and/or automatically.

ii) The bus transfer could be manual (Pre-planned) in the event of transfer of load from one source to the other source or vice versa.

iii) The transfer could also be automatic in the event of fault characterized by operation of protection relay and/or by low voltage on unit bus during normal operation in case the low voltage is not caused by bus fault.

iv) The manual and automatic bus transfer would be arranged in such a way that any of the following modes of operation is possible.
a) Manual Bus Transfer -
   With Voltage Interruption - Slow Changeover
b) Automatic bus transfer
   Without Voltage interruption - Fast changeover
v) The fast bus transfer panel shall be used for fast changeover backed-up by slow changeover control, annunciation, monitoring and development of the Bus Transfer Logic of unit switchgears. Fast bus transfer panel may be conventional relay based type or microprocessor based.
vi) The fast bus transfer panel shall be totally enclosed, floor mounted panel conforming to degree of protection IP-42. The minimum thickness of cold rolled sheet steel used shall be 2.0 mm.

10.2 415 V SWITCHGEAR AND MOTOR CONTROL CENTRES

As shown in the Auxiliary One Line Diagram, 415 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 generating plant. If control centres or distribution panels not described in this Specification be needed, they shall be supplied with each facility.

415V Switchgears shall be provided with following Bus Transfer scheme:
i) Automatic Slow Bus Transfer in both direction
ii) Manual Transfer without voltage interruption with check synchronisation facility
iii) Manual Transfer with voltage interruption

The switchgears and motor control centres are classified into the following:
- One (1) sets of 415 V common switchgear
- Three (3) sets of 415 V unit switchgears
- Four (4) sets of 415 V motor control Centres

10.2.1 SWITCHGEAR (POWER CENTER)

a. Type and Rating
   Type
   Indoor, steel sheet formed cubicle, single bus draw-out type.
- **Rating**
  
  **Rated voltage**: 415 V  
  **Rated frequency**: 50 Hz  
  **Rated normal current**:  
  **Incoming and bus tie circuit**: 2,500 A  
  **Feeder circuit**: 600 A  
  **Rated short circuit current**: Minimum 40 kA (rms), 1 Sec.  

- **Number of circuit**: Determined by the Bidder, but (two) spare feeders shall be provided on each switchgear.

(b) **Kind of Unit**

Determined by the Bidder, but 2 (two) spare feeders shall be provided on each switchgear. The switchgear shall be of 3 phase, 4 wire, neutral solidly grounded, 415 V power center type with circuit breakers 40 kA interrupting capacity. The switchgear shall contain the following kind of circuits as general.

- **Incoming and bus tie circuit**  
  2,500 A, 40 kA (rms) ACB  

- **Motor feeder circuit**  
  600 A, 40 kA (rms) ACB  

- **Feeder for motor control center**  
  600 A, 40 kA (rms) ACB  

- **Voltage transformer unit**  
  All circuit breaker shall be able to draw out horizontally.  
  All incoming & outgoing feeders including Bus Coupler will be draw-out type for new 400V Switchgear.

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.

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>Rated voltage</th>
<th>: 415 V</th>
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</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>: 50 Hz</td>
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</tbody>
</table>

- Rated normal current

<table>
<thead>
<tr>
<th>Incoming</th>
<th>: 2,500 A</th>
</tr>
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<tbody>
<tr>
<td>Feeder circuit</td>
<td>: 450,200 or 100 A</td>
</tr>
</tbody>
</table>

- Rated short circuit current

: Minimum 40 KA(rms, 1 Sec.)

- Number of circuit

: as required

including three(3) spare feeders on each motor control centre.

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, 40 kA (rms), moulded circuit breaker.

- Motor feeder circuit

400, 200 or 100 A, 40 kA (rms) moulded circuit breaker, contactor,
and reserve units if required.

- **Non- motor feeder circuit**

  400, 200 or 100 A, 40 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**

  All new 400V MCCs shall be of draw-out type. All other ACDBs /DCDBs will be non draw-out type There will be no Bus Coupler for MCCs/ACDBs except for DCDB and UPS DB.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. All motor feeder cubicles shall be of draw-out type.

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.

i. **Thermal Overload**

  i) Thermal overload relays shall be three element, positive acting, ambient temperature compensated with adjustable settings.

  ii) Single phasing preventer shall be provided as an inbuilt feature of the thermal overload relay.

  iii) Relays shall be manual reset type with changeover contacts; Resetting of relays shall be possible with compartment door closed. Colour of the resetting button shall be BLACK.

  iv) Incomers of 400V MCCs and DBs shall be provided with one out of two interlocking scheme and the changeover shall be done in dead bus condition manually.

### 10.3 NON SEGREGATED PHASE BUS DUCT (NSPBD)
Non Segregated Phase Bus Duct (NSPBD) shall be provided between 415V terminals of Station Service Transformer and 400V Switchgear terminals.

Bus duct connections shall be from the top. All connecting bus work shall have the same continuous rating as associated Switchgear/MCC/DB bus and shall be fully braced for the LT system short circuit current.

All provisions such as matching flanges and other accessories required for proper connection to bus duct shall also be supplied.
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Section 11

Control and Protection
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11.5 GT/Steam Turbine Generating Remote Unit Control

11.5.1 GT/Steam Turbine Generating Unit Remote Control Switch

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11.5.3 GT/Steam Turbine Generating Unit Remote Metering

11.6 132kV Switchgear Control and Protection

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11.6.2 Step up Transformer Panel

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11. CONTROL AND PROTECTION EQUIPMENT

11.1 GENERAL REQUIREMENTS

The Bidder 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 Combined cycle generating unit, interfacing with existing GT Control system, 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 / ABB Sweden / Siemens Germany

b) Step-Up Transformer Protection : ABB, Switzerland / ABB, Sweden/Siemens, Germany

c) 11/6.6/0.415 KV AUX. Transformer : Siemens, Germany / Areva, UK-France / ABB, Finland / ABB, Switzerland / ABB, Sweden.

d) 11KV/6.6kV/400V Switchgear : Siemens, Germany / Areva, UK-France / ABB, Finland / ABB, Switzerland / ABB, Sweden.

11.1.1 CODES AND STANDARDS

The latest edition and addenda of the following publications are applicable to the extend indicated by the specific reference. All equipment furnished and work covered in this design criteria document will generally comply with the approved standards, specifications and regulations, codes and tests as follow:

- American Society of Mechanical Engineers (ASME)
- American National Stanadards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- The Instrumentation, System and Automation Society (ISA)
- Nation Fire Protection Association (NFPA)
- Institute of Electro-Technical Commission (IEC)
- National Electrical Manufacturers Association (NEMA)

If differences exist between codes or standards or procedures and requirements herein, the more stringent requirements shall apply.

KKS identification system shall be used for identification codes for systems and components.
11.2. CONTROL FUNCTIONS OF COMBINED CYCLE 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.

The automatic start-up and shut down sequences shall be initiated either from the local control room or the central control room. Synchronisation shall be automatic with provision for local and remote manual control.

Start/stop of any auxiliary system such as lube oil system, turning gear, boiler purging etc. during the start-up/shut down of the GTG shall be fully automatic. The start-up sequence shall include automatic testing programs for the equipment such as the emergency lube oil pump. The start-up/shut down of the GTG shall be initiated by the operator from the DCS operator stations in CCR/ LCR at the GTG screen graphic display or from the Plant Master Sequencer.

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.

The Start Up Sequence shall be configured to step through in the event that plant conditions are already achieved i.e. a GT is already in service in simple cycle mode and the operator wishes to start the ST; GT is on turning gear and combined cycle mode is selected and the operator wishes to start the ST, etc. All practical permutations should be accounted for by the sequence logic.

The DCS shall be configured to provide an operator initiated CCGT Start up
Sequence. The sequence logic will verify Common Auxiliary System conditions, start/verify CCGT Auxiliary Systems, verify operator start up selection criteria, start up GT, start-up HRSG, start up ST, load generators to operator selected CCGT load. Synchronizing of the units shall be prompted by the DCS and initiated by the operator as part of the Start Up sequence.

The DCS will be configured to provide the operator with a choice of configuration for start-up: Simple or combined cycle operation of GT/HRSG; Plant Bypass mode etc. The selection criteria shall be made on the CCGT Start Up Sequence graphics and the selected criteria reflected on all relevant Unit sequence and plant control graphics.

11.3 GAS TURBINE GENERATING UNIT LOCAL CONTROL [HMI, Computers]

At present the gas turbine unit have its own local unit control room.

Equipment, materials, accessories furnished, mounted, and connected on the local unit control panel shall provide: 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 watt-hour meter with indicating lamp for voltmeter
- Generator var-hour 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 provide: include, but not be limited to the following.
- Automatic synchroniser
- Speed matching
- Voltage matching
- Voltage acceptance
- Synchronising check or synchro- acceptor

The Bidder 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.

11.4 GAS/STEAM TURBINE GENERATING / HRSG UNIT PROTECTION

Automatic protection devices complete with annunciation system shall be provided to protect the Steam Turbine generating unit at all items, regardless of whether locally or remotely controlled, against any malfunction of the unit or control system and shall, at least, include the following:

<table>
<thead>
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<th></th>
<th>Alarm</th>
<th>Alarm &amp; Gen CB Trip</th>
<th>Alarm &amp; ST shutown</th>
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<td>Unit DC Supply under-voltage and ground fault</td>
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<td>b</td>
<td>Auxiliary motor overload</td>
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<td>c</td>
<td>Inlet Steam pressure/ temperature high</td>
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<td>Fuel gas inlet pressure low</td>
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<td>Incomplete start sequence</td>
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<td>Generator over-current</td>
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<td>Generator reverse power</td>
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<td>Loss of excitation</td>
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<td>Negative phase sequence current</td>
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<td>1&lt;sup&gt;st&lt;/sup&gt; stage</td>
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<td>2&lt;sup&gt;nd&lt;/sup&gt; stage</td>
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<td>x</td>
<td>Generator over voltage</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>Generator ground</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; stage</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; stage</td>
<td>x x x</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>Generator field ground</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>aa</td>
<td>Generator breaker ground</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>bb</td>
<td>Field breaker trip</td>
<td>x x</td>
<td></td>
</tr>
</tbody>
</table>
The protection system of the HRSG and steam/water cycle shall be functionally spate form DCS system.

The list of HRSG trip criteria shall include as a minimum, but not limited to:

- Drum water level Low-Low
- Drum water level High-High
- HP steam temperature High-High
- The relevant GTG Tripped
- Diverter damper position to HRSG Closed
- Manual emergency stop Actuated

The above alarms shall be indicated and available in the HMI at CCR.

### 11.5 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.

Tile following control shall be provided, but not be limited to, on the remote unit control.

- Unit start / stop
- Active load raise / lower
- Voltage raise / lower (Reactive load control)
- AVR manual/auto selection
- Tap raise/lower
- Plant Mode
- Barring/Heating/Full speed selection
- Mode changeover base / peak
- Synchroniser: manual / off / auto
- Emergency Stop

Any additional facilities necessary for the safe and efficient operation of the plant shall be included

The above shall be indicated and available on HMI at CCR.

11.5.1 GAS TURBINE /HRSG/ STEAM TURBINE GENERATING UNIT REMOTE INDICATION

- Ready to start
- Auxiliaries running
- Normal start sequence in progress
- Start sequence completed
- Shutdown sequence in progress
- Generator breaker open / close
- Flame indication
- Temperature control indication
- Mode selection indication base / peak
- All trip cause
- On Load limit operation
  - main steam inlet valve open/close
  - Steam stop valve –open/close
  - load selected

Any other status indication necessary for safe and efficient operation of the STG/HRSG

Following minimum monitoring shall be provided from DCS for STG

Analogue (as applicable):

- Turbine speed
- Generator voltage
- Generator frequency
- Generator current
- Active load generator
- Reactive load generator
• Generator Watt/VAR vector meter
• Power factor
• Generator frequency
• Exciter voltmeter
• Inlet steam pressure and temperature
• Exhaust steam pressure (Vacuum) and temperature
• Turbine casing temperatures
• Differential expansion
• Shaft axial shift
• Bearing metal temperatures
• Condensate hot well level
• Control valve opening
• Tap changer position
• Energy metering by pulse

Any other indication necessary for safe and efficient operation of the Steam Turbine Generator set

11.5.2 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)
11.6 CONTROL AND PROTECTION

11.6.1 132 KV SWITCHYARD PROTECTION

Control and Metering for two nos. bays (for 1GT+1ST) shall be done through existing Sub-station control and monitoring system (SCMS) located in existing Substation Control Room. The existing SCMS shall be interfaced with the new DCS through redundant softlink for monitoring. Redundant interface modules and serial data links to LDC system using the communication protocol IEC 60870-5-104 shall be provided.

11.6.2 GENERATOR STEP-UP TRANSFORMER PROTECTION (for STG)

(1) Generator Step-up Transformer (GSUT) protection panel shall be equipped with one number independent numerical relay. Proposed 132kV side CTs & VTs shall be used for GSUT protection as well as 132kV Cable protection. Necessary neutral side CTs, auxiliary relays, test terminal blocks, lockout relays, etc. shall also be provided. Bidder shall also provide one no. hand reset type Master trip relay in order to execute the corresponding GCB, EHV CB opening & necessary interlock.

(2) The GSUT Protection panel shall be equipped with the following items of protection, but not be limited to:

i) Transformer H.V side INST./IDMT Over current Protection : 50/51

ii) Transformer H.V side INST./IDMT Earth Fault Protection: 50N/51N

iii) Transformer H.V Neutral side Restricted E/F Protection: 64R

iv) Transformer H.V. Neutral side back-up IDMT E/F Protection: 51NGT

v) Transformer Differential protection: 87GT

vi) Differential protection covering interconnecting cables / overhead conductors at both sides : 87C

vii) Over fluxing Protection: 99GT

viii) Breaker Failure Protection: 50BF

ix) Neutral Voltage displacement protection: 59N

x) Buchholz Protection: 63

xi) Oil temperature Protection: 26

xii) Winding temperature Protection: 49

xiii) Pressure relief valve Protection: 63PT

xiv) Oil Level: 71

xv) OLTC buchholz protection

xvi) OLTC oil surge protection
xvii) Cooler bank failure

xviii) Power supply failure to Marshalling Box

The above are minimum specified protection functions as required. The protections shall be furnished with accessories like timers, auxiliary relays, interposing CTs & VTs, tripping relays, lockout relays etc. as required to fulfil the functional requirement of control, indication, interlock & protection. Actual requirement shall be based on the bidder's study and proposed CCPP configuration subject to Owner's approval.

11.6.3 UNIT AUXILIARY TRANSFORMER PROTECTION

Unit Auxiliary Transformer protection panel shall be equipped with one number independent numerical relay. Necessary neutral side CTs, auxiliary relays, test terminal blocks, lockout relays, etc. shall also be provided.

i) Transformer H.V side INST./ IDMT Over current Protection: 50/51 UT

ii) Transformer H.V side INST./ IDMT Earth Fault Protection: 50N/51IN

iii) Transformer L.V-1(6.6kV) side restricted earth fault protection: 64R

iv) Transformer L.V-1(6.6kV) side back-up IDMT E/F Protection: 51NS

v) Transformer Differential Protection covering interconnecting cables at both H.V & L.V-1 side: 87UT

vi) Buchholz Protection: 63

vii) Oil temperature Protection: 26

viii) Winding temperature Protection: 49

ix) Pressure relief valve Protection: 63PT

x) Oil Level: 71

xi) OLTC buchholz protection

xii) OLTC oil surge protection

xiii) Cooler bank failure

xiv) Power supply failure to Marshalling Box

The above are minimum specified protection functions as required. The protections shall be furnished with accessories like timers, auxiliary relays, interposing CTs & VTs, tripping relays, lockout relays etc. as required to fulfil the functional requirement of control, indication, interlock & protection. Actual requirement shall be based on the bidder's study and proposed CCPP configuration subject to Owner's approval.

11.6.3 SYNCHRONIZING PANEL

Synchronising of the Generating units shall be performed within the DCS with
following indication:
One (1) Lot Synchroscope
One (1) Lot Voltmeter (0-120 kV)
One (1) Lot Frequency meter (48-52 Hz)

11.6.4 MODIFICATION OF EXISTING PROTECTION PANELS
Modification of protection, metering and control system of existing 132kV GT Bay in line with protection, metering and control system of proposed 132kV ST bay shall be done.

11.7 11 KV GENERATOR SWITCHGEAR
The 11 KV instruments, and other necessary things:
One (1) lot Control switch for 11KV circuit breaker for incoming
One (1) lot Control switch for spare 11 KV circuit breaker
One (1) lot 11 KV bus voltmeter selector switch
One (1) lot Incoming circuit ammeter 3 Nos.
One (1) lot 11 KV bus voltmeter (0-11KV)
One (1) lot Incoming ammeter (0-9000 A), 3 Nos.
One (1) lot Spare breaker watt meter
One (1) lot Spare breaker Var meter
One (1) lot Spare breaker watt-hour meter with indicating lamp for voltage failure
One (1) lot Mimic bus
One (1) lot Annunciation (minimum 15 windows)
One (1) lot Test terminal blocks
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.

H.V side CTs, for all above mentioned protections of Unit Auxiliary Transformer shall be provided within 11KV Switchgear.

The 11 KV, 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 415 V feeder circuit breaker control switch
- Required no. of 6.6 KV ansd 415 V voltmeter selector switch
- Required no. of 6.6 KV and 415 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 (minimum 15 windows)
- One (1) lot Mimic bus
- One (1) lot Test terminal blocks

All incoming and outgoing feeders, main electrical switchboards, sub-boards and feeds to main plant auxiliaries shall be monitored and operated at the existing CCR via the DCS. The status and data associated with the electrical distribution system shall be displayed in the CCR via the DCS and shall include all systems down to a voltage level of 415 V, the DC and UPS board.

The controls and indications shall include, but not be limited to, the following:

a. Status of circuit breakers, isolators, bus couplers and earth switches on switchboards, including incoming feeders, feeds to main auxiliaries and feeds to sub-boards.

b. Alarms associated with circuit breakers, isolators, bus couplers, earth switches, transformers and electrical protection equipment.

c. Transformer tap positions.

d. Transformer winding and oil temperatures

e. Power (MW), reactive power (MVar), current (A), voltage (kV), frequency (Hz), phase angle and power factor. Metering of energy exported and imported and statistical metering

f. Power system stabilizer (if applicable)
11.9 INSTRUMENTATION AND CONTROLS

11.9.1 General Requirement

All equipment and components shall be of an approved and reliable design and shall incorporate the latest development in proven technology. A consistent control and instrumentation philosophy shall apply throughout the Plant and shall be implemented in terms of range of equipment exhibiting a minimum diversity of type and manufacture. The objective shall be to standardise as far as possible all measurement and control equipment through the Plant in order to rationalize operation, maintenance and to reduce spares holding.

The rules of good engineering practice and the relevant applicable standards and regulations shall be strictly observed.

All equipment/components shall be designed according to the prevailing local climatic conditions and shall be suitable for continuous operation under site conditions.

Each component shall be identified and tagged in accordance with the Plant Identification KKS System. Instrument scale ranges shall be expressed in SI units.

The drawings enclosed with the specification are indicative and bidding purpose only. Any further necessary improvement required during detailed engineering and execution shall also be implemented by bidder.

11.9.2 DESIGN REQUIREMENTS

The primary objective for the design of instrumentation and control systems shall be to assist in the attainment of maximum unit availability.

Instrument sensing, transmission, measuring system shall be of latest microprocessor based/solid state electronic type with signal transmission in current mode with 4-20 mA level except for local instruments.

All components and systems offered by the Bidder shall be of established reliability. The minimum target reliability of each component shall be established by the Bidder, considering its failure rate and meantime between failures (MTBF) and meantime to repair (MTTR), such that the availability of the complete system is assured for 99.7%.

The design of the control systems and related equipment shall adhere to the principle of "fail safe" operation at all system level. "Fail Safe Operation" signifies that the loss of signal, loss of power or failure of any component will not cause a hazardous condition and at the same time prevent occurrence of false trips.

The types of failure which shall be taken into account for ensuring operability of the plant shall include but not limited to:-

- Failures of sensors or transmitters producing high or low signal
- Failure of main and/or redundant controller other modules during automatic operation.
- Loss of motive power to final control element
- Loss of control power
- Loss of Instrument Air

11.9.2.1 Field Measurement Redundancy

The measurements for critical loop control and protection shall be provided with three separate sensors/transmitters with 2 out of 3 selections (2oo3).

The triple redundancy shall be completed in all aspects by means that each of the triple redundant sensors shall be connected to a separate DCS/PLC input module and shall have a separate circuit including field sensor cable, junction box, input card, power supply etc.

The protection signal shall be taken from the analogue signals as a result of 2 out of 3 selections of the three limit-monitoring functions. The same 2 out of 3 analogue signal used for the protection may also be used for analogue control, if analogue control is applicable.

The measurements serving for important interlock protection signals of equipment shall be generally dual redundant with 1oo2 (one out of two) selections

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 Bidder shall supply shielded cables and surge arresters where necessary.

Shock absorbing mountings shall be supplied for instrumentation equipment where required.

11.9.2.2 Control and Protection Philosophy

Control and Instrumentation equipment is required for the purposes of control, monitoring and protection of the plant:

- Control and operation
  This is defined as the control of the plant under routine operation.
- Monitoring
  This is defined as the monitoring of process variables, plant states, alarm conditions and the display and logging of these parameters.
- Protection
  It is the minimum requirement of the control and instrumentation systems that automatically prevent dangerous and damaging conditions arising in the plant under normal and abnormal conditions of service.

To meet the objectives stated above the monitoring and control of the power station processes and electrical systems shall be undertaken by the use of modern and well proven microprocessor-based systems.
All systems, sub-systems and components of the entire plant proposed under the scope of the works shall be fully monitored, supervised and controlled in order to achieve safe and reliable operation of the plant.

All plant protective systems must be implemented on a triple redundant basis, with the redundancy concept being implemented right from the field instrument level up to the control processors, and back to the final control elements in the field. In order to ensure a high degree of plant safety, reliability and availability Failure of any one item of the control and automation system should not lead to the shutdown of the generating unit, nor should it result in unsafe operation of any part of the plant.

The protection system shall be part of the DCS, however physically and functionally separated from it. The protection systems shall be separated system-wise.

Sensing devices which initiate emergency shutdown shall be specific to this purpose and shall perform no other function than to operate a master shutdown relay that shall be provided at the local panel under this Contract. Protection loops shall operate independently from control loops.

It shall not be possible for the operator to invalidate the protection system. A control philosophy, which involves the operation of a protective device during normal operation of the plant including plant shutdown, will not be acceptable. The protection systems must operate independently from control systems.

Segregation of the trip signal multi-channel protection shall be observed in the equipment layout in marshalling and equipment cubicles.

Protection logic shall not be bypassed in Auto/Manual selection of controls

11.9.2.3 Requirements Due To Explosion Hazard

Intrinsically safe (Ex 'I'), increased safety (Ex 'e') and flameproof (Ex 'd') or other protection methods for I&C systems shall be used as applicable for classified zones. All equipment necessary for mounting in these hazardous areas shall meet the requirements of IEC 60079 or an equivalent National Standard. The equipment shall be certified by the appropriate National Certification Bureau and its proposed application shall fully comply with all conditions of the certificate.

In case of intrinsically safe (IS) loops, suitable intrinsic safety barrier shall be provided. The cabling and accessories associated with intrinsically safe circuits shall be coloured blue and segregated from any other cabling, etc. to accomplish the IS installation in conformity with IEC-60079 or equivalent National Standard.

Equipment Protection Class

For outdoor equipment the minimum ingress protection class shall be as follows:

- Transmitters: IP 65
- Binary sensors: IP 65
- Analysers: IP 65
Actuators IP 65
Distribution boxes/Junction Boxes IP 65
Protection Class for Panel/Cubicles
Indoor Air conditioned (A.C.) areas IP 32
In door Non A.C. areas:
a. Ventilated enclosures IP 42
b. Non Ventilated IP 54
Out door IP 55

Protection against exaggerated ingress of dust shall be provided by rubber sealing of doors, filters on forced ventilation slots etc.

11.9.3 Field Mounted Equipment

11.9.3.1 General Requirements

Materials for instrumentation and control equipment, which are exposed to the measured media, shall be compatible with the conditions of the selected media and with the piping material. Piping, tubing, fittings, and wiring shall be arranged so that any instrument or device may be removed or serviced without disturbing the piping, tubing or wiring associated with other instruments.

All I&C equipment exposed to sun shall be protected against direct sun radiation by means of appropriate sunshades.

Every instrument requiring power supply shall be provided with a pair of easily replaceable glass cartridge fuse of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.

Instruments for similar functions (e.g. local gauges, transmitters, etc.) shall be of the same make and type across the whole plant to the maximum possible extent. As a minimum, the uniformity of manufacturer shall be guaranteed for each system.

Measuring ranges of local indicators, transmitters, etc. shall be selected in such a way that the rated value of the measuring variables appears at approx. 75 % of the span.

All measuring equipment shall have high accuracy and repeatability through the entire range of 0 - 100 %.

Measuring elements and chambers of transmitters, pressure internal switches, etc., shall be of stainless steel or better material.

Pressure stubs with isolating valves shall be provided.

Switches employing micro-switches are preferred. Mercury switches will not be accepted.
Position limit switches on safety-related and critical applications shall meet the requirements of appropriate IEC standards.

Direct reading pressure gauges, vacuum gauges, compound gauges and gauges used in conjunction with pneumatic signals from transmitters shall be protected from damage due to vacuum conditions occurring.

Nine nos. (3 nos. per phase) Resistance temperature detectors (RTD’s) shall be provided for all HV motors, for winding temperature monitoring. Each element shall be 3 wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Control system.

1 no. duplex PT-100 type RTD shall be provided for each bearing of MV equipment and its driving equipment (motor).

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.

Following minimum requirement of field instruments shall be fulfilled by Bidder

**Local Field Instrumentation**

The local measurements shall include but not be limited to the following items:

- Pressure gauges at HP valves
- Pressure gauges at the suction and discharge side of pumps including on header section, if two or more pumps are employed for the same services. Except immersion type pumps where pressure gauge at suction side is not foreseen.
- Pressure gauges on tanks (other than atmospheric ones) and heat exchangers. No pressure gauges are to be installed at coolers. However, pressure gauges are to be installed at the piping upstream/downstream of coolers.
- Differential pressure gauge and transmitter for all filters and strainers
- Temperature gauges at heat exchanger inlets and outlets
- Generally, temperature gauges on hot liquid filled tanks
- Thermometers at bearing oil outlets
- Test valves, connections and thermowells necessary for commissioning, testing and maintenance.
- For performance tests separate tappings, test valves, connections thermowells, etc. shall be provided beside the existing remote measurements, which shall not be removed from the DCS during the execution of the performance tests.
- Level gauges/measurements on heat exchangers with condensate, on tanks, pits, reservoirs, etc.
- Local gauges at systems inlet/outlets
- Local gauges close to tappings for remote measurements

**Field Instrumentation for Plant Control**

Field instrumentation shall be provided for all signals for remote tasks to fulfil the aims of the Plant Control as specified in any part of this Specification and to guarantee the safe and reliable operation of the Plant.

Remote measurements for typical variables shall be provided for:

- All controlled variables
- Upstream and downstream of control valves and pressure reducing stations
- Remote indication of pressure and temperature in the main supply and return line
- Systems inlets and outlets
- Headers
- Values alarmed in the CCR and values important for the safety and availability of the Plant
- Values important for the Plant operation, monitoring and alarm.
- Values important for the Plant management functions, balances, efficiency calculations, etc.

**Instrument Ranges**

The ranges of the instruments shall be selected based on the following philosophy:

- For pressure measurement, the maximum operating pressure will be within 70 to 80% of the maximum scale range.
- For temperature measurement, the maximum operating temperature will be within 80 to 90% of the maximum scale range.
- For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
- For level measurement, the maximum of the range will cover the overflow point or six inches from the top of the vessel and the minimum of the range will be six inches above the bottom of the vessel. Also, the gauge glasses will be stacked with overlap to cover permissive, alarm and trip levels.
- For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow
- For electro-chemical measurements (conductivity, pH, dissolved O2, Silica etc.), the maximum range will be around 10 to 15% higher than the recommended alarm settings.
- For gas analyzers, the maximum range will be around 10 to 15% higher than the recommended alarm settings.

11.9.3.2 MEASUREMENTS

A. Transmitters (Pressure, Differential Pressure, Level and Flow)

Transmitters shall be of the 2-wire or 4-wire, SMART type with HART protocol with remote calibration option and isolated from earth and have an output signal range of 4-20 mA DC/0-20 mA DC/0-5V.

Hand held calibrators shall also be supplied along with the transmitters for calibration of the transmitters.

All transmitters shall have an accuracy of ± 0.075% or better of FSR and ± 0.2% for remote seal type transmitter.

All transmitters shall be of the indicating type and shall have a built-in indicator displaying physical units.

All transmitters shall be provided with test connections. All the pressure transmitters shall be supplied with 3-way valve manifold and all the differential pressure transmitters shall be supplied with 5-way manifolds.

The manifolds, valves, fittings and tubing shall be of SS316. Snubbers/pulsation dampers shall be used where the process media is unstable for measurement such as the discharge of a pump. Over range protection shall be used where necessary. The coil syphons and condensate pots shall be used for steam services. Transmitters shall be provided with suitable drain and vent points.

Position Transmitters

Position transmitters of the potentiometer type will not be accepted for any automatic control purpose. Inductive position transmitters or similar types shall be provided. SMART type with HART communication protocol position transmitter shall be provided.

Characteristics of the position transmitters shall be linear with a linearity deviation of not more than 1 %. The reproducibility shall be better than 0.3 %.

B. Switches (Pressure and Differential Pressure)

The preferable type/construction shall be Bourdon/Sealed Diaphragm, Piston actuated sensing element. Indicators with contacts are not acceptable. Materials for Bellows, Bourdon tube and movement shall be SS316.

Accuracy shall be ± One (1) percent or better of full range. Over pressure range shall be 150 percent of max design pressure. Contact shall be 1 DPDT /2 SPDT with auto reset with internal adjustable snap action micro switch. Class shall be IP 65/ Explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

Accessories like 3/ 5 valve SS316 manifold, syphon for all steam lines, protective separating for fuel oil and corrosive liquid lines etc. shall be provided.
C. Pressure Measurement

Pressure and Differential Pressure Indicator (PI and DPI)

Pressure gauges shall Bourdon tube type when the pressure ranges are suitable for an accurate Bourdon tube measurement. For low pressure below 10 psig (0.67 kg/cm²) a diaphragm/bellows type gauge shall be provided. DP gauges shall bellows or diaphragm type. Materials of bourdon tube, bellows, and movement shall be SS316.

Pressure gauge size shall be min 150 mm (6”) and case material shall be SS316 as a minimum.

Gauges shall be liquid filled (Glycerin or Silicon) typically for services which have high vibrations, temperature fluctuations and/or moisture and condensation issues.

For gases and vapor services, pressure transmitters shall be mounted above and as close to the pressure taps as possible while still maintaining accessibility. Impulse lines shall slope continuously downward from transmitter to root valve such that they are self-draining with a slope of 1:10.

In application such as slurries, boiling or fouling services, viscous, corrosive or dirty a fluid for which bourdon is unsuitable the preferred solution is a liquid filled diaphragm. Armoured capillary shall be provided for fuel oil and corrosive liquid service.

The error for pressure gauges shall be limited to ± 1 % of the span (FSD) or Class 1 as per EN 13190.

High pressure gauges shall be supplied with a relief device/blow-out (rubber plug at rear side) for safety in case of leaks.

Each pressure gauge shall have a 3-valve manifold with draining and test ports, syphon shall be provided for all steam lines. Each differential pressure gauge shall have a 5-valve manifold. The manifolds, valves, fittings and tubing shall be of stainless steel 316.

External zero adjustment shall be provided for all gauges. Over range protection shall be 150 percent of full scale. Enclosure Class shall be IP 65/ Explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

D. Temperature Measurement

Temperature Transmitters

Smart type and Indicating type, field mounted temperature transmitters with an accuracy of ± 0.10%, ref. Junction compensation, span/zero adjustment, auto calibration, burn out protection upscale, input - output isolation, circuit ungrounded, ambient temperature error 0.1% per 10 deg C change to provide linear output of 4-20 mA DC (2 wire system) HART compatible signals for analogue inputs to DCS and PLC. NEMA 4 or equivalent degree of protection for enclosure. Material of accessories will be SS316. Enclosure Class shall be IP 66/ Explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

Thermocouples and Resistance Temperature Devices
The Type of thermocouple shall be K type (Chromel-Alumel) or Type S/R (Platinum Rhodium-Platinum) or T type (Cu-CuNi) as per process requirements with limits of error according to ANSI-96.1 – 1982

Thermocouples shall be provided with field mounted transmitters. Thermocouples shall have suitable cold junction compensation.

Any cold junction compensation shall be carried out at the indicator

For process temperature up to 200° C, RTD shall be used, beyond 200° C temperature thermocouple to be used.

Thermocouples shall be manufactured from a continuous length of cable from hot junction to the first termination box or cold junction cabinet whichever is appropriate in the design concerned. The thermocouple hot junction shall be insulated from the cladding. All the thermocouples shall be duplexed unless otherwise specified.

All thermocouple cables shall be mechanically protected. Also, high temperature resistant cables must be employed wherever high surrounding temperature is expected.

RTDs and thermocouples shall be equipped with waterproof connection heads. These shall be arranged in such a way that the connection heads do not exceed 80 °C and that the measuring inserts are easily exchangeable. The temperature sensors shall be selected in such a way that only a small number of different spare inserts is required.

RTDs shall generally be of type Pt 100

For RTDs 4 wire circuits shall be used. However, 3-wire RTDs are acceptable where RTD will be directly connected to the PLC based system.

Transmitters shall be used for all resistance thermometer measurements

The thermowells shall be of stainless steel 316 or Inconel and of adequate length to ensure sufficient penetration into the fluid to give a precise measurement.

The cold junction compensation shall be done by the remote control system itself using conventional type junction boxes with internal temperature measuring element wherever applicable.

Generally, inserts with two thermocouples/resistance thermometers shall be provided so that one of them is available for spare (duplex type).

Bidder shall provide calculation for thermowell as per ASME – PTC-19.3.

Accuracy shall be

For Type K T/C : ± 1.1 deg. C. (for 0 to 277 deg. C) and ± 0.4 percent (for 277 to 1280 deg.C) Class-A

For Type S/R T/C : ± 0.6 deg C or + 0.1 %, whichever is better.

For Type T T/C : ± 0.5 deg C or + 0.4 %, whichever is better.
Enclosure Class shall be IP 65/ Explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

All Thermowells in high velocity steam service shall be checked for Strouhal's frequency limit to arrive at a safer size and design of Thermowells.

**Metal Temperature Thermocouples (if applicable)**

Measuring medium shall be metal temperature. Material of thermocouple shall be Chromel Alumel Type K. Type of thermocouple shall be duplex with separate hot junctions, ungrounded. Characteristics of thermocouple shall be of special limits of error as in ANSI thermocouple MC 96.01. Enclosure Class shall be IP 65/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**Temperature Switches (TS) (if applicable)**

Type/construction of switch shall be industrial type inert gas filled with capillary and separable thermo well and contacts directly connected to bourdon element/vapour pressure sensing, gas filled, bellows type preferred. Capillary shall be armoured stainless steel. Accuracy shall be One (1) percent of setting and differential. Repeatibility shall be 0.5% of setting. Contacts number shall be DPDT/2 SPDT with snap action micro switch.

Capillary length shall be as per requirement. Packing glands shall be provided. For high pressure service, steam temp, Fuel oil temp. measurement as per required rules and regulations. Switches designed for cross ambient operation shall be used in applications where the ambient temperature will approximate or exceed the switch set point. Enclosure Class shall be IP 65/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**Temperature Indicator (TI)**

Local thermometers shall be of the bimetallic or gas expansion, dial-type. Mercury in glass thermometers will not be accepted.

The bulbs shall be of stainless steel and of adequate length to ensure sufficient penetration into the measured fluid to give a precise measurement.

Local thermometers shall have an accuracy of ± 1 % of the span range (FSD) or better and shall be insensitive to ambient temperature variations, shocks and vibrations. Response time shall be maximum 15 seconds without thermowell and 30 seconds with thermowell. Local pressure gauges and other dial instruments shall be of a standard 150 mm diameter. The hardened shatter proof front glasses shall be of the anti-glare type.

Capillary shall be made of armoured SS (Applicable for capillary Type). Capillary length shall be as required.

Enclosure class shall be IP 66/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**E. Level Measurement**

**Direct Mounted Displacer Type Level Transmitters (LT).**
Type/construction shall be external float (displacer). For corrosive liquids, suitable anti-corrosive coat/lining shall be provided. Material of float shall be of SS316. Material of torque tube shall be of SS316/Monnel. Overall accuracy shall be 0.2 % of span. Electronic output shall be 4 to 20 m Amp. DC (Two wire), HART. Power Supply shall be 24V DC nominal. Local LCD indicator with scale of engg unit shall be provided.

Accessories like matching SS flanges with bolts, nuts and gaskets, drain valve, air filter regulator shall be provided. state of art and field proven displacer type level transmitters shall be provided.

For oil and corrosive Separator diaphragm seals for liquids shall be provided.

Enclosure class shall be IP 66/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**Ultrasonic Level Transmitter**

Principle of operation shall be “Detection of reflected ultrasonic pulse based”. Measuring Ranges shall be up to 30 meters (typical). Signal processing shall be microprocessor controlled. display shall be large alpha-numeric back lit LCD/LED. Diagnosis shall be on-line. Power supply shall be 230V AC 50 Hz / 24V DC. Signal output shall be 4-20 mA DC (isolated) with HART. Accuracy and repeatability shall be ± 0.25% of span or better. Cable connection shall be plug in type. Accessories like cable gland, prefab cable and mounting accessories like canopy, SS316 flanges etc. shall be provided.

Enclosure class shall be IP 65/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**Capacitance Type Level Transmitter**

The total system shall consist of capacitance probe, pre-amplifier and transmitter. Probe shall be rod or suspended electrode and rope type probes may be used only where required probe length is greater than 3 meters. Material of construction shall be 316 SS. Accuracy shall be ± 1% of full scale. Enclosure shall be conforming to IP-65, (Explosion proof for NEC Class 1, Division 1 area). Response time shall be 100 msec or better. Accessories like counter flange, cable gland, prefab cable if any shall be provided. Preferable features like alarm output contacts with adjustable set point facility shall be provided.

**Guided Wave Radar/Radar Level Transmitter**

The type shall be guided wave radar (contact type)/radar (non-contact type) as per specification. Application shall be for turbine lube oil tank, HSD tank level, condenser hotwell and LP heaters, and other low pressure/vacuum vessels. Environment Class shall be highly abrasive with gases and fumes. Probe material shall be SS 316. Accuracy shall be ± 5 mm. Type of Transmitter shall be SMART, 2 Wire. Operating Principle shall be Time Domain Reflectrometry. Enclosure Class shall be IP 6.5 Local LCD/LCD display shall be provided.

**Level Switches (LS)**

Level switches shall be external float cage type with magnetic switch actuator/conductivity type/capacitance or RF type depending upon the application.
Displacer type top mounted (for all clean water sumps) and conductivity type (for high Pressure and high temperature enclosed vessel like drain pot, HP heaters etc.

Float/displacer material shall be SS316. Sensing probe material shall be stainless steel 316

Number of Contacts shall be DPDT/2 SPDT. Accuracy shall be One (1) percent of setting and differential. Repeatability shall be one half (1/2) percent of setting. Contact Type shall be snap action micro switch.

Electronic unit for conductivity type level switch shall be separate

Accessories shall be provide with counter flanges, still pipe of requisite length with anticorrosive coating for sump services.

Enclosure class shall be IP 65/ explosion proof for NEC Class 1, Division 1 area/flame proof as per requirements.

**Level Indicators (LI)**

Local level indicators of tanks can be gauge glass (reflex or tubular)/magnetic type/float and board type depending on the application. Level gauge shall be equipped with a scale in cm and of sufficient length according to the height of the tank. The level indicator shall also have a scale in percentage.

For local measurement at pressurised vessels the bicolour water indicator type shall be used. For clear readability electric illumination shall be installed. For chemical vessels, each of the level indicators shall be provided with a scale of two (2) sides, one side in level units (e.g. cm) and the other side in volumetric units (e.g. cm³, m³, etc.)

Clear readability under all conditions, day and night shall be guaranteed whether with internal illumination, spot light, street /area illumination or by any other way which is the Bidder’s responsibility.

All tubular glass type gauges shall be furnished with safety protective shields.

Tank gauging systems of suspended float type, where provided, shall have all components of 316 stainless steel; this includes the materials for wire, pipe, fittings, sheave elbows, etc.

**F. Flow Measurement**

**Flow Meter and Transmitters**

**Primary Elements**

Concentric orifice plates shall be used as the standard measuring method. Flow straighteners, and minimum upstream and downstream straight piping lengths shall conform to concerned International standards and codes. Other flow measuring methods, like turbine wheel or ultrasonic, shall also be acceptable.

Orifice plates shall be 316 SS and will not be less them 3 mm thick up to 300mm pipe and not less them 6mm for pipes having more diameter. Beta ratio will be determined by the Bidder based on the service but will be between 0.34 & 0.70.
For metering applications, vortex, flow turbine type, ultrasonic, magnetic or positive displacement methods may be used.

Flow nozzles shall be used for steam flow measurements. It shall be of 316 SS. vent holes, located at top and drain holes at bottom of nozzle. Beta ratio shall be around 0.7. Flow nozzle shall be supplied with 3 pairs of D and D/2 tapping nipples, primary root valves, and maintained branch pipes. Bidder shall submit sizing calculations of flow elements during detailed engineering for Owner/Engineer review and approval.

For large size diameters magnetic or ultrasonic measurement techniques may be used.

The throats of flow metering nozzles and orifices shall be properly protected against erosion by means of stellite lining.

**Transmitters**

The differential pressure transmitters used for flow measurements shall withstand maximum process pressure with one side at atmospheric pressure.

The square root extraction of the measurements shall be carried out within the DCS.

**Indicators**

Local flow indicators may be of differential pressure type, propeller type, lever type or floating body (variable area) type. U-tube manometers and mercury filled instruments shall not be permitted.

The accuracy for the indicators shall be ± 2 % of the maximum measuring range or better.

Sight flow gauges shall be of the through vision type, with a glass window at each side of the flowing

**G. Vibration Measurement**

All motors, pumps and rotating machine above 1 MW shall be equipped vibration monitoring system. Vibration shall be measured in both X and Y directions. Each vibration monitoring shall provide raw data and alarms to DCS.

The following criteria shall be used as a guideline for rotating machinery, in order to ascertain the monitoring points, principles of what signal shall be measured, what is displayed, and what mechanical conditions entail alarm and/or trip status:

Non-contacting proximity probes shall be provided unless otherwise specified for measuring rotor shaft vibration and axial position. They will also be used to determine phase angle of primary rotor imbalance.

Vibration measurements shall be in displacement microns peak to peak.

System and equipment shall meet the requirements of API 670 or equivalent International Standard.
In cases where, because of process conditions, accessibility or non-critical service may entail the use of machine casing mounted vibration transducers, the transducers shall be of the "acceleration" type incorporating a filter network, if necessary, along with integration in the monitor unit for vibration read-out in velocity mm/s RMS. For alarm only, one (1) transducer may be used.

For alarm and trip conditions three (3) transducers shall be used with a voting system (i.e. one high reading out of three -alarm, two out of three trip). Contacting type transducer systems and equipment shall meet the requirements of ISO 2954.

Velocity type transducers shall be used as an alternative to accelerometers when machine rotational speed and generated vibration frequency conditions dictate.

The performance of the devices must not be impaired by the temperature variation in the surroundings. The devices must be protected, if required, against heat by employing suitable radiation shields, isolation pads etc. However such use of protection must not degrade the performance of the device.

For STG Vibration and Condition Monitoring system can be supplied by OEM vendor but in any case shall be connected to DCS for alarm and data transfer.

All Generators shall have their own complete condition monitoring and diagnostic system for the windings’ vibration and temperature.

Facilities like shaking table shall be provided for calibrating and testing each measuring channel be used.

11.9.3.3 FINAL CONTROL ELEMENTS

A. Control Valves

The control valves and accessories shall be designed constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler and pressure vessel code, ISA, and other standards specified in section 11.1.1

All the control valves and accessories offered by the Bidder shall be from reputed, experienced manufacturers of specified type and range of valves.

All drain and vent valves shall be equipped with actuators for remote control, which shall be operated during start-up, normal operation, and shutdown of a unit. Local controls shall be limited to the necessary minimum and be applied only in systems which do not require direct control during start-up, normal operation and shutdown regimes.

The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve stem travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. While deciding the size of valves, the Bidder shall ensure that valves outlet velocity does not exceed 8 m/sec for liquid services, 150m/sec for steam services and 50% of sonic velocity for flashing services.
Sizing CV shall generally be calculated based on normal pressure drop and 1.5 times normal flow. However, when maximum flow is greater than 1.5 times normal flow, size CV shall be calculated based on 1.1 times maximum flow.

Control valves for steam and water applications shall be designed to prevent cavitation, flashing on the downstream side of valve and downstream piping.

Double seated valve leakage shall not exceed 0.5% of rated capacity. Single seated valve leakage shall not exceed 0.01% of rated capacity.

Valve stem shall be polished and finished to 2-4 Microns RMS in case of teflon packing.

Hysteresis of valve shall be limited to 5% of input signal span for valves without positioners and 0.5% of input signal span for valves with positioners.

All on-off control valves and prime mover breakers shall be provided with switches and/or relays to indicate status remotely. Valve and breaker status indication logic shall be as follows.

- Valve fully closed or breaker open  - Green light on
  - Red light off
- Valve fully open or breaker closed - Green light off
  - Red light on
- Valve in mid-travel  - Green light flashing on
  - Red light flashing off
- Abnormal circuit condition  - Amber

**B. Valve Actuators**

For control and on/off valves and dampers pneumatic, electric actuators, solenoid actuators or electro-hydraulic actuators shall be used.

Each control valve/damper actuator shall include an inductive position transmitter with 4 – 20 mA output signals.

Electric actuator enclosures with position transmitters and limit switches shall be provided with space heaters to maintain the inside temperature above dew point if required.

For valve actuators ‘ON’/’OFF’ type or regulating type, the limit switch opened and limit switch closed, Torque switch opened and Torque switch closed acted indication shall display in to HMI station. Both switches shall be hardwired up to digital input module in order to display the actuator acted status.

An adequate allowance for stem force, at least 0.15 Kg/sq.cm per linear millimetre of seating surface, shall be provided in the selection of the actuator to ensure tight seating unless otherwise specified.

The bypass control valves shall have the stroking time of not more than 3-4 seconds for fast opening and 10-15 seconds for normal stroking.
All control valves shall be of tight shut-off design and the actuators shall be designed for maximum shut-off differential pressure acting across the valve.

All actuator accessories such as air locks, hand wheels/hand-jacks, limit switches, torque switches positioners, solenoid valves, diffusers, external volume chambers, position transmitters, tubing and air sets and junction boxes etc. shall be provided as per the requirements.

Pneumatic positioners shall be side mounted, weather proof type, complete with pressure gauges. All control valves having positioners shall have mounting plates with drilled holes for mounting of air filter regulators. All air connection shall be 1/4" NPT (F) unless otherwise limited by conditions such as speed of response.

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.

A hand wheel shall be provided for manual operation. Provision of locking device for manual operation to prevent unauthorized operation of actuator shall be provided.

**Electrical Actuators**

The electric motor actuators for isolating valves/dampers shall be equipped with an integrated power control unit, i.e. external reversing or thyristor starter cabinets shall not be provided.

**Pneumatic Actuators**

Pneumatically driven control valve assemblies shall be provided with electro-pneumatic positioner, limit switches, position transmitter, pressure gauges, air filter regulator set, air lock relay and hand wheel.

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

On failure of instrument air, electronic signal, and/or power supply it shall be possible to design the valve to open, to close or to remain in the last position. A defined seating force shall be adjustable, if air-to-close action is desired.

**Solenoid Actuators**

The solenoid valves shall be of standard weather- and waterproof type. The insulation of the coils shall be of class "H". The solenoid valves shall have a manual testing facility with a tool or special key for testing purposes and normal status indication to avoid misuse.
Three-way solenoid valves shall be designed for universal operation so that the supply air may be connected to any port. Solenoid valves shall have either pigtail wires or screw terminals for electrical connections. Valves shall be selected to incorporate body construction, trim materials, and internal arrangements suitable to the application. Solenoid enclosures shall be IP65 for outdoor and IP54 for indoor or NEMA 4. For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location.

Hydraulic Actuators

Generally, these actuators shall only be used where high thrusts are required combined with fast operating times.

The units offered shall be of the self-contained fully sealed types which allow removal of the complete unit to a clean room for any maintenance requirements. Units accepting either 4 – 20 mA signals or pulsed input signals shall be acceptable.

Failure of the internal hydraulic supply shall result in the actuator locking in its last operating position or stroking to its fail safe position and a suitable alarm being given to the operator.

11.10 Distributed Control System (DCS)

Existing Turbine Control System Description:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>GE</th>
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</thead>
<tbody>
<tr>
<td>Model:</td>
<td>Mark V</td>
</tr>
<tr>
<td>Type</td>
<td>Speedtronic</td>
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</tbody>
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11.10.1 General

A fully integrated unitary DCS (ABB(Germany, USA, Singapore), Foxboro(USA, Singapore), Siemens(Germany), Alstom (France), GE (USA) to be supplied for monitoring, control, display, alarm and recording of selected physical and electrical parameters associated with GT, HRSG, STG and associated auxiliaries and plant BOP system. All monitoring and control interactions shall be done via VDU, keyboard and Mouse/Track ball.

All the hardware software’s shall be latest and field proven as available in the market. The Bidder shall offer latest system available and shall also confirm that DCS system hardware / software shall be upgraded free of cost (for hardware up to commissioning of the project and software up to handing over of the project), whenever at later stage such upgradation takes place for his system offered by him or by his collaborator.

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 (reference DCS Control Hierarchy – Model MML-351715-I-DR-00-00-202). 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:

- Integrated with existing GT Control & Protection
- Boiler 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 Bidder shall account for the following requirement. The operational functions of control, and supervision of the combined cycle power plant, its auxiliaries, the 132 KV substation, 11 KV, 6.6 KV and 400 V station and unit switchboards, and emergency diesel generator shall be carried out remotely from the Central Control Room (CCR).

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 Bidder 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.

It is to be noted that, heterogeneous solution for the proposed control system of the Steam Turbine and HRSG shall not be accepted.

The use of black box systems with PLC's or local controls for ancillary Plants or systems shall be limited and shall be subject to the Engineer's approval including the selection of the manufacturer/type of the control system. PLC's or digital control systems shall be of a uniform type, compatible with the main DCS system and built redundant in accordance with the requirements outlined in Specification Volume 2, Section 11.12.

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.

11.10.2 DCS System Description

11.10.2.1 General Requirements

One unified Distributed Control System (DCS) based on free configurable microprocessor and of approved design for power plant application shall be used.

Human interfacing with process shall be done via Process Operation Station (POS).

It is the Bidder's responsibility to provide a control system, which fulfils all approvals by the respective authorities.

The overall coordination, monitoring and control of the power station plant and the main operator interface shall be via the Central Control Room and the Local Control Room (CCR/LCR connection). This connection shall be designed to have a functionally and geographically distributed architecture utilizing a number of independent controllers. These controllers shall be capable of autonomous operation and provide control, both continuous and sequential control, data acquisition and calculation facilities.

DCS system shall be have 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 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.
➢ 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.

➢ The following guideline shall apply regarding the data loading of various items of DCS and the response time of the system, which will determine the extent of functional distribution.

  o Maximum permissible loading of various components shall be as follows:
    o Multi-loop Multifunction Controller - 60%.
    o Input / Output - 80%
    o Console - 80%
    o Historical Storage - 75%
    o Data Highway / communication link - 60%

➢ Response time of the control system should be adequate to maintain control over the process under all regimes of operation. Response time shall include the delay and dead time both internal and external to DCS. Response time pertaining to DCS shall include the I/O scan time, data communication time, processing time etc. Maximum permissible response time for various functions is as follows:

  o Data acquisition
    Analogue values-500ms
    Binary values-250ms
    Time critical binary values like position or torque feedback signals ≤10ms
  o Closed loop control
    Fast control loops (critical loops)- 250ms
    Slow control loops- 500ms
The digital inputs for SOE shall be monitored at 1 milli second resolution.

- 1 s to get an alarm on the display;
- Updating of process variables and conditions
  - Analogue inputs ≤ 2sec
  - Digital inputs ≤ 1sec
- Reaction time from issuing command up to execution (Switching relay of control actuators) ≤ 1.5sec
- Signal change (check back signal from individual control level) up to display on monitor ≤ 1sec

The DCS 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 Bidder shall identify the extent to which his proposed DCS achieves multi-vendor inter-operability. The Bidder 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 authorization, 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.

(l) 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.

11.10.2.2 System Design: Redundancy of Control Equipment

Operational availability of the entire control system is of prime importance.

The CPU / Controllers, communication modules, data highway, power supply modules, etc. for all DCS shall be 100% hot standby redundant. The I/O’s & communication modules of DCS should be hot swappable and auto reconfigurable and the replacing of such modules should not affect the monitoring and control process or causing tripping of unit.

Hot standby 100% redundancy shall be provided for all input/output cards where inputs/outputs are used for critical loops. No redundancy at I/O card level is required which are executing purely data acquisition/monitoring functions.

In addition to above, 20% wired input/output spare channel should be provided for each I/O modules

The Bidder 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

11.10.2.3 DCS Hardware Requirements

A. Controller

Each controller envisaged for this project shall have following features as minimum:-

• Processing word length of 32/64 bit (Preferably 64 bits)
• Redundant power supplies
• Power fail/auto start feature
• Self-monitoring & diagnostic feature
• Real time data controller, computer/PC based soft controller are not acceptable.
• Redundant communication ports with speed of 100Mbps or more
• Deterministic communication with other controllers through switches
• Redundant controllers placed separately and no sharing of motherboard
• Hot-withdrawable and hot-insertable
• Processing time of parameter freely configurable
• Time stamping, limit value monitoring

These controllers shall be capable of performing open loop control, closed loop control, logic, supervision and monitoring functions.

The quantity of controllers shall be decided based upon the capacity of the controller and the plant configuration. However the processor load should not be more than 60 %. The bus loading must not exceed 60% in plant upset conditions.

B. Input/Output

I/O Module shall have features not limited to the following

• Interface with field sensors, signal conditioning, A/D conversion, signal validation, diagnostic, engineering conversion, etc.
• Interface with smart transmitter though smart interface module with optical and galvanic isolation
• Failure reporting.
• Replaceable under system power on condition.
• Backplane mounted non-redundant I/O bus and I/O communication processor shall be redundant.
• Galvanic/optical channel to channel Isolation shall be built in module. The current limitation shall not be considered as channel isolation.
• All the I/O modules should have fuse protection or protection against short circuit of input or output signal in the field to avoid the damage of module.

The number of channels for I/O shall be not more than 16 for Analogue I/O’s and 32 for Digital I/O’s

C. Power Supply Configuration and Modules

Redundant 24 V DC supplies shall be input to the DCS process control station by two (2) separate cables from two (2) separate battery systems. De-coupling diodes shall be provided inside the control station. Power supply modules inside the control station shall be provided redundant. Redundant I/O modules, interface modules, etc., shall not be supplied via a single fuse. No power supply looping is permitted between cabinets.
D. Communication and Interface Modules

All communication and interfacing modules shall be redundant. The modules shall serve for

• Communication with the process bus system;
• Communication with the remote I/O’s.
• Interface to the portable diagnostic/configuration device, etc

E. Human Machine Interface (HMI)

The bidder must provide HMI package platform working on Latest version of Windows operating system. The backup interval for continuously trended data (at least 50 parameters) should be minimum six months.

Programs defining the operation of modulating control systems, sequence control and interlock systems shall be held in non-volatile memory such that they will not be corrupted on loss of power supply. Suitable facilities shall however be provided to modify control parameters and control and interlock logic by modification of the appropriate programs held in the control equipment. Program back up facility to compact disk of interface computer shall be provided. As a minimum, the following configuration shall be provided:

• Processor: 64 bit
• Ram: 4 GB minimum
• Hard Disk: 500 GB minimum
• Frequency: 3 GHz minimum
• CD/DVD writer as applicable for backup/ restores functions.
• Monitor: dual VDU, 24" High resolution LED Full flat monitor
• Track ball
• Membrane Type key board with configurable function keys
• Optical storage device of adequate capacity

Wherever required, CPU and other peripherals shall be fitted in appropriate dust and weatherproof enclosures with forced ventilation arrangements.

Operator’s window to the process shall be various workstations with colour LED monitors, keyboard, mouse, colour laser jet printers, large video screen monitors, multimedia beeper/buzzer etc.

Operator's terminals shall permit the operation and monitoring of the unit under normal condition and in all emergencies.

The operating system on the workstations running the HMI functions shall be a standard, reliable, well known, state-of-the-art Windows based OS system
Each HMI shall be adequate with all operators’ function such as quick access to plant & process. Complete operation of the unit shall be possible from any operator station. Multiple active windows, not less than 4 (four) nos. simultaneously, shall be displayed on the HMI screen.

Display navigation shall be with least number of keystrokes or steps.

F. Large Video Screen (Optional)

Bidder shall offer Two (Nos. 02) 84” LED large video display/screen (LVS) along with associated workstations, placed upright in front of the operator with seamless integration with DCS for monitoring salient plant parameters, plant status, alarms, graphics etc. The LVS controller/s shall interface with DCS for monitoring and display of real time information. LVS shall be placed in the central control room.

The system shall display complete and partial overview of the plant, alarms in the form of normal window appearance, important parameters of the plant and the electrical system in the form of SLD etc.

The software shall have capability to display multiple windows on the screen. The system shall have facility to zoom on any part of the display.

The display program shall be such that the entire viewing area of the screens is utilized and sides are not left blank. It shall be possible to call up a screensaver display to show Owner's company logo when the screens are not in active operation.

LVS shall primarily be used for:

• Display of important data, graphics
• To provide real time clear luminous view to share information to operators and visitors.

The offered system should be able to work in 24/7 days environment and is of industrial nature.

G. Engineer's Workstations

Redundant Engineer's Workstations and Historians shall be provided, with 24 inches LED monitor.

It shall perform programming /configuration of complete system and HMI and perform system diagnostic. System shall be adequately protected with software & hardware locks etc., against any inadvertent and un-authorized access.

It shall be capable of storing data, loading, editing, testing, tuning, and monitoring all the controllers. System shall be complete with monitor, keyboard, mouse and colour laser jet printer.

H. Historical trending & Recording

Bidder shall provide redundant historian system on the plant network for the storage of historical trends, plant data, alarms, events and parameters. An optical disk drive with on line retrieval and storage arrangement for storing the historical files shall be provided. Minimum capacity of the Historian System shall be 1TB, however the system shall be sized to store data for 5 years of plant operation. It
should be possible to store and retrieve the data from the storage device in the file format and it should be possible to query and sort the data by time & date. It should be possible to have historical recording with a resolution of 1 sec to 24 hours and these timings should be selectable from the operator station.

I. Sequence of Event Recording (SER)

Sequence of events list originating from turbine control system must be interfaced with the DCS system provided by the Bidder. Pre-trip and post-trip reports shall also be provided. Production reports for the shift, day, week, month etc. should be provided in the DCS system so that the data from the turbine control system can be properly logged and printed.

J. Alarm

All the alarms originating from the turbine control system must be communicated to the DCS, seamlessly integrated into the alarming system of the DCS and should be stored in the history alarms in the DCS. Acknowledgement and resetting of alarms must be possible provided the control location is on DCS. However, if the control is on local or remote location and still if the alarms are acknowledged or re-setted from the particular location, the alarm screen in the DCS system must be automatically refreshed to display the latest status of the alarms. The alarms indicated in the DCS alarm screen must display correct alarm status in respect of alarm time, alarm text, alarm state etc. At any given time the alarms appearing in the DCS must fully and exactly match with those appearing in the turbine control system and auxiliaries. All alarms shall be available at all workstations of the DCS, without any restrictions.

K. Printers

Printers for Alarm, Log, Report, Trend and Mimic print out. Alarm and event logs shall be of 1msec resolution time stamping. All printers shall be Network Printers.

11.10.2.4 DCS Software Requirement

A. General

The latest version of the manufacture's operating system software shall be provided fully developed, tested and installed at the time of Preliminary Acceptance Test.

The use of standard proven software is required. All necessary software licenses shall be included. All software must be in English language only.

All non-critical applications, system and executive programmes shall be written in a structured high level language except where time criticality forces the use of assembly languages.

The bidder shall supply details of Quality Plans and software development procedures used in the production of all systems and application software used for the project.

The application software and associated displays, reports, databases, etc, shall be configured and fully tested when installed at site. The creation or modification of
displays, reports, databases or control strategies shall be possible with the system on-line by the engineering personnel without affecting the plant operation, Modifications to the software shall be done in straightforward and logical steps using, wherever possible, graphic displays.

B. System Loading and Backup

The plant instrumentation & control systems engineer shall be provided with the facility to load all software and data not held in non-volatile memory, from a transportable medium.

A comprehensive backup utility shall be supplied which allows the user to transfer plant configuration and displays date onto a medium, which may then be stored away from the system. This utility shall cover backing-up of database configuration built on the system in an off-line mode and not in use on the operational system. A cartridge tape drive or optical disk drive shall be provided for storage of the backup files and data. The utility shall also be provided to faithfully restore such backups in case of a requirement.

C. Operator interface software

The operator interface software shall enable the operator to carry out the necessary actions in a safe and efficient manner. In particular the following features shall be included, as a minimum:

• software shall be structured in such a way so as to provide a hierarchy of control from automatic sequential plant start-up through to manual control of an individual item

• during manual intervention by the operator (sequence initiation and individual device control under normal and failure conditions), all software derived, hardwired and overrides shall be visible to the operator

• where process measurements have been duplicated for improved reliability, the signals shall automatically switch to the good signal in the event of a fault. The operator should have, for the purposes of maintenance, the on-screen facility to select either signal or the average, as the measured variable of control

D. Test Software

Test software shall be supplied with the system and this shall confirm to the same standards as system software.

The software shall ensure that there is no risk of corruption of operational data in this mode of operation.

E. Protection of software against malicious programs

The bidder shall supply a complete cyber security system, to protect the control system software against malicious programs from internal and external attacks. Such software must be duly licensed and upgradeable for a period of five years after commissioning and commercial operation of the system. Any external link or access to DCS must be firewalled and only in read only mode.

F. Software and Licenses
All software must be duly and fully licensed. The original software diskettes, CDs, Tapes etc. along with manuals and other accessories must be handed over to Employer. All the licenses also must be handed over to Employer. The operating systems software must be upgraded with latest available service packs suitable to the control system. All software must be freely available for use to employer.

G. Security

Key switch or password protection shall be available for all engineering and supervisory functions, which allow database configuration and editing. Security levels shall be 3 or 4 and shall be finalized during technical discussions.

The characteristics of each of the devices or attachments on the apparatus side of the interface required to permit the desired functions shall be compatible in every respect for interfacing to the telemetry remote station.

11.10.2.5 Communication Network Bus System

Basically two types of bi-directional bus systems shall be envisaged. Remote bus system to communicate between stations by use of co-axial cable or fibre optic cables and industrial grade managed type Ethernet switches within built diagnostic features, 20% spare ports and redundant 24 V DC power supply shall be provided with control system.

Local bus to communicate between the different modules/cards of the same station/system and extensions.

The bus system shall have the following features.

- Redundancy in the system for high reliability of communication.
- The redundant buses work continuously.
- All bus couplers, bus interfaces etc. shall also be redundant.
- Insensibility against external disturbances, noises etc.
- Insensitivity of a fault in one bus system to other bus system.
- High data transmission rate to communicate with the system response requirement.
- Availability of information of all modules at each point of the system.

The characteristics of the local bus (I/O Bus / Peripheral Bus) and control bus (Data highway) shall be as follows or better:

**I/O Bus / Peripheral Bus / Local Bus / Cubicle Bus**

<table>
<thead>
<tr>
<th>Redundant</th>
<th>Transmission rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>10 Mbps or better</td>
</tr>
</tbody>
</table>

**Control Bus (Data Highway)**

<table>
<thead>
<tr>
<th>Redundant</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Transmission rate 100 Mbps/1Gbps

Highway Characteristics

Communication between the operator station and the functional groups of control microprocessors shall be by means of redundant data highways. The system shall be fully operational with one highway out of service, with no degradation in performance. The data highways shall be effectively immune to the types of electrostatic and electromagnetic interference that can be expected in the power plant. To end this fibre optic highway is preferred. If the vendor does not supply a fibre optic highway, he must state, in detail, the precautions which must be observed in installing the highway in order to immune interferences and shall also state whether precaution must be observed to avoid ground loops due to differences in ground potential throughout the plant.

The communication network shall have the possibility of adopting "open architecture" to enable the user to get the benefit of flexibility in choosing hardware and software. Network shall also be provided with external surge protection system and industrial firewall.

**Industrial grade managed type Ethernet switches**

High performance industrial grade layer 2/3 managed type redundant Ethernet switches shall be provided with in built diagnostic features, 20% spare ports and inbuilt redundant 24 V DC power supply features and integrated security features (IPS, ACL, Firewall).

11.10.2.6 Interface with Other Control system

Plant Auxiliaries and BOP systems which have a proprietary control system shall be interface with Plant DCS via serial link interface with redundant Modbus interface.

GT and ST control system shall also be interface with the Plant DCS via suitable serial link protocol.

Data exchange with other control systems (plant auxiliaries/BOP) for control, interlock & protection shall be through hardwired input/output.

11.10.3 Acceptability of Control Systems

The proposed DCS for this project shall 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 proven design (State of the art)

(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 Bidder shall submit sufficient information in response to each of the above items to enable the Engineer to complete his assessment.

If the Bidder 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.

11.10.4 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 Bidder 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 Bidder 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 Bidder 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.

11.10.5 Bidder's Control Room Design Review

The Bidder 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, which will be discussed and finalised.
Bidder shall do a site survey for location of the new control room and appropriately suggest the suitable location for the new control room. It is advised to keep the new control room to be near the existing CCR.

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.

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 Bidder 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 Bidder 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 Bidder shall develop his proposal, tailored for the requirements of this project and for the design characteristics of his equipment. The Bidder shall be required to justify his control room layout, which shall be subject to approval.

11.10.6 Central Control Room Operator Interface
11.10.6.1 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 Bidder shall take into account 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.

11.10.6.2 Equipment and Facilities Associated with the Central Control Room

The CCR shall be equipped with the following:

(a) HMI for Combined cycle power plant control

(b) HMI for Supervisor's control

(c) Printers

(d) HMI for BOP and Electrical systems

(e) Workstation for Fire fighting, HVAC, CEMS, SWAS (as applicable)

(f) Control Desk, consoles and Chairs etc.

(g) Document storage system in a room besides the control room.

Associated with the above, engineering control:

(a) Printers

(b) HMI for Engineer's control

(c) HMI for Manager's control

(d) Employer's commissioning control

11.10.6.3 System Architecture
Refer to Plant Control System Architecture, drawing no MML-351715-I-DR-00-00-0201.

11.10.6.4 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 existing 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 (4)
(c) Operators' workstation (4) each including high resolution colour VDUs (2)
   - Associated functional keyboard and Mouse
   - Workstation computer
(d) Video copier unit (colour)
(e) 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
(f) Working space with telephones

The following minimum 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 existing GT and its auxiliaries
  (a) Emergency trip push buttons (fitted with lift up cover flap to prevent inadvertent operation) for existing Gas Turbine trip, HRSG trip, steam Turbine trip, and generator trip.
  (b) Emergency stop pushbuttons (key lock resettable) shall be provided locally for each major plant drive (uni-directional).

11.10.7 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.

Refer DCS Control Hierarchy Model Block Diagram drawing no. MML-351715-1-DR-00-00-0202

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 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:

11.10.7.1 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.

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.

11.10.7.2 Sub-Group Controls

(a) 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.

(b) Emergency trip push buttons (fitted with lift up cover flap to prevent inadvertent operation) for existing Gas Turbine trip, HRSG trip, steam Turbine trip, and generator trip.

(c) Emergency stop pushbuttons (key lock re-settable) shall be provided locally for each major plant drive (uni-directional).

11.10.7.3 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.

11.10.7.4 Block Co-ordination/Unit Control 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 the existing 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 existing Gas Turbines, HRSG's, and Steam Turbine

(c) Re-start of block, existing 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 existing Gas Turbine "ready list"
(b) Start up of the existing Gas Turbines in the pre-selected order
(c) Auto synchronisation of existing 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
(i) 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.

(l) Preparation of BOP auxiliaries

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 Bidder’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 necessary to produce a complete working system shall be provided by the Bidder.

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.

11.10.7.5 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

For 1:1:1 configuration: Operating existing Gas Turbine is in combined cycle and included in BLC. The measured steam Turbine generation is subtracted from the required block load and the resultant is the load output of the existing Gas Turbine Generator.

ST will follow GT and the loading should stop when the target plant load is achieved

(ii) Existing Gas Turbines in open cycle:

Existing operating Gas Turbines is included in the BLC. 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:

• Existing Gas Turbine generators
• HRSG's
• Steam Turbine generators
• 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.

(iii) Plant Life Monitoring ((Fatigue Monitoring: Boiler, ST)

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

**Turbine Stress Evaluator (TSE) and Life time counter:** TSE shall be provided to analyze, monitor, display and control the thermal stress levels of the turbine. It shall automatically co-ordinate with the auto-run-up program and loading program in order to ensure that the permissible turbine stress levels are never exceeded. In case the allowable safe thermal stress margin is exceeded during run-up/loading, the TSE shall automatically halt the speed/load in position until the thermal stress has come down within the allowable margin, which shall then release the halt of the speed/load, and the run-up/loading program shall then re-start automatically. If the stress margin is exceeded during the run-up program at the critical speed, the TSE shall then reduce the speed to a safe value below the critical speed and halt on it until the stress becomes normal and the run-up program shall then re-start automatically. The safe value below the critical speed shall be well defined as it shall not allow to keep reducing the speed down through the whole range.

In connection with the automatic turbine speed/load control a stress evaluator shall calculate the actual thermal stresses existing on any critical turbine parts and compare them with the maximum permissible stresses. The turbine stress evaluator shall supervise and monitor, based on the surface temperature of the HP-rotor and IP-rotor, the stress of the steam turbine during all operating conditions and forms signal that limits the steam turbine controller. (Depending on bidders offering and subject to Owner’s approval)

Because the surface temperature of the rotor cannot be measured, a substitute metal temperature shall be provided. This measurement includes thermocouples, which shall be installed at proper places where the temperature of admission steam is identical with the temperature of the rotor.

The difference between actual and maximum permissible stress value shall determine the maximum permitted gradient of turbine speed or load changes.

Turbine speed or load permissible gradient variation shall be indicated in the central control room. These signals shall be incorporated into automatic turbine speed and load control system. It shall be possible to put turbine stress evaluator on advisory mode operation in which case its output signals shall be only displayed but shall not influence turbine speed and automatic load control.

Alarms shall be provided when the difference between the actual and permissible stress value exceeds its present minimum.

In addition to the stress evaluation, a lifetime counter for the steam turbine shall be provided. The counter shall calculate lifetime reduction compared with rated operation dependent upon stresses, frequency, temperature, warm and cold starts, load changes, over speed tests and other conditions according to the design, data figures given by the OEM.

**HRSG Stress Evaluator and Lifetime counter**

In connection with the automatic control system of the HRSG a stress evaluator shall calculate the actual thermal stresses existing on any thick part of the HRSG (drum, headers, etc.), and compare them with maximum permissible stresses.
Similar to the steam turbine stress evaluator, the permissible gradient variation shall be indicated, recorded and incorporated into automatic start-up of the combined cycle. The stress evaluator of the HRSG shall be effective during the start-up of the HRSG and shall determine the positioning of the diverter damper. It shall not have any effect on the GTG loading gradient. When the diverter damper is fully open and the HRSG is loaded, the stress evaluator shall be disabled.

All other functionality will be similar as those of the steam turbine stress evaluator specified in above clause.

The stress evaluator shall be combined with HRSG Lifetime Counter

11.10.7.6 Modulating Controls

In order to meet the needs of automation, the modulating controls shall incorporate extensive logic control functions including the automatic initiation of:

- bumpless 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 feedforward 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).
11.10.7.7  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 Bidder 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.
Bidder shall provide all graphics for safe and automatic operation of the Plant. This should include graphics of Packaged System, Electrical system (SLD) etc. Color coding will be discussed during detail engineering.

(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.)

### 11.11.8 Signalling to Load Dispatch Centres

Interface equipment and co-ordination shall be provided to facilitate communications with the Load Dispatch Centre (LDC). Bidder to refer DCS-LDC interface drawing no. MML-351715-I-DR-00-00-0511

Redundant interface modules and serial data links to LDC system from DCS shall 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.

### 11.11.9 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 Bidder panel (or breaker panel or control valve or motorised valve) will bypass incoming control signals including permissive interlocks.

The Bidder 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.

### 11.11.10 Emergency shutdown systems/Automatic Trip System
Automatic trips shall be provided to protect the plant and personnel from damage and danger. These shall be independent of any operator action and shall operate on basic plant items in an integrated manner such that dangerous situations shall not be aggravated. They shall be operational at all times, irrespective of the plant control mode and shall be independent of other control and instrumentation systems.

The bidder shall be responsible for the co-ordination and provision of an integrated tripping system which shall interface with other protection systems and initiate the protection requirements of the plant.

The Bidder shall develop in conjunction with all his sub-suppliers a plant inter-trip philosophy document/drawing which shall be used to control and implement the protection requirements of the plant. The document shall clearly identify the areas of interface and responsibility.

The Bidder shall note that the system trip interfaces shall include but not be limited to the following:

- Gas Turbine
- Steam turbines
- Generators
- Steam generators
- Fuel systems
- Fire and gas detection systems
- Unit and station electrical systems
- Manual initiation by the operator from designated emergency shutdown stations.

The protection must not be invalidated under any of the following circumstances:

- Any normal operating conditions with the sequence control in operation.
- Failure of the sequence control equipment
- During maintenance of the sequence control equipment
- During all periods of plant operation

The protective facilities shall normally fail to safety, that is, fail to the condition which would normally protect the plant. All trip and alarm initiating devices shall be independently of any control from indicating devices or signals.

11.11. Control System Technology and Design

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 Bidder with a single
entity (i.e. management group). The Bidder 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 Bidder 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 Bidder 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.

11.12 Black Box

The term "black-box" defines the standardised electrical equipment for the control and power part of an auxiliary system or component which is usually designed, delivered, erected and commissioned by the manufacturer of the mechanical equipment.

The latest proven PLC system shall be provided. PLC of same family shall be preferred for ease of maintenance and spare where ever possible.

In case of using Black Box PLC based system, the redundancy and reliability requirements shall apply as those specified for the DCS and the features be similar

PLC system will be interfaced with DCS through redundant communication links for important process parameters. PLC shall confirm to IEC – 61131.
Protection and control signals between DCS and Black box control system shall be hardwired to DCS. The number of hardwired signals shall be decided during detail engineering.

A local panel display on the PLC cubicle shall be provided. All individual process alarms and system status alarms shall be relayed to the VDU of the PLC. The alarm and status signals of some parameters (i.e. status of main equipment, parameters/signals important for the generation, group alarm signal for process disturbance/ system fault, etc.) shall also be forwarded to Plant DCS for monitoring in the CCR. The systems shall be monitored on the DCS workstations with own mimic(s). Hardware and software failures during data transmission shall be monitored and alarmed.

Following systems shall be considered, however bidder can suggest alternative control system for BOP auxiliaries, which shall be subjected to approval.

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Systems</th>
<th>Type of Control</th>
<th>Interface with DCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel Oil Forwarding (as applicable)</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>2</td>
<td>Demin water</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>3</td>
<td>Plant Air</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>4</td>
<td>Instrument Air</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>5</td>
<td>HVAC</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>6</td>
<td>Chemical Dosing</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>7</td>
<td>Fire fighting</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>8</td>
<td>Diverter Damper</td>
<td>Black Box/DCS</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>9</td>
<td>Service water</td>
<td>Black Box/DCS</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>10</td>
<td>Potable Water (as applicable)</td>
<td>Black Box/DCS</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>11</td>
<td>Water Treatment Plant</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>12</td>
<td>Condensate Polishing (as applicable)</td>
<td>Black Box</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>13</td>
<td>CEMS</td>
<td>Black Box/DCS</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>14</td>
<td>SWAS</td>
<td>Black Box/DCS</td>
<td>Modbus/Ethernet TCP/IP</td>
</tr>
<tr>
<td>15</td>
<td>Emergency DG set</td>
<td>Black Box/DCS</td>
<td>Remote start/stop, group initialisation and monitoring in the DCS</td>
</tr>
</tbody>
</table>

### 11.13 Control desk, panel and console design

The CCR control desks and panels shall be of a co-ordinated rigid design of suitable surfaces for mounting VDU/keyboard units, discreet controls and indications being supplied as part of the DCS and proprietary I&C systems. Desk arrangements shall be as per the existing control room layout.
The bidder shall be responsible for co-ordinating the design of the CCR desks, workstations, panels, furniture, lighting and room fixtures/fittings/finishing to ensure that uniformity of design is maintained and that the aesthetic appearance of the CCR reflects its status in the station.

The desks shall include in their construction, facilities in the desk-top and the base of the units to route cable from VDUs, keyboards, telephones, etc., lockable drawer/storage space, levelling and fixing devices. For free moving devices such as keyboards, etc., sufficient space shall be allocated to prevent excessive movement of the devices during normal plant operation and sufficient protection to prevent stressing of connections or cables. The height of the desks shall be determined by the need of the operator to look over the top at control panels, etc., when he is in his normal position at the desk. There shall be one fully adjustable swivel chair for each workstation plus one additional chair. Control desks and panels shall have a protection rating of IP42.

11.14 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).

11.14.1 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.

11.14.2 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

### 11.14.3 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.

### 11.15 Vibration Monitoring and Condition Monitoring System
Conditioning monitoring system shall be integral part of DCS. The system shall gather the necessary information directly and process and analyse them in real time mode without interacting with the functionality of the control system(s).

Vibration and temperature of rotating or reciprocating machinery over 1MW will directly wired to DCS. 4-20mA will be provided by the MV drive supplier for vibration and temperature monitoring directly in DCS.

The condition monitoring system shall take care of predictive maintenance of all machines / equipment’s. The Condition monitoring system shall provide computerized machinery management with continuous, online data acquisition, archiving, and display capabilities. Static and dynamic data shall be collected; the data acquisition modes can be both automatically and manually initiated, based on alarm conditions, start-ups/shutdowns, and other events.

The data shall be stored in the system as a "fingerprint" taking all influencing variables into account. The analysis computer monitors the changes and gives warning in case of impermissible change. Beside the "fingerprint" also the measured historical data stored in the DCS long-term archives shall be forwarded to the system for monitoring of trend curves and for comparison of the data in different periods.

Condition monitoring for STG shall be supplied by turbine vendor, however the same shall be interface with DCS for alarm and data. The analysis of condition of STG shall be part of STG performance and conditioning monitoring system. The turbine control system shall include necessary hardware and software for protecting and monitoring the machine condition and alerting operators when the vibration exceeds the pre-defined normal range.

The result shall be visualised on the workstations belonging to the system as graphic picture (profile display), as barcharts, tables, etc. One redundant workstation shall be installed for the Condition Monitoring System in Central Control Room. One (1) printer shall be provided which shall be accessible from any workstation.

11.16 Master Clock

An electronic satellite GPS clock system (2*100% redundant system) and calendar device shall be supplied as part of the control system and shall not require resetting after a loss of supply but may be set to reflect standard time so that the time on event records and alarms is consistent with standard time. This clock shall be a master time keeping clock for the control system and shall be able to give output pulse to various subsystem slave clocks. All the timings associated with alarms, trends and other indications shall be based on these timing

The DCS shall be equipped with a redundant GPS-based Master Clock system with NTP Server and IRIG-B output (modulated and un-modulated). This shall feed the time signal to all workstations and Controllers on the DCS network, including wall clocks system

The Master clock system shall be state of art and as a minimum include one (1) no. common redundant master clock, necessary number of slave clocks, independent power supply equipment and specified interface for synchronisation all the control and protection systems, installed at site to ensure uniform time
indication throughout the various plants facilities and time synchronization between various systems.

Master clock system shall be located in the equipment room of the central control room. The DCS system shall be synchronised with the master clock system at least once an hour. The stability of the master clock system shall be better than 10ms/day.

Master clock shall have separate signal conditioner facilities to transmit clock pulses for time synchronizing other equipment in the power plant such as DCS system, GT control system, ST control system, Black box control system for BOP, SER and for all microprocessor based system like Emission monitoring system, Steam and water sampling and analysis system, Switchyard SCADA, Generator Protection/ Metering System, and other Numerical Protection Relays of the plant electrical system etc.

The DCS shall be synchronised with the master clock once in every hour. The SERs shall be synchronised with master clock every 15 minutes. The master clock shall be located in central control room and shall have facility for automatic synchronising with external radio/satellite signals. Slave clocks shall be located at various plant facilities.

11.17 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. The exact location of the monitoring station(s) shall be decided during detail engineering.

The following parameters shall be monitored:

- Wind Direction
- Wind Speed
- Ambient Temperature
- Ambient Pressure
- Solar Radiation
- Relative Humidity
- Rainfall

Weather station shall allow monitoring, logging of parameter values, archiving and report generation for environmental monitoring authorities and plant management personnel.

Output signal of all meteorological monitoring analysers shall be connected to plant DCS for monitoring, archiving and report generation for environmental monitoring authorities. Necessary software for the purpose shall be loaded into DCS.
11.18 Continuous Emission Monitoring System (CEMS)

A common CEMS panel for GTG/HRSG (i.e. Bypass & Main Stack) shall be provided; this panel shall be placed in the CEMS shelter near the Main HRSG Stack.

Continuous Emission Monitoring System shall include the following:

i. Continuous monitoring equipment for the following exhaust gas emission and reference parameters shall be provided for each GT bypass stack and each HRSG stack: NO\textsubscript{x}, SO\textsubscript{2}, Total Particulate Matter (TPM), O\textsubscript{2}, CO, CO\textsubscript{2}, exhaust gas temperature and exhaust gas pressure.

ii. Data acquisition module (pre-processing unit)

iii. One (1) Redundant workstation with one (1) A4 coloured printer common for CEMS for separate evaluation of the emission monitoring and sample analyses results with connection to the main DCS, allowing extraction of the emission monitoring data and relevant reference parameters from the DCS for environmental analysis. The PC workstation shall be located in the Central Control Room (CCR), refer to ‘Schematic Diagram CEMS’ drawing No. MML-365191-I-DR-00-00-501

iv. Submission of monthly report of emission to be Bangladesh EPA as applicable

The system main components shall be:

- Sample probes
- Temperature controlled heated sample lines
- Condensate pots
- Sample gas pumps
- Sample coolers
- Solenoid valves system
- Multi-component analyser system
- Calibration gas bottles filled with gas for automatic calibration
- Data acquisition modules
- Emission calculator
- Emission Monitoring computer system for data evaluation

The sample coolers, analysers and pre-processing equipment shall be installed in an air conditioned shelter near to the main HRSG stack.

11.18.1 Measuring Instruments

Measuring modules for NO\textsubscript{x}, SO\textsubscript{2}, CO, CO\textsubscript{2}, O\textsubscript{2}, as well as total particulate matter (TPM), Temperature and Pressure shall be provided for each monitoring station and be capable of future system extension (addition of sensor modules).
For the gaseous substances a multi-component analyser system shall be used. Analysers including cubicle and sampling probe with self-testing and auto calibration shall be provided.

Following is the minimum specification for each measurement:

### NO$_x$

<table>
<thead>
<tr>
<th>Method</th>
<th>Non-dispersive infrared absorption or UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring ranges:</td>
<td>0 - 1000 ppm in appropriate ranges;</td>
</tr>
<tr>
<td>Resolution:</td>
<td>better than 0.5 % of full scale of range used or 1 ppm, whichever is greater;</td>
</tr>
<tr>
<td>Repeatability:</td>
<td>better than ± 1 % of full scale of range used or ± 1 ppm, whichever is greater;</td>
</tr>
<tr>
<td>Stability:</td>
<td>better than ± 2 % of full scale of range used or ± 1 ppm, whichever is greater, over a period of 2 hours;</td>
</tr>
<tr>
<td>Zero drift:</td>
<td>better than ± 1 % of full scale of range used or ± 1 ppm, whichever is greater, over a period of 2 hours;</td>
</tr>
<tr>
<td>Noise:</td>
<td>0.5 Hz and greater, less than ± 1 % of full scale of range used or ± 1 ppm, whichever is greater, over a period of 2 hours;</td>
</tr>
<tr>
<td>Response time:</td>
<td>&lt; 5 s from entry of the sample into the analyser to attaining 95 % of the final reading;</td>
</tr>
<tr>
<td>Signal output:</td>
<td>4 - 20 mA</td>
</tr>
<tr>
<td>Status signal outputs</td>
<td>Shall be provided and linked to the DCS;</td>
</tr>
<tr>
<td>Power supply:</td>
<td>230 VAC, 50 Hz UPS;</td>
</tr>
<tr>
<td>Ambient op. conditions:</td>
<td>7 - 50 °C;</td>
</tr>
<tr>
<td>Calibration gas to be included</td>
<td></td>
</tr>
</tbody>
</table>

### SO$_2$ Monitor

<table>
<thead>
<tr>
<th>Method</th>
<th>non-dispersive infrared absorption or UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring ranges</td>
<td>0 - 50 ppm and, in appropriate ranges up to 1000 ppm</td>
</tr>
<tr>
<td>Resolution</td>
<td>better than 2 % of full scale or 2 ppm, whichever is greater</td>
</tr>
<tr>
<td>Repeatability</td>
<td>better than ± 1 % of full scale of range used or ± 1 ppm, whichever is greater</td>
</tr>
<tr>
<td>Stability</td>
<td>better than ± 3 % of full scale of range used or ± 1 ppm, whichever is greater, over a period of 2 hours</td>
</tr>
<tr>
<td>Zero drift</td>
<td>better than ± 2 % of full scale of range used or ± 1 ppm, whichever is greater, over a period of 2 hours</td>
</tr>
<tr>
<td>Noise</td>
<td>0.5 Hz and greater, less than ± 2 % of full scale of range used or ± 0.05 %, whichever is greater, over a period of 2 hours</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt; 5s from entry of the sample into the Analyser to attaining 95 % of the final reading;</td>
</tr>
<tr>
<td>Signal output</td>
<td>4 - 20 mA</td>
</tr>
<tr>
<td>Power supply</td>
<td>230 VAC, 50 Hz UPS</td>
</tr>
<tr>
<td>Ambient operation conditions</td>
<td>7 - 50 °C</td>
</tr>
<tr>
<td>Calibration gas to be included</td>
<td></td>
</tr>
</tbody>
</table>

### O$_2$ Monitor

<table>
<thead>
<tr>
<th>Method</th>
<th>Continuous Paramagnetic Oxygen Analyser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring ranges</td>
<td>0 - 25 Vol % in appropriate ranges</td>
</tr>
<tr>
<td>Resolution</td>
<td>better than 0.2 % of full scale of range used or 0.05 %, whichever is greater</td>
</tr>
<tr>
<td>Repeatability</td>
<td>better than ± 0.2 % of full scale of range used or ± 0.05 %, whichever is greater</td>
</tr>
<tr>
<td>Stability</td>
<td>better than ± 2 % of full scale of range used or ± 0.05 %, whichever is greater</td>
</tr>
</tbody>
</table>
### CO Monitor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Non-dispersive infrared</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>0 - 2,500 ppm in appropriate ranges</td>
</tr>
<tr>
<td>Resolution</td>
<td>Better than 0.5 % of full scale of range used or 1 ppm, whichever is greater</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Better than ±1 % of full scale of range used or ±2 ppm, whichever is greater</td>
</tr>
<tr>
<td>Stability</td>
<td>Better than ±2 % of full scale of range used or ±2 ppm, whichever is greater</td>
</tr>
<tr>
<td>Zero drift</td>
<td>Better than ±1 % of full scale of range used or ±2 ppm, whichever is greater</td>
</tr>
<tr>
<td>Noise</td>
<td>0.5 Hz and greater, less than ±1 % of full scale of range used or ±1 ppm, whichever is greater</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt; 50 s from entry of the sample into the Analyser to attaining 90 % of the final reading</td>
</tr>
<tr>
<td>Signal output</td>
<td>4 - 20 mA</td>
</tr>
<tr>
<td>Power supply</td>
<td>230 VAC, 50 Hz; UPS</td>
</tr>
<tr>
<td>Ambient operation conditions</td>
<td>7 - 50 °C</td>
</tr>
</tbody>
</table>

### CO₂ Monitor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Non-dispersive infrared</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>0 - 20 % in appropriate ranges</td>
</tr>
<tr>
<td>Resolution</td>
<td>Better than 0.5 % of full scale of range used or 100 ppm, whichever is greater</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Better than ±1 % of full scale of range used or ±100 ppm, whichever is greater</td>
</tr>
<tr>
<td>Stability</td>
<td>Better than ±2 % of full scale of range used or ±100 ppm, whichever is greater</td>
</tr>
<tr>
<td>Zero drift</td>
<td>Better than ±1 % of full scale of range used or ±100 ppm, whichever is greater</td>
</tr>
<tr>
<td>Noise</td>
<td>0.5 Hz and greater, less than ±1 % of full scale of range used or ±100 ppm, whichever is greater</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt; 50 s from entry of the sample into the Analyser to attaining 90 % of the final reading</td>
</tr>
<tr>
<td>Signal output</td>
<td>4 - 20 mA</td>
</tr>
<tr>
<td>Power supply</td>
<td>230 VAC, 50 Hz; UPS</td>
</tr>
<tr>
<td>Ambient operation conditions</td>
<td>7 - 50 °C</td>
</tr>
</tbody>
</table>

### Total Particulate Matter Monitor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Continuous measuring of optical transmission, beta-ray attenuation or turboelectric method</td>
</tr>
<tr>
<td>Measuring ranges</td>
<td>0 - 200 mg/m3</td>
</tr>
<tr>
<td>Resolution</td>
<td>2 % of full scale of range used</td>
</tr>
<tr>
<td>Detection Limit</td>
<td>2 % of full scale</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Signal output</td>
<td>4 - 20 mA</td>
</tr>
<tr>
<td>Power supply</td>
<td>230 VAC, 50 Hz; UPS</td>
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<tr>
<td>Ambient operation conditions</td>
<td>7 - 50 °C</td>
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**Temperature Measurement**

<table>
<thead>
<tr>
<th>Method</th>
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<td>Measuring ranges</td>
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<td>Signal output</td>
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<td>7 - 50 °C</td>
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**Pressure Measurement**

<table>
<thead>
<tr>
<th>Method</th>
<th>Semiconductor or capacitor sensor</th>
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<tbody>
<tr>
<td>Measuring ranges</td>
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<tr>
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<tr>
<td>Signal output</td>
<td>4 - 20 mA</td>
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<tr>
<td>Power supply</td>
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</tr>
<tr>
<td>Ambient operation conditions</td>
<td>7 - 50 °C</td>
</tr>
</tbody>
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11.18.2 **Signal Output to DCS System**

The actual emission concentrations of NOx, SO2, CO, CO2, O2, and total particulate matter measured at the installed exhaust gas monitoring stations as well as the corresponding alarm messages (instrument failure, limit exceeded) shall also be made available for the DCS system of the Plant. All conventional signals interfaced with the DCS shall be made available as potential free contact for binary and as galvanically isolated 4-20 mA for analogue signals and shall be directly hardwired to plant DCS i.e. not through data acquisition module.

11.13.3 **Data Extraction from DCS to the workstation**

One (1) workstation common for Block 1, 2 and 3 for evaluation of environmental data shall be connected to the main DCS system, allowing extraction of the pre-processed emission monitoring data.

11.19 **Steam and Water Analysis System (SWAS)**

The analysis and sampling systems shall be capable of satisfactory continuous operation without attention other than routine maintenance (e.g. weekly checks).

Each analyser shall have an integrated indicator. The outputs from the analysers shall be 4-20 mA DC.

The power supply shall preferably be 24 V DC.

SWAS shall be interfaced with the DCS via redundant serial link for monitoring. Alarm for all significant parameters measurements which exceed their permissible limits including those of sample conditioning system, shall be repeated in the
central control room.

One sampling rack shall be provided which shall include sample conditioners, analysers, air and electrical distribution, cooling water distribution or coolant circulating system and manual sampling points, all piped and wired on a common frame. A protection device shall be incorporated in the sample cooler to isolate the analyser and raise an alarm in the event of excessive temperature. The assembly shall be arranged for convenient removal from on-line operation to facilitate routine maintenance and calibration whilst at the same time the manual sampling remains available.

Each Sampling line of the sampling system shall be equipped with following components:

b. Sample cooler (if sample temperature is more than 30°C)

c. Pressure reducing valve

d. Analysis pump (if sample pressure below atmospheric)

e. Hand operating extraction valve;

f. All necessary pipes, valves, measurement, control and monitoring equipment

Analysers

All analysers shall be of microprocessor based design. The minimum specifications mentioned below shall be complied; however bidder to propose the latest model of analysers with complete technical specification during detailed engineering for approval of Owner/Engineer

Dissolved Oxygen Analysers

The analyser shall continuously monitor the dissolved oxygen in the process stream.

The analyser shall be of the amperometric or galvanic cell type. The analyser shall have at least two (2) switch selected ranges. One range shall be 0 to 50; the other shall be the manufacturer's standard. Both ranges shall be available as a remote output.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td>Accuracy</td>
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<tr>
<td>Sensitivity</td>
<td>0.1 ppb or better</td>
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<tr>
<td>Temperature compensation</td>
<td>up to 55 °C</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt; 1 min</td>
</tr>
</tbody>
</table>

pH-Analysers

The sensing element system shall provide continuous operation for six (6) months or longer under normal operating conditions.

The sensor output shall be automatically compensated for process temperature variations within the design range. The base temperature shall be 25 °C.
Conductivity Measurements
Conductivity elements shall be either flow-type or immersion type as determined by the Bidder to be best suitable for the service, AC - bridge design.

Silica Analyzer (SI OX)
Silica analyser shall be Multi-Channel Calorimetric Analyzer (with auto reagent shut off feature in case of sample loss or power loss) built in phosphate inhibition feature Microprocessor based type.

Sodium Ion Analyzer
Analyser shall be microprocessor based continuous flow through sample type with sodium responsive electrode and reference electrode having pH adjustment facility

Phosphate Analyzer
Analyser shall be microprocessor based Continuous flow through sample type with calorimetric detection system.

Chloride Analyzer
Analyser shall be microprocessor based Continuous flow through sample type
with calorimetric detection system.

| Temperature compensation | Up to 80 °C. 
|--------------------------|------------------
| Accuracy                 | Better than 5 microgram/litre |
| Sensitivity              | Better than 1 ppm |

### 11.20 Simulator for Operational Training

The primary objective of the training simulator is to allow the station operational & maintenance staff to gain the practical experience on how to operate the most complex process units in various situation including normal operations at different throughputs and different operating modes:

- Plant upsets and equipment malfunctions;
- Process unit normal start-up and shutdown;
- Situation after a planned or emergency shutdown;
- Recovery from various malfunctions and upsets

The plant training simulator equipment shall be additional to and independent from the DCS. An appropriate data transfer mechanism from the DCS for processing of real time data shall be provided. The Bidder shall provide the hardware and software for the simulation of the process behaviour and for the operation, monitoring and control functions, as well as the correct implementation of these functions in the simulator equipment.

The simulator shall replicate the actual look of a single power block and the common facilities including all large screen displays

The bidder have to provide One Simulator with 5 (five) work stations for operational training of Combined Cycle Power Plant.

The bidder shall give a detailed functional description of the simulator hardware and software included in his offer. Appropriate interface to the DCS for reading real time plant data shall be provided. However, interface to the plant DCS must be secured by means of using latest state of the art redundant pair firewall. Moreover, additional layer of network security must be ensured to safeguard the plant DCS from external malware/ perceived data theft/hacking.

### 11.21 Instrument Installation

#### 11.21.1 Junction Boxes

Junction boxes shall be used to connect the field-mounted instruments to the multi-core cables laid to the electronic cubicles.

The material shall be of stainless steel, or, non-metallic material such as fibre glass subject to Owner/Engineer’s approval.

Junction boxes shall have 20 % spare terminals after final commissioning.

The terminal blocks inside the junction boxes (for non-hazardous area) shall be of
screw type with an individual isolation facility for each signal to facilitate maintenance work without the need to disconnect the terminals. Terminal block shall have proper number tagging on the strip and wire.

Junction boxes for hazardous area shall conform to IEC 60079 or equivalent national standard and shall be certified as suitable for the zone classification of the area to be installed.

All junction boxes shall be provided with earthing bars/terminals/connections.

11.21.2 Installation of Field Equipment

11.21.2.1 Instrumentation

Each device shall be mounted and piped so that removal and replacement shall be accomplished without interruption of service of adjacent devices.

Piping and tubing shall not run across the face or rear of any device in a way that will prevent the opening of covers or obstruct access to leads, terminals, or instruments for servicing. Multiple measurements shall be arranged on instrument racks.

In general, each instrument / sensor shall have its own tapping point and its own root valve(s). Moreover, each instrument shall have its own instrument isolation valve or manifold in addition to primary process root isolation valve.

Field instruments shall be located away from equipment/locations where severe/continuous vibrations or shocks may occur or be expected. Where necessary vibration/shockproof equipment of appropriate grade shall be provided.

For the measurements of steam or condensing vapours appropriate condensing devices (e.g. condensate pot with filling port) shall be provided at the tapping point.

Installation of instruments shall conform to the latest edition of BS 6739 or other equivalent Standard.

Instrument brackets or accessories for surface or pipe mounting shall be supplied with each field mounted instrument e.g. pressure and temperature gauges.

The material of impulse lines and tubing shall be of stainless steel (316). 304SS material will not be accepted. Fittings shall also be of stainless steel (316). The connection from instrument primary isolation valves shall generally be in welded small bore piping with socket weld connections or in small-bore tubing with double ferrule compression fittings.

The minimum bending radius for lines shall be three (3) times the outside diameter of the pipe.

Process sensing impulse lines (pipes) shall be of 12 mm O.D stainless steel (316). Sampling lines for analysers shall be of 8-10 mm ID size. Connection of stainless steel instrument lines to primary isolating valves (root valves) shall typically be made by socket-weld adapters.
Instruments fittings for manifold, isolation valve connection etc. shall be ½”.

All instrument air piping shall be sloped so drainage toward drip legs or moisture traps will be facilitated.

A shutoff valve shall be installed at each takeoff from the branch header for air supply lines to the equipment requiring instrument air.

Individual instrument signal lines shall be 6-12 mm OD of stainless steel tubing (316). Copper tubing is unacceptable.

Instrument Valves shall be of approved manufacture, design and material, 316 or better. Blow-down valves shall be provided on all steam and water applications.

The instrument isolating valves shall be located on the connecting pipe at the measuring device end of the line.
Instrument isolating valves shall be rated to at least 100 °C and the pressure of the main process line.

Downstream of the instrument isolating valves a test connection with cap shall be provided for local pressure gauges. Transmitters shall have a test connection with test valve and closing cap. For differential pressure transmitters the test valves shall be provided on both, high and low pressure side with clear identification.

Equalising valves shall be provided for all differential pressure measuring devices. With the exception of those services which use seal pots without partitions, the equalising valve shall be positioned as close to the measuring device as possible and shall form part of an instrument valve manifold.

**11.21.4 Instrument Testing**

The Bidder shall perform erection and cold function tests to ensure that the instrument is in working condition. All tests are to be recorded and signed.

After installation, instrument air piping shall be pneumatically tested in accordance with the appropriate standards.

Instruments shall be isolated during pressure testing of the piping and tubing to prevent damage.

All testing equipment shall be in good working order, properly maintained and calibrated i.e. shall have valid calibration certificate.

In the case of measurement and control systems involving electronic or pneumatic transmission, a simulated input signal shall be injected and varied over the full range. Each device shall be calibrated and checked for correct operation at site. Static head shall be taken into account, where applicable.

The Bidder shall be responsible for proper protection of the instruments and devices that may be damaged by any of the required tests.

Loop checks of electronic instrument circuits shall be performed to ensure that wiring is correctly terminated, shielding is properly grounded, and that the complete circuit operates correctly. Loop sheet diagrams, showing the complete electronic loop from the field instrument to the final control element operation in DCS shall be made available at least one month before commencing the testing.

Particular attention shall be paid to intrinsically safe equipment cabling and wiring,
checking and testing.

All analogue instruments shall be verified that the output is correct in the range and span of the instrument. Span checks shall be at 0, 25, 50, 75, and 100 % of range and vice versa.
Section 12

Cabling and Grounding
12. CABLING AND GROUNDING

12.1 General

12.2 Cable Types

12.2.1 11KV XLPE Power Cable

12.2.2 6.6 KV KLPE Power Cable

12.2.3 600 V Power Cable

12.2.4 Control and Instrument Cable

12.2.5 132 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 Bidder shall design, supply, install, terminate and commission all the cables for the plant. However, existing cables shall be utilized and retained as far as possible. Existing cables which will not be required for the conversion project shall be removed from the site and handed over to the Employer to a place inside the Power Plant as selected by the Employer.

(2) Voltage Drop

The maximum permissible voltage drop across the cables shall be such that in no case the voltage drop shall exceed 2.5% of motor rated voltage under normal running condition and 10% of motor rated voltage under motor starting condition. Running voltage drop at other static electrical equipment terminal shall never exceed 5% of equipment rated voltage.

For a fuse/MCB/MCCB protected circuit, cable should be sized to withstand the let-out energy. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.

(3) Armouring

All cables except 132 KV power 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 11 KV XLPE POWER CABLE & ISOLATED PHASE SOLID BUS DUCT

(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 11 KV cable shall not be less than 500 sq. mm. 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 The single core 11 KV XLPE Copper conductor power cable and other
necessary items for the completion of the cable system.

The power cable and accessories shall be designed and constructed in accordance with the requirements of latest IEC Standard. High Voltage Cross linked Polyethylene Insulated cable” and 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.

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 11 KV cables.

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.

12.2.3 600/1000 V Power Cables

The cables shall be installed 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, instrument cables shall be rated 600 volt, stranded high conductivity annealed, tinned copper, twisted pair (with min. 20 twists for meter) extruded PVC insulated with overall and / or individual screening, extruded PVC inner sheathed, galvanized steel wire armoured, extruded outer sheathed with FRLS PVC. All control and instrument cables shall be designed, fabricated, and tested in accordance with the latest JIS or IEC Standards.

Triplex cables similar to instrumentation cables can be used for RTDs. Instrumentation cables carrying digital signals shall have overall screening along with drain wire and analogue signal carrying cables shall have each pair screening and overall screening along with each pair drain wire and overall drain wire.

Signal cable : 1.5 Sq. mm for single pair, screened
0.5 Sq. mm for multipair, individual pair and overall shielded

Control cables shall be 1100V AC grade, multicore, stranded copper conductor having 7 strands, PVC insulated, inner FRLS PVC sheathed of type ST-1, galvanized steel wire armoured and outer sheath made of FRLS PVC compound of type ST-1. In situations where accuracy of measurement or voltage drop in control circuit, warrant, higher cross sections as required shall be used.

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

Cables for analogue signals shall be instrumentation paired cable of 0.5 sq. mm copper conductor size, with individual pair shielding and over all shielding as mentioned below.

Cables for binary signals shall be instrumentation paired cable of 0.5 sq. mm copper conductor size as mentioned below with over all shielding only.

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.

All the thermocouple cables shall utilize stranded conductors with twisted and shielded pairs. Insulation and over jacketing shall be color coded in accordance with the requirements of ANSI MC 96.1. The shield wire for each thermocouple furnished for external connections shall be terminated on an ungrounded terminal/ Instrument grounding. The thermocouple compensating/extension cables shall be 1.5 sq.mm conductors. The compensating/extension cables should not have any joints and the cable should run from thermocouple head to system cabinets directly. The minimum size of the instrumentation cables will be 1.5 sq.mm.

The Separate duct banks / cable trays shall be provided for instrumentation and control cables to avoid any electrical interfaces. The cable trays shall be a perforated type for I&C cables.

The separate communication duct bank shall be provided for communication cables/ telephone cables.

The fiber optic cables (FOC) shall comply with ANSI/FDDI standards and shall be designed for indoor and outdoor (according to requirements) environments in riser shafts, metal conduits/raceways above the ceiling and duct banks between buildings. HDPE sub ducts shall be used to protect FOC in the underground duct bank. The cable jacket shall be flame retardant as per NFPA rated and water resistant with color coding to help distinguish fiber media from other premise cables. The cable shall be non-metallic in construction. The FOC shall be single mode, non-metallic, tight buffer and graded index type. The maximum attenuation shall be 1.2 dB/km at 1300 nm wavelength. The minimum fiber counts (strands) shall be six (6). The communication cable/Optic fiber cables should be laid in two different routes in the power plant.

-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 132kV 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 132 KV cable shall not be less than 300 sq. mm. 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 132 KV cables.

(1) **Laying**

132 KV Cables, laid underground, shall be provided with RCC slab on three sides.

### 12.3 **RACEWAY & SUPPORTS**

Raceway shall be provided for all cables, and these shall be rigid conduit / metal trough type cable trays.

Cable tray/conduit system shall be electrically continuous and grounded.

Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.

Raceway shall include all fittings, junction boxes, flexible attachments, raceway support hardware, etc.

Proper cable supports and cable cleats shall also be provided.

### 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 Bidder 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 addition to the above grid shall be provided, if required. The minimum outer diameter of grounding rod shall not be less than 20 mm., but selected size shall be substantiated by calculation, to be approved by BPDB.
Section 13

DC Power Supply & UPS 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

Existing DC 125 V DESCRIPTIONS:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>AMARAJA, INDIA</th>
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<tr>
<td>Voltage</td>
<td>125 V</td>
</tr>
<tr>
<td>No of Cell</td>
<td>64</td>
</tr>
<tr>
<td>Description</td>
<td>Maintenance free lead acid battery</td>
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Combined Cycle Plant requirement:

The DC and UPS system shall consist of:

- 125 V DC battery and charger
- 24V DC (125/24 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 125V. The main DC loads shall be as follows:

- Generator circuit breaker closing and tripping
- DC lubricating oil pumps for STG rotating plant
- Protection relay systems
- HV switchyard equipment controls
- MV/LV Switchboard and motor control centre closing and tripping.

The main 125V DC system shall consist of 2x100% battery and chargers each connected via individual MCCB/MCB 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 125 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 125V 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 125V 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 two (02) 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.

Battery Charger as well as UPS will be Thyristor based or IGBT based High frequency type. Moreover UPS shall be provided with IGBT based Static Voltage Regulator (SVR).

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 400 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
Under-voltage alarm
Output circuit disconnected 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 a 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 Bidder.

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
14.7 Solar System Power Supply
14. LIGHTING AND SMALL POWER SUPPLY

14.1 GENERAL

(1) Scope of Works
The Bidder 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 125volt DC supply required for emergency lighting services shall be obtained from the batteries supplied under the Section 13. Under AC failure conditions for the DC, 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 and 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 Bidder 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 Bidder.

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Illumination Level (Lux)</th>
<th>Type of Fitting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power Generating Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<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>
</tr>
<tr>
<td></td>
<td>Inside of control package</td>
<td>500</td>
<td>Fluorescent lamp with reflector guard</td>
</tr>
<tr>
<td></td>
<td>Inside of crane rain shelter</td>
<td>20</td>
<td>Fluorescent lamp or mercury vapour lamp with reflector and diffuser</td>
</tr>
<tr>
<td></td>
<td>Around ST unit</td>
<td>20</td>
<td>Mercury vapour lamp with floodlight fitting</td>
</tr>
<tr>
<td></td>
<td>Road or path</td>
<td>10</td>
<td>Mercury vapour lamp with highway fitting or floodlight fitting</td>
</tr>
<tr>
<td>b</td>
<td>132 KV Switchyard</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Around Switchgear</td>
<td>20</td>
<td>Mercury vapour lamp with floodlight fitting</td>
</tr>
<tr>
<td></td>
<td>Roadways</td>
<td>10</td>
<td>Mercury vapour lamp with highway fitting</td>
</tr>
<tr>
<td>c</td>
<td>Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control room</td>
<td>500</td>
<td>Fluorescent lamp with reflector and diffuser</td>
</tr>
<tr>
<td></td>
<td>Electrical room and cable room</td>
<td>50</td>
<td>Fluorescent lamp with reflector and guard</td>
</tr>
<tr>
<td></td>
<td>Office</td>
<td>500</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>Toiler, corridor, etc.</td>
<td>50</td>
<td>-do-</td>
</tr>
</tbody>
</table>
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 Bidder shall design DC emergency lighting and power supply system for the power station, and illumination level of DC emergency lighting shall be as follows.

The lighting shall consist of 125V DC operated 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 CC 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, 10 A 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 Bidder.

14.7 SOLAR SYSTEM POWER SUPPLY

Each of the following buildings shall be provided with Solar Power System of capacity 2kW at their roofs for local power distribution:

(a) Electrical & Control building,

(b) New Admin building,

(c) Workshop

(d) Chemical building

PV cells shall be Polycrystalline type. Necessary Inverters, Power Distribution Board, earthing, cabling etc. shall be provided accordingly for power distribution of the entire building for lighting and small power requirement.

During non-availability of Solar Power System, the power requirement of each building shall be fulfilled with the normal auxiliary power supply from Combined Cycle Power Plant.

The complete lighting & small power systems for the above buildings shall be designed and installed in accordance with the Section 14.
14.7.1 General requirements of Solar System

i. The Inverter shall have the provision of external auxiliary power supply (240V, 50Hz and 1-Ph & N) for the power consumption in the sleep mode at night.

ii. All equipments related to Solar System shall be suitable for following variations:

- Voltage variation : ± 10 %
- Frequency variation : ± 5 %
- Combined voltage & frequency variation : 10 %
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Section 15

Fuel Handling Facilities
15. **FUEL HANDLING FACILITIES**

15.1 Fuel System

15.2 Natural Gas System & Handling Facilities

15.3 Existing Data of Fuel Gas Analysis Report
15.1 **FUEL SYSTEM**

At present Natural Gas is used as a fuel for Gas Turbine.

15.2 **Natural Gas Handling Facilities**

The gas turbine unit was furnished with gas fuel system. The gas handling system including Gas Booster Compressors was used to deliver gas fuel from RMS to the Generating unit.

15.4 **Existing Data of Fuel Gas Analysis Report**

**DESIGN BASIS:**

The design basis presented in this section is as per customer qualifications For Gas Conditioning Skid and as per relevant P & I diagram enclosed

**PROCESS DESIGN CRITERIA:**

Gas to be treated: Fuel Gas

<table>
<thead>
<tr>
<th>GAS COMPOSITION:</th>
<th>% (By Volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constituent</td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>3.278</td>
</tr>
<tr>
<td>CO2</td>
<td>0.950</td>
</tr>
<tr>
<td>H2S</td>
<td>0.0001</td>
</tr>
<tr>
<td>CH4</td>
<td>81.85</td>
</tr>
<tr>
<td>C2H6</td>
<td>8.109</td>
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<tr>
<td>C3H8</td>
<td>3.925</td>
</tr>
<tr>
<td>IC4</td>
<td>0.725</td>
</tr>
<tr>
<td>NC4</td>
<td>0.775</td>
</tr>
<tr>
<td>IC5</td>
<td>0.118</td>
</tr>
<tr>
<td>NC5</td>
<td>0.159</td>
</tr>
<tr>
<td>C6+</td>
<td>0.040</td>
</tr>
</tbody>
</table>
MOLECULAR WEIGHT: 19.8
PRESSURE AT INLET: 22.5 Kg/ cm sq
TEMPERATURE: 50 deg C
OPERATING PRESSURE: 22.5 Kg/ cm sq (G)
GAS FLOW: 11,000 NM$^3$/ HR (Min)
30,857 NM$^3$/ HR (Nor)
44,000 NM$^3$/ HR (Max)
POWER AVAILABLE: (AT SKID LIMITS) : 110V DC, 11V AC, 24 V DC
HAZARDOUS AREA CLASSIFICATION: Class 1, DIV 11, GR C&D
CORROSION ALLOWANCE: 3 mm
INSTRUMENT AIR AVAILABLE: (AT SKID LIMITS) : 8.0 kg/cm sq
INSTALLATION: Out door
Section 16

Fire Detection & Protection Facilities
16. **Fire Detection & Protection Facilities**

16.1 General

16.2 Design Requirements

16.3 C0₂ 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**

At present Fire Fighting pump house with 1 Jockey pump & 1 Diesel pump and fire fighting reservoir for 100 MW & 71 MW GTG(s) Unit was used in the plant area. The Bidder shall have to renovate/ modify the pump house including its equipment to capable the pumps for 150 MW CCPP Power plant & 71 MW power plant.

The Bidder 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 steam turbine packaged units.

Hydrant system including (motor driven and diesel engine driven fire-fighting pumps, jockey pump- if required) water main, hydrant stands, hoses, water sprinkle system in the control room, water pool 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 CO₂ 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 en-
closures, 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 steam turbine
generating units, electrical building, and 132 kV switchyard where necessary. 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.

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) Twenty 5 kg C0₂ extinguishers
(2) Five 20 kg C0₂ extinguishers with trolley
(3) Twenty 5 kg Dry chemical extinguishers
(4) Five 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
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
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

17.7 Telemetering facility

17.8 Closed Circuit Television (CCTV) System
17. COMMUNICATION FACILITIES

17.1 GENERAL
The Bidder shall design, manufacture, deliver to the Site and install the following communication facilities for combined cycle plant:

a. Internal telephone system
b. Paging system

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 Bidder, but the interconnecting cables between the PABX and the public telephone network shall not be the responsibility of the Bidder 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.

Extension to exchange lines and PLC lines for dialling a single access digit shall make outgoing calls.

Operator access from extension by dialling a single digit shall be required.

Trunk barring on outgoing calls shall be provided as required on selected extensions.

Provision for limited barring on outgoing calls from selected extensions shall be provided.

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.

Call transfer between extensions on incoming and outgoing public exchange calls shall be provided.

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.

ii. 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 Board.

17.2.2 TELEPHONE FACILITIES

PABX telephones should be located as follows:

a. Control room (2)

b. Control package of Steam 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

1. **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 Board 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:

Dielectric strength (for 1 minute)

Between conductor and outer conductor : 6KV AC
Insulation resistance : More than 10 M ohms / km
Attenuation : 3.2dB/km at 300 kHz
Impedance (nominal) : 77ohms at 300 kHz

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 Bidder.

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 (5) 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**: 120% current of battery 5 hour rate charging current at minimum.
   - **Performance**: Performance shall be same as these shown on Section 10.2 (3).
   - **Required Number**: 1 set.

### 17.6 Telemetering Facility

Separate Marshalling Kiosk shall be provided for Telemetering terminal for future connection with SCADA.

### 17.7 Communication & SCADA Equipment

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.
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. Adequate number of dome type cameras with facilities like Zoom, pan, tilt etc. would be provided at various operating areas. The camera shall have a resolution of at least 480 horizontal lines. An operating console with controls shall be provided in the CCR for this purpose. The monitors would be located at control locations such as central control room, Operation in-charge room etc.

The camera pictures shall be displayed at the CCR 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 80 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
- switch yard
- 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
Section 18

Maintenance Facilities
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
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 Tools

18.2.1 General

18.2.2 Special Tools

18.2.3 Hoist

18.2.4 Other Maintenance Facilities

18.2.5 Transportation
18. MAINTENANCE FACILITIES

18.1 Overhead Electric Crane

18.1.1 SCOPE

The Bidder shall provide and install Overhead cranes for the ST Hall, complete in all respects including longitudinal gantry structure, gantry rails, conductors, power supply, weather protection shed etc.

18.1.2 EXTENT OF SUPPLY

The equipment to be supplied by the Bidder under this specification shall include, but shall not be limited to, the following:-

   a. One (1) Lot Semi-indoor/ indoor type electric overhead crane for ST Hall 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 : As required for lifting the heaviest single piece with 20% margin

      Auxiliary hoist : 10 ton

   b. Sufficient sets of steel wire hoisting ropes

   c. All integral electric cabling and wiring

   d. All limit switches

   e. One (I) set of gantry structure, gantry rails, girders, holding down bolts, securing plates, abutments, and weather protection shed.

   f. One (I) set of power supply cables and trolley conductors complete with supporting brackets and one (I) set of power supply indication lamp

   g. One (I) 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 (I) auxiliary hoist.

18.1.4 RATING
The rating of the crane shall be as follows:

(1) Hoisting capacity
   a. Main hoist : to be determined by the Bidder, depending on the
      heaviest piece during maintenance [ST, GBC & CW Pump (main hoist capacity minimum 130 ton
      or above as required for lifting the heaviest single piece with 20% margin)].
   b. Auxiliary hoist : 10 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 : 3 phase, 4 wire, 400 V AC, 50 Hz and terminal voltage

(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 Bidder 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.
18.1.8 ELECTRICAL DESIGN

The Bidder shall furnish and install all electrical equipment on the crane including all motors, electrically operated brakes, air circuit breakers, switches, contactors, 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 Bidder shall also supply the main runway conductors, insulators, brackets and associated accessories.

The main power supply shall have a short circuit capability of 25 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.

1. 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 400 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 its 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 Bidder.

(7) Runway Conductors and Trolley Conductor

The Bidder shall furnish the main runway conductors, insulators, support brackets, and all other necessary equipment required for installation. The Bidder 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 Bidder. 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 Bidder for power supply conductors. Power cables and isolation switch for the supply to the power supply conductors shall also be supplied by the Bidder.

18.1.9 GANTRY STRUCTURE, RAILS AND GIRDER

The Bidder 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 2 Part A.

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 Bidder and all tests shall be in accordance with the relevant IEC Standard.

The Engineer and the Board shall witness these tests.

The Bidder shall supply all equipment including weights for the above tests. The Bidder shall also be responsible for the disposal of the materials used for the test load.

18.2 TOOLS

18.2.1 GENERAL

The following tools and equipment shall be supplied under this Contract and the Bidder is required to give a full list with details in the Schedule of Tools and Appliances when submitting his Bid.

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 Taking Over Certificate.

18.2.2 SPECIAL TOOLS

The Bidder shall provide all special tools required for maintenance of the HRSG, Steam Turbine, Steam Turbine Generators and their auxiliaries and hand them over in good condition to the BOARD. A list of all such tools shall be incorporated with Bid. Bidder shall not be permitted to use any equipment/ machinery/ tools, which are to be supplied under the Contract.

Special tool list with unit price shall be submitted with Bid.
18.2.3 HOIST

The Bidder shall have to provide Hoists for maintenance of equipments as required.

The hoist shall be of electrical or chain- block type and the capacity shall be selected taking into consideration of weight of object. 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, Fire fighting pump house, Chemical plant.**

18.2.4 Other Maintenance Facilities

   a. One (1)  30 ton mobile crane.
   b. One (1)  5 ton truck with 3 ton jib crane.
   c. One (1)  5 ton fork lift (Engine Driven)
   d. One (1)  1 Ton Half truck.

18.2.5 Transportation

   i)  2 Nos. Double Cabinet Pick-up (Not less than 2400 CC each) including catalytic converter
   ii) 1 No Microbus (Not less than 1800 CC, for 9 persons)
   iii) 1 No. Car (not less than 1800 CC)
   iv) 2 Nos. Motor Cycle (100 CC each)
   v) 1 No. Truck (5 Tons)

All above mentioned vehicles shall be Japan country of origin.
Section 19

Tests and Inspections
19. **Tests and Inspections**

19.1 General

19.2 Workshop Test

19.2.1 Existing Gas Turbine

19.2.2 Heat Recovery Steam Generator And Ancillaries

19.2.3 Steam Turbine And Ancillaries

19.2.4 Generator

19.2.5 Exciter

19.2.6 Step-up Transformers

19.2.7 132 kV Switchyard Equipment

19.2.8 Control and Protection System

19.2.9 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 / HRSG / Steam Turbine Units

19.3.3 Field Inspections and Tests on Switchgear, Equipment

19.4 Acceptance and interim Operation

19.5 Operation & Maintenance

19.5.1 Operation & Maintenance during Defect liability Period
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan December, 2016 Single - Stage: Two-Envelope
19. Tests and Inspections

19.1 GENERAL

The Bidder 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 Bidder's or sub-Bidder's works to determine or assess compliance with the provisions of this Specification or to witness the Bidder's inspections or tests.

The Bidder 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 Bidder 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 Bidder shall also provide evidence as to the similarity of the equipment tested and the Contract equipment.

(4) The Bidder 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.

19.2.1 Existing Gas Turbine

After Renovation/ Inspection/ Overhaul of existing 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 Bidder shall state in his proposal the performance and reliability tests to be carried out in the works. The Bidder shall give the Engineer notice of the tests at least four(4) weeks in advance. The tests to be carried out shall include, but not be limited to, the following:-
a. Dynamic balancing together with over-speed tests of the turbine and Compressor rotors
b. Bench testing of all accessories
c. 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

ST 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 TRANSFORMERS

The transformers shall be completely assembled at the factory and shall be subjected to the following tests by the Bidder, in accordance with the latest revisions of IEC 60076 "Power transformers" and 60551 "Measurement of transformer and reactor sound levels".

General inspection

- Measurements of Winding resistance
- Voltage ratio measurement and check of polarity
- Measurement of impedance voltages
- Measurement of load loss
- Measurement of no-load loss and current
- Test of temperature rise
- Induced over-voltage withstand test
- Separate-source voltage-withstand test
- Insulation resistance measurement (megger)

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

19.2.7 132 KV SWITCHYARD 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) Outdoor Cable Termination End

The test shall be performed in accordance with relevant IEC

- General inspection
- Power frequency spark-over voltage test
- Lightning impulse spark-over voltage test
- Measurement of leakage current and insulation resistance

(7) Steel Structures

General inspection

Material quality and quantity check

(8) 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

(9) Stranded Conductors for Overhead Line and Grounding System
   - General inspection
   - Tensile strength test

(10) 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
- DCS FAT

19.2.9 OTHER MATERIALS AND EQUIPMENT

All other materials and equipment shall be tested at the Bidder'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 Bidder shall conduct the tests at the Site in accordance with these clauses and the conditions of the Contract.

b. The Bidder 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 Bidder.

c. The Bidder 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 Bidders. The Engineer will also be responsible for overall co-ordination and safety control of tests.

d. The Bidder 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 Bidder 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 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 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.

(3) Reliability Test Period

a. The tests on completion shall include a reliability test period for each generating unit and auxiliaries, which shall commence when the Bidder has notified the Engineer that the unit is ready for commercial operation. During this period, the unit and auxiliaries will be required to operate under the working conditions of the station, within their operating limits, either continuously or intermittently as required by the operation of the station, without failure or interruption of any kind for a period of one (1) hundred hours. The units will be operated by the station staff and the Bidder shall provide at his own expense a suitable representative during each operating shift to direct the station staff on the operating techniques and the running of the units. The Bidder may make minor adjustments to the units, provided that such adjustments do not in any way interfere with or prevent the commercial use of the units by the Board or result in reducing the output of efficiency.

b. Should any failure or Interruption occur in the operation of the units due to faulty design, materials or workmanship under the Contract but not otherwise, sufficient to interrupt the commercial operation of the units, the reliability test period of one(1) hundred Hours shall recommence after the Bidder has remedied the cause of the defect.
19.3.1 TESTS AND COMPLETION

(1) The Bidder shall give to the Board and Engineer in writing twenty one (21) days notice of the date after which he will be ready to make the tests on completion. Unless otherwise agreed, the tests shall take place within ten (10) days after the said date, on such day or days as the Engineer shall in writing notify the Bidder.

(2) If the Board and Engineer fail to appoint a time after having been asked to do so or to attend at any time or place duly appointed for making the said tests the Bidder shall be entitled to proceed in their absence, and the said tests shall be deemed to have been made in the presence of the Board/Engineer.

(3) If, in the opinion of the Board/Engineer, the tests are being unduly delayed he may by notice in writing call upon the Bidder to make such tests within ten (10) days from the receipt of the said notice and the Bidder shall make the said tests on such day within the said ten (10) days as the Bidder may fix and of which he shall give notice to the Engineer. If the Bidder fails to make such tests within the time aforesaid the Engineer may himself proceed to make the tests. All tests so made by the Engineer shall be at the risk and expense of the Bidder unless the Bidder shall establish that the tests were not being unduly delayed in which case tests so made shall be at the risk and expense of the Board.

(4) The Board except where otherwise specified, shall provide free of charge, such labour, materials, fuel, water, as may be requisite and as may be reasonably demanded to carry out such tests efficiently. However all the calibration devices, standard or sub-standard special test instruments, stores, apparatus etc., required to conduct all the tests would be provided, arranged and installed by the Bidder at his own cost and expenses. The Bidder will pay all expenses including the custom duties etc. on the import or export of all such instruments etc.

(5) If any portion of the works fail to pass the tests, tests of the said portion shall, if required by the Engineer or by the Bidder, be repeated within a reasonable time upon the same terms and conditions save that all reasonable expenses to which the Board may be put by the repetition of the tests shall be deducted from the Contract price.

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, each 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 gas turbine units, 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 initial commercial operation period.

The time consumed in start-up and trial operation shall be considered as a part of the erection and installation period.

(3) Initial Commercial Operation (ICO)

The Bidder shall be responsible for running on initial commercial operation period at the Site on each unit, including all auxiliaries and controls for the Plant. The Bidder 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.

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

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 Bidder and certified by Engineer. The tests shall be conducted in accordance with ISO 2314 or ASME PTC 22 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 Bidder.

The Board shall provide without charge such labour, material, fuel and water 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 gas turbine generator shall run at 25%, 50%, 75% and 100% of base rating and peak load prior to placing the unit into commercial operation and to prove that sudden load rejections from loads up to maximum capability can be accommodated by the turbine without the speed rise being sufficient to cause the over-speed trip to initiate.

The output and heat rate tests will be carried out on each unit in the following manner:

i) 1/2 hour at 1/4 load

ii) 1/2 hour at 1/2 load

iii) 1 hour at 3/4 load

iv) 1 hour at 4/4 load

Full load at the generator terminal 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.

Generator power output shall be held as constant as possible during the performance test.

The Steam Turbine Generator shall run at 50%, 75% and 100% load corresponding existing GT load rating prior to placing the STG into commercial operation and to prove that sudden load rejections from loads up to maximum capability can be accommodated by the turbine without the speed rise being sufficient to cause the over-speed trip to initiate. The load rejection test of STG shall be carried out from 100% load, 75% load to ensure i) existing GTG is running at the same load that they were running before load rejection ii) diverter dampers of existing GT is open to bypass stack iii) LP/HP steam bypass are working perfectly with relevant steam control valves & auxiliaries.

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 the generator terminal 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 Bid.

(5) Test Reports

The Bidder 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 Bidder and the Engineer.

19.3.3 FIELD INSPECTIONS AND TESTS ON SWITCHGEAR, EQUIPMENT

The following site tests shall be performed by the Bidder.

(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 Bidder. 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 Transformers

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 Bidder shall provide to the Engineer six bound copies of all site test sheet as final records.

(6) 132 kV Switchyard

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 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. Current and Voltage Transformers

All current and 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 Bidder 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 Bidder of his responsibility for first inspection.

(2) Should the equipment furnished by the Bidder 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 Bidder's supervisory operating personnel, until such defects have been remedied and guarantees met with. In the event that defects necessitate 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.

### 19.5 Operation & Maintenance

#### 19.5.1 Operation & Maintenance during Defect Liability Period

The Bidder shall provide One (1) Competent Instrumentation & Control engineer who will work as warrantee engineer on behalf of Bidder during 24 months of Defect Liability Period. The Bidder shall also provide all the spares, consumables and services needed for scheduled/ unscheduled maintenance of all the equipment of combined cycle power plant during the Defect Liability Period and will engage required manpower in addition to the above stated person.
Section 20

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20. Civil Works

20.1 GENERAL

20.1.1 GENERAL REQUIREMENTS

The Bidder's proposal shall cover all requirements of the Bid 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 Bidder shall upon examining the bid documents and 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 Bidder for the Project.

The Engineer shall reserve the right to examine the Bidder's design and to instruct a change or modification by the Bidder.

These modifications shall be carried out by the Bidder without additional cost as a result of any claims made by the Bidder on the Board.

Approval of the design by the Engineer shall not relieve the Bidder of liability for the construction works.

The Bidder shall familiarise himself with the site levels, subsoil, weather and climatic condition (Tsunami/High tides/Earth Quake etc.) and another data necessary to enable him to estimate the bearing capacity and foundation requirements, for use in the preparation of his Bid. To fix up Formation Level, it is to be recommended and be considered that Formation Level would be 0.8 m above of High Flood Level (HFL) or 1 m above of nearby national highway which ever higher among them. On the other hand, the design of earthquake emergency electricity supply shut off system should have to be incorporated with the system.

It is the Bidder'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 Bid shall include for all local eventualities.

The Bidder shall quote firm prices which shall remain valid throughout the Contract Period on all items in the Price Schedule unless other-wise stipulated.

20.1.2 TOPOGRAPHIC SURVEYS

The Bidder shall carry out Topographical and contour surveys of plant area, well location and water pipe line route and discharge channel route 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 SITE INVESTIGATION

The project land was filled in 2014. The depth of earth filling is 4 to 5 meter throughout the project site. The Bidder may conduct soil investigation if deemed
necessary at his own cost before submission of the bid.

After signing of contract the Bidder shall carry out detailed geotechnical investigation in all work areas under his scope for establishing the sub-soil conditions & to decide type pile and foundations for the structures envisaged, construction methods, any special requirements, ground improvement treatment called for/ remedial measures for sub-soil / foundations etc. for soft sub-soils, aggressive sub-soils & water, expansive / swelling soils etc. prior to commencement of detailed design / drawings. Bidder shall obtain the approval for the field and laboratory-testing scheme proposed by him from the Owner before undertaking the geotechnical investigation work and shall submit the report containing the findings and recommendations.

Field test shall include but not be limited to the following:

Boreholes, Standard Penetration Test (SPT), collection of disturbed and Undisturbed soil/rock samples (UDS), Trial Pits (TP), Plate load test (PLT), Dynamic Cone Penetration Test (DCPT), Pressure meter tests (PMT), Seismic Refraction Test (SRT), CBR test, Electrical Resistivity Tests (ERT) and collection of soil & water samples for chemical analysis etc.

Field and laboratory investigations shall be done in accordance with provisions of the relevant parts of the latest revisions of British/ American Standards. The laboratory tests shall be conducted on soil & water samples collected during field investigations (bore holes, trial pits, borrow material) in sufficient numbers (minimum of 40% of samples disturbed and undisturbed each) and not be limited to the indicative type of laboratory tests. Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU & CD), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free swell Index, Shrinkage Limit, Swell Pressure Test, Proctor tests, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel.

On completion of all field & laboratory work, Bidder shall submit a detailed Geotechnical investigation report for Owner’s approval. The detailed Geotechnical investigation report shall contain geological information of the region, procedure adopted for investigation, field & laboratory observations/ data/ records, analysis of results & recommendations on type of foundation for different type of structures envisaged for all areas of work, recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc. The report shall also contain recommendations on type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total/ differential settlement permissible for structures and equipment, minimum depth and width of foundation with supporting calculations and type & design of piles in terms of safe capacity, length, diameter termination criteria etc. Safe slope of deep excavation and embankment shall be recommended. Potential of liquefaction affect, if any under seismic condition due to presence of fine sand under saturated condition shall also be examined and finding shall be included in the report.
20.1.4 SITE LABORATORY

The Bidder 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. A qualified and experienced Laboratory technician shall have to be posted in Laboratory. A complete set of equipment and instrument for testing of building material, concrete test, temperature measurement, balance, sieves, oven etc. shall be kept in the Laboratory. 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 Bidder 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 Bidder 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 Bidder.

20.1.7 STANDARDS AND CODES OF PRACTICE

The engineering & execution of all Civil, Structural & Architectural works shall be based on the latest edition or revision of the applicable portion of the following Codes and Specifications. In case any particular aspect of work is not covered by these Standards, other standard specifications, as may be specified by the Engineer, shall be followed.

a) The Bureau of British Standard Codes.
b) National building Code of Bangladesh (BNBC)
c) Environmental protection agency
d) American Codes and standards (ASTM, ACI,)
e) Local Statutory regulations
f) Rules & Regulations of local authorities

The Civil Works shall be designed and constructed in accordance with the Specifications, relevant Standards and Codes of Practice approved by the
Engineer. Local code of practice shall be followed where not mentioned. The Bidder 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 Bidder shall obtain English translations when required and send them to the Engineer.

The Bidder 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) : Sysmic Zone-3, Zone coefficient, Z=0.28
- b. Design Storm : Based on frequency-intensity Duration curves prepared for Hobigonj Zone
- c. Wind velocity : 50.6 m/s
- d. Design load for road : H-20-S16-44 (AASHO)
- e. Standards and codes of practice : BNBC 2015, ASTM, ACI, and international codes of practice and other Standards to be approved by the Engineer

20.2 SCOPE OF CIVIL WORKS

The Scope of work pertaining to investigations works, studies, different structure, facilities and system are covered in the technical specification. The details of some of Plant buildings, equipment foundations, non-plant buildings and residential quarters are as follows:

1) Geotechnical investigation and site preparation including Filling, levelling and grading for the entire site handed over to Bidder.
2) Power House Building,
3) Steam Turbine foundations
4) Control Building (For combined cycle control),
5) HRSG foundations
6) Chimney
8) Transformer Foundations
9) River water intake pump house, including all Hydrological and Soil investigations of water intake point at River Boral and River protection works at intake point of River.
10) Water Intake system and pipe line works. "Land filling and construction of Permanent protection with permanent structure for installation of cooling water intake pipe line from Boral River to CW pump house as well as Discharge Channel to river" will be
included with 'Water Intake System and pipe line works'.

11) Water treatment plant civil works including clarifier, D.M. Plants, Acid & Alkali storage area

12) Cooling Tower Civil works

13) CW channel and CW Pump house

14) Gas RMS related civil works

15) Fuel Oil storage tanks and pump house

16) Fire water tank and pump house

17) Oil water separator

19) Switchyard equipment foundation and civil works

20) Effluent treatment plant and Central Monitoring Basin

21) Sewerage system and septic tanks

22) Two storied Store Building (600 sq. meters per floor) and storage yard

23) All equipment foundations, pedestals, support etc. as described in Mechanical and Electrical specification and as per requirement of project.

24) Storm water drainage system, Sumps, pits,


26) Potable Water distribution system including one overhead tank on roof of control building

27) Pipe and Cable rack structures with foundations, cable trench and pipe tranches

28) Plant Roads, Culverts, Passage ways, access ways for transporting of equipment during overhaul

29) RCC Paving works in chimney area, Boiler area, Main power house area and other areas as necessary.

30) "Boundary wall with Permanent river protection works" in the east side (Korotoya river side) of the Project area. Boundary wall (the part of which will be flood protection wall against Korotoya river water), Parking area, Fencing, Flag poles (3 Nos), Main Entrance Gate and Guard room.

31) All dismantling and demolition works and diversion of existing over ground and underground facilities as required. Dismantling works of two 132 KV transmission tower (As required) and the materials to be shifted from project site.

32) The scope of civil works shall also include all repair, rectification, replacing and strengthening (as required) including painting and finishing works of existing civil/ structural facilities in existing open cycle plant site.

33) Administration Building (Three storied having floor area of 250 sq. meters in each floor with 10 rooms per floor)
34) Workshop building (minimum floor area 500 sq. meters)
35) Air Compressor Building
36) Chemical building
37) Permanent Jetty construction (225Ton load handling capacity) adjacent to river Boral
38) Landscaping works

Bidder Details of Residential accommodations, Rest House and few other buildings are described below:

(i) Studio type Dormitories (4 storied, minimum 10 independent studio type apartments per floor. The Floor Space for each Apartment shall be 60 square meters excluding stairs, Each Independent Studio type Apartment contains One Room, One Kitchen & One Toilet).

(ii) Rest house (2 storied, minimum 300 square meter/floor),

(iii) Officers Quarters:-

a) Single storied: 2 apartments (125sqm each apartment);

b) Four storied: 2 building (8 apartments each building, 100 sqm each apartment)

c) 4 storied: 2 building (8 apartments each building, 80 sqm each apartment)

4) Staff Quarter:

a) 4 storied: 1 building (8 apartments each building, 60 sqm each apartment)

b) 4 storied: 2 building (8 apartments each building, 50 sqm each apartment)

5) Army barak Two storyed building having 200 sqm floor area in each floor.

Solar system shall be provided as per cl.no.14.7.

Facilities for domestic gas connection, electrical connection, and domestic water connection have to be provided for each apartment.

The Administration Building design should follow sustainable design techniques so that easy access of natural air and lights to the building is to be confirmed. Moreover, CCTV Security system for control room, Turbine-Generator building, sub-station area, fuel gas system area should be provided to facilitate plant security system.

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 BPDB.

However, approximate dimension of 1) control building [two storied, 10 (ten) air-
conditioned rooms including control room (18 m x 20 m), battery room, auxiliary room shall not be less than 24 Metres x 24 Metres and 2) Administrative building [three storied, 10 (ten) rooms with 4(four) Toilets including air-conditioned Manager’s room, conference room, etc. shall not be less than 14 Metres x 25 Metres.

The nature of work shall generally involve Topographical and contour survey of project site and pipeline route survey, site specific study & investigation (like detailed Geo-technical investigation, water intake point hydrological studies, location of pump house), route alignment survey for water intake pipe line, site clearance, earth work in site levelling, borrowing of earth, excavation in soil/rock, dewatering, dressing to required profile, sheet piling or shoring/strutting, controlled filling with earth/sand, backfilling around completed structures and plinth filling, disposal of surplus earth/rock, concreting including reinforcement and formwork, piling works, masonry work, machine foundations works, plastering, painting, single / double skin metal wall cladding, roofing including permanent steel decking, flooring, acid and alkali resistant lining, doors/windows, ventilators, under deck insulation, false ceiling, false flooring, roof water proofing, fabrication and erection of all structural steel and miscellaneous steel (such as, steel staircase, cable/duct/pipe supports, ladders, walkways, railing, chequered plate/grating floor, inserts, anchor bolts, etc.), CW ducts/pipes, paving, gravel filling, precast RCC covers, cable ducts/duct banks, expansion joints, rain water pipe, water supply, toilet & kitchen fittings, lift-well, sewerage, insulation, stop logs/gates/valves, damp proofing, water proofing, anti-weed and anti-termite treatment, roads, drainage, fencing, final grading & landscaping and site clearance before handing over, other related items of work, all complete as per specification and functional requirements. Bidder shall provide all temporary construction facility and enabling works.

The scope of work described here is of general in nature. The Bidder shall provide all structures/facilities required for the effective functioning of various systems of the power plant, whether or not they are specifically mentioned.

In case of any conflict between stipulations in various portions of the specification, various standards and codes, the most stringent stipulation shall apply for implementation by the Bidder.

**BUILDINGS AND FACILITIES**

The description against each building / system is indicative only and not exhaustive. Although most of the systems are covered here but any other system (Civil, Structural and Architectural) required for successful completion of the project shall form a part of this contract and shall be deemed to be included.
Power House Building

The building will have structural steel framed structure, which shall house the turbine generator and related equipment. The roof is supported by steel trusses. The structure is braced in the direction of the crane travel but provided with suitably designed rigid joints at roof level and framing at other floor levels. E.O.T crane with walkway will operate in the turbine hall for handling equipment. Within the building, the concrete pedestal for supporting the turbine generators and boiler feed pumps (as required)/motors shall be completely isolated from the building floors for vibration control.

The concrete floor shall be designed for construction and maintenance loadings of TG. All external sides shall generally be cladded with permanent colour coated double skin insulated metal cladding sheet from 3.0m (approx.) above ground floor up to roof.

Brickwork shall generally be provided all-round from ground floor up to 3.0m (approx.) height. All internal walls shall be of brickwork. Windows, doors, claddings and finishing shall be provided as per requirement.

The roof over Turbine Hall shall be flat with a gentle slope of about 1 in 100 towards the transformer yard. The roofing will be done by cast-in-situ RCC slab over permanently colour coated (on exposed face) galvanized M.S. troughed metal decking of approved profile supported by steel purlins, spanning between two adjacent roof trusses. The minimum thickness of sheet shall be as per the design requirement considering worst load combination subject to a minimum thickness of 0.8 mm. The roof will be provided with membrane waterproofing for making the roof waterproofed.

All floors shall be cast-in-situ RCC slab over removable shuttering with hatchways as required. RCC slab-on-grade on ground floor shall rest on hard core metal filling over well-compacted earth. Ground floor slab will have drainage trenches covered with steel grating. The foundation system shall be pile foundation with pile cap and plinth beams.

Stairs and platforms shall be provided, as required, for maximum utility and safety. Stairs shall have to be provided as per applicable regulations and any other statutory requirements.

Control Room Building

Construction Control Room Building

(1) Main construction materials

Frame : Reinforced concrete

Roof : Reinforced concrete roof with
        : Roof water proofing.

Exterior wall : Reinforced concrete and/or brick.

Partition wall : Brick

Floor : Concrete with plastic tile, ordinary tile, trowelled mortar finish, etc
Foundation: Pile foundation

(2) Windows:

Aluminium sash shall be provided. Window area shall be generally more than 1/6 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 Bidder may submit the layout to suit any particular requirement subject to the approval of the Engineer.

(6) Other Requirements:

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.

**HRSG Area Civil Work**

HRSG supporting structure shall be of Steel structure frame supported on RCC pile foundation system. The roof / canopy and side sheeting material as required shall be permanently colour coated single skin metal cladding sheet (non insulated). The specification of the sheet including thickness and profile shall be as specified elsewhere in the specification but shall not be less than the required design thickness.

Civil works for HRSG elevator shall consists of RCC elevator pit, elevator shaft enclosure with pre coated metal cladding having airtight joints with sealing compound. All equipment foundation in boiler area shall be provided as required.

**Transformer area**

Transformer foundations shall be provided as per requirement.

Transformers are to be founded on RCC pile foundation with rails on the top (if required) with oil soak pits filled with clean metal aggregate of 40mm nominal size. Burnt oil pits shall be provided to convey leaked oil from the soak pit to the burnt oil pit. RCC fire wall of adequate thickness and height to satisfy applicable regulations shall be provided in between transformer and this shall be painted.
Entire area shall be RCC paved surrounded with 3 m high PVC coated chain link fencing with gates. Where rails (if required) cross the fencing, fencing shall be made of removable type to facilitate transport of transformer. Floor shall be sloped towards peripheral drains, which shall lead to a sump from which the drainage is led through an oil water separator.

Foundation for Bus duct support, RCC trenches, RCC drains shall be provided as per requirement. Transformer track (if required) shall have rigid RCC foundation connected to unloading bay of TG building to facilitate handling and maintenance.

**Compressor House**

This shall be a single storied steel framed building. Roof shall be of RCC supported on permanent deck Sheets supported on steel beams. Side cladding shall be with precoated metal profiled sheet. Rolling shutter of adequate size should be provided for taking the equipment inside. The roof framing shall support an under slung crane of adequate capacity. Compressor foundation shall be isolated from the grade slab.

All trenches shall be sloped towards drain sumps. Trenches shall be provided with chequered plate cover. Steel glazed windows shall be provided for ventilation and natural lighting. A minimum of 2 flush type steel door shall be provided for movement of personnel. Dimension of the building shall be decided as per approved layout and functional & maintenance requirements.

All trenches shall be of RCC and shall be designed as water tightness structure. There shall be no entry of cables/pipes to these trenches below grade level from outside. All these trenches shall be covered with chequered plate over steel framing. Adequate number of sumps shall be provided to drain these trenches.

**Chimney**

The chimney foundation shall be designed for the most critical combination of forces and moments, resulting from all possible combinations of the various loadings from the chimney system during all stages of constructions. The effect of water table shall be considered and the foundation shall be checked for overturning for minimum and maximum vertical loads. There should be no uplift under any portion of the foundation for any loading condition and as such pile shall not be subjected to any tension. Since chimney is a wind sensitive structure no allowance shall be made in the load carrying capacity of the bearing strata/piles under wind loading. No allowance shall be made in the stresses for design of foundation in seismic loading. Grade of concrete for foundation shall be minimum C30

Design and construction of various components and systems of the Steel chimney including external platforms shall be in accordance with relevant Standard. Imposed loading for design of all chimney components shall not be less than 5 KN/m². Additional 25% of liner load shall be taken as impact loading for liner erection. The chimney and its components shall be designed to resist the most onerous forces resulting from all the possible combinations of the various loadings.
The other components of the chimney include test ports (for continuous pollution monitoring), grade level slab of RCC with metallic hardener floor finish, door at grade level electrical power distribution boards, lighting panels, power and control cabling and wiring systems, staircase, Stair and platforms lighting, socket outlet, lightning protection and grounding system, aviation obstruction lighting, communication system, and other items of work, though not specifically mentioned but reasonably implied and necessary to complete the job in all respects.

**FUEL OIL SYSTEM**

Details and general arrangement for the fuel oil handling system shall be provided as per approved layout as described in mechanical part of the technical specification. Civil works shall generally covers the areas described in subsequent clauses

**Pump House**

This shall be single storey RCC frames structure building with brick cladding. A separate maintenance bay and MCC room shall also be provided in the pump house.

**Pipe / Cable Trestles**

For routing fuel oil pipes, trestles and foundations are to be provided for supporting the pipelines/cables at suitable intervals. Crossovers, operating platforms and necessary thrust resisting arrangement at pipe bends shall be provided as required. 750 mm wide platform shall be provided as a walkway along the length of the trestles.

**Fuel Oil Tank foundation**

Fuel oil steel storage tank and foundation with anti-corrosive bitumastic layer below tank shall be provided as per stipulation of relevant code. RCC dyke wall and floor slab be provided as per requirement.

Design of RCC dyke wall, Floor and tank foundation shall be as per API standard.

RCC oil water separator pit (as required) shall be provided as per American Petroleum Institute Standard.

**WATER INTAKE SYSTEM**

Requirement of river water intake system shall be based on the once through cooling system. The system has been described in Mechanical Part of the specification. The Bidder shall offer the systems based on these consideration.

The water intake system shall generally cover the following:

a) System study including all Hydraulic Studies related to river water supply and soil investigation

b) River water Intake Pump House /Switch gear / control room for water supply
c) The approach and routing of water pipe lines and discharge channel

d) Pipe support for intake system. The Pipe line system (1 KM approximate length) shall be supported with adequate RCC support arrangement such as pedestal, thrust block, Anchor block including protection against flood water as per requirement to be decided by Vender.

e) RCC Discharge Channel (1 Km approximately) for discharging water back to river.

Cooling Water System

River water shall be used for condenser cooling purpose and a cooling water (C.W.) pump house for housing cooling water pumps shall be provided. Separate bays shall be provided for each pump by providing intermediate dividing piers of RCC between the pumps as per approved scheme.

a) Pump house shall be provided with minimum two sets of stop logs for the respective pump bay dimensions along with electrically operated hoisting arrangements. Steel embedment required for stop logs shall be provided for all the bays.

b) All bays of pump house shall be provided with a removable trash rack including electrically operated hoisting arrangements and cleaning arrangements. Moreover, one spare trash rack of respective pump bay dimension shall also be supplied for pump house. Steel embedment required for trash racks shall be provided for all the bays.

c) Stop logs, trash racks and hoists shall also be supplied in accordance with the specifications requirement.

The sub-structure of all pump house including their fore bays shall be RCC with C30 grade of concrete. The superstructure of all pump houses shall consist of structural steel frames, side metal sheet cladding and RCC roof over permanent shuttering desk sheets.

C.W. pump house shall be structurally separated from their fore bays by providing an expansion joint. All pump houses shall be provided with a separate maintenance bay for maintenance of various equipment and an electrical switchgear room. Length of maintenance bay shall be adequate for one pump maintenance. G.I. Hand-rail with NB 32 mm (medium) pipe shall be provided on the operating floor towards fore bay side.

CW Channel

The channel shall be of RCC section with wall projecting minimum 500mm above finished ground level. GI Handrails with NB 32 mm (medium) pipe shall be provided on both walls of the channel where height of channel wall is less than 1200 mm above finished ground level. The channel cross section near cooling tower shall match the cross section details of outlet channel from cooling tower. An expansion joint with PVC water stop shall be provided in the outlet channel from cooling tower.
Induced Draught Auxiliary Cooling Tower

General Requirements

The cooling tower shall be designed for continuous operation. The hot water distribution system shall be designed to ensure equal distribution of heat load and flow all over the fill area. Wood / timber shall not be used as material of construction in any part of the cooling tower.

The cooling tower complete with tower and basin shall be of RCC/FRP construction.

The structural requirements and other aspects of the various components of the cooling tower shall be as described below:

Basin

The basin walls/ floor shall be of RCC construction. It shall be made water tight against leakage of the cooling water to the outside and shall be designed as per relevant code.

Fill Support

Fills shall be supported on RCC/FRP grid in easily removable sections. The spacing of supports and the thickness of the splash bars shall be adequate to prevent sagging.

Supporting Structure

Cooling tower framework shall be of RCC/FRP construction. The supporting structure shall be designed to withstand dead load such as weight of the tower and circulating water, live load from the mechanical equipment and wind / seismic loads. Dynamic analysis shall be carried out for fan shaft gear reducer support beams / foundations.

Partition Wall

Partition wall of sufficient thickness of RCC frame work with brick infill, shall be provided from basin top to the bottom of fan deck.

Fan Deck

Fan deck shall be of RCC and of adequate thickness and shall be designed as per code. Access doors shall be provided into each cell through the fan deck and drift eliminators for easy access to the cooling tower interior for inspection and repairs. Suitable drainage shall be provided for Fan deck to drain rainwater away from the fan openings.

Access Doors

All parts subjected to periodical maintenance and inspection such as fills, drift eliminators, fans shall be accessible. Access doors shall be provided at the basin level (through casing side) in each cell and in each fan stack. The doors shall be
so designed as to be easily opened from the inside of the tower and should open outwards. Bolts, locks etc., on such access doors shall be such that they cannot accidentally become fastened. The doors shall have easily openable shutter of leak proof design and of M.S construction with painting applicable for structural steel.

Fan Stack

Fan Stack (cylinder) shall have an extended stack of venturi shape to attain conversion of velocity head to static pressure.

Rings for fan stacks shall be of the same material as that of fan stack and shall be concentric with the fan.

Stairways

Stairways shall be provided on both side from the ground level for access to the fan deck. The staircase width shall not be less than 1200 mm. Suitable landings shall be provided on the staircase at intervals of not more than 4 m vertically. Aluminium angles of minimum size 50 x 25 x 3mm shall be fixed at the nose of the riser and tread.

Handrail

Handrails shall be provided around fan deck, on stairway, on walkways and on hot water distribution deck in double rows with 40 NB pipe uprights of 1000 mm high at a spacing not more than 1500 mm interval. In addition top rails, knee rails and toe boards shall also be provided. Top and knee rails shall be of 32 NB pipes and toe board shall be of size 65 x 8 mm. All handrail pipes shall of medium class. All handrail components shall be galvanised in accordance with code.

Water treatment plant facilities:

The work include W.T. plant building, Chemical building, Clarifiers, Filter water reservoir, D.M. Plant works, Tank and equipment foundations. Details and general arrangement for the system shall be provided as per approved layout as described in mechanical part of the technical specification. The building and equipment foundation, tank foundation shall be provided as per requirement.

Effluent Treatment Plant (ETP)

All civil works required for ETP pertaining to effluent treatment system shall be as per the approved layout and details of effluent treatment system.

Work Shop Building

It shall be of RCC framed structure building. Roofing shall be of in-situ RCC slab with brick cladding wall with minimum built up area of 500 m². It shall be provided with cast-in-situ concrete roof. Cranes/ Monorails shall be provided as per requirements. It shall accommodate the machinery and facilities listed in the Mechanical section of the document. In addition, the workshop shall provide for office space, locker room and change room for workers, toilet etc. Entry and exit of trucks / forklift shall be through adequately sized rolling shutters. A minimum of 2 single-leaf, steel flush doors shall be provided for entry of the staff. Adequate windows with grills shall be provided for ventilation and lighting. Offices inside shall be of glazed Aluminium partition above 900 mm high single-brick wall. Total
height of partition including brickwork shall be 2400 mm.

**Permanent Stores**

Permanent Stores is two storied building and shall be of RCC framed structure with brick cladding with minimum built up of 600 m² per floor. Roofing shall be of in-situ RCC. Loading and unloading platform for trucks, Monorail, ramps for movement of forklift etc shall also be provided. Separate office space, chemical storage, hot storage, electrical storage, A/C storage, toilets etc shall be provided. All windows shall be provided with MS grills for security. Rolling shutter of adequate size shall be provided for movement of truck / forklift etc. Grade slab shall be designed for truck traffic. Provision for open and semi-covered storage areas shall also be provided in stores complex.

RCC paving shall be provided for open yard storage. The store complex shall be enclosed with chain link fencing having entry gate and security post.

**Parking Shed**

Car park shall be partly covered parking having total parking area 300 m². Cycle & scooter shed shall have 300 m² area.

Shed area shall be of structural frame with regular rolled / circular section with metal sheeting. Concrete floor shall be placed on well compacted hard base. Floor shall be constructed with proper expansion/construction joints. Covered & open parking space shall be provided near different buildings and facilities as per requirements.

**Army Barak Building**

The building is two storied building and shall be of RCC framed structure with brick cladding with minimum built up of 400 m² per floor. Roofing shall be of in-situ RCC with roof water proofing treatment. Kitchen, Dining hall and toilets etc. shall be provided. All windows shall be provided with MS grills for security. Door of adequate size and numbers shall be provided. The building shall have fencing all round with a gate for entrance.

**Non plant building and Staff Quarters:**

All the building shall have RCC/ steel framed structures with brick panedl wall with RCC Floor. The roof shall be RCC roof with roof water proferring treatment. Adequate nos of doors and windows shall be provided.

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 Defect liability Period of the Works. Moreover, during design, construction and operation phases, all works and activities of this project should be followed by health, safety and environmental practice, international standards and guidelines.

The Scope of Work shall include, but not be necessarily limited to, the following:

- **Site Works**: Removal of existing structures, Land Development, Site clearance, excavation and filling of the Site to formation level 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 pile foundations shall be provided for the steam turbine generating unit, 132 kV switchgear, and elevated water tank, water/steam supply system, overhead travelling crane, Platform/Standard Jetty for loading & Unloading at canal side, 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.

Corrosion Protection

The Bidder shall examine the requirement of corrosion protection for above and below ground structure, that would be required particularly for steel and concrete works. Type of treatment of underground structure shall be decided on the basis of detailed soil investigations report and chemical analysis of soil & water. Further whenever structures are likely to be exposed to corrosive environment due to storage of chemicals or due to any other reasons, special measures are also required to be taken care of. A comprehensive scheme for the corrosion protection shall be submitted to Owner for approval in line with the requirement specified below.

Plain and Reinforced Concrete

Plain Concrete is prone to sulphate attack and Reinforced Concrete to both sulphate as well as chloride attack. Corrosion protection shall be applied according to ACI 318-07, ACI 318-08, ACI 322-07 and British standard. Super plasticizer admixer shall be added to concrete to enhance workability and reduction in water cement ratio. Thermo-mechanically treated (TMT) bar shall be used as reinforcement for Concrete. For RCC structure, control of crack width shall be ensured as per relevant codes.

Steel Structure

All steel members of buildings and structures shall be provided with suitable high performance chemical resistant protective coating system. The minimum maintenance free life of protective coating shall be ten years as per ISO 12944. Provision of additional sacrificial thickness of 2 to 4 mm shall be made as a corrosion margin for steel members.

Galvanising shall be provided generally for switchyard structure, stop log and electro forged grating and the mild steel parts in contact with water or water vapour. For outdoor structural steel works including switchyard structures, rate of galvanizing shall be minimum 900 gm/m² and for indoor application this shall be minimum 610gm/m².
20.3 EARTHWORKS

20.3.1 GENERAL

The Bidder 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 Bidder 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 Bidder 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 Bidder 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 Bidder 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 Bidder 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 contract price of civil work shall include all related cost 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 com–plying with the contract requirements.
20.3.3 FILLING

The project site requires some amount of levelling grading and land filling works. The finished final grade level shall be 800mm above high flood level of the area. The area along land boundary requires adequate amount of filling which is to be decided by the vendor.

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 Bidder 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 form 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 300 mm thickness. The Bidder 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 shall be compacted to a density not less than 95% MDD and for sandy soil shall be 85% of relative Density.

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 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 Bidder 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

Considering the poor load bearing capacity of soil, all building and major equipment foundation shall have pile foundation.

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 Bidder.

In the event that piled foundations are proposed, the Bidder shall submit a detailed design for piled foundations to the Engineer for approval. The Bidder 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 Bidder 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 to 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 Bidder 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 two and a half times 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.

(2) Pre-cast Piles

The Bidder's arrangements for the provision of piles shall be to the approval of the Engineer. The Bidder 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 dimensions 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 l2mm 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 after 28 days specified on the drawings or as otherwise described.
(3) Driving Piles

The Bidder shall submit with his Bid 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 Bidder 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 Bidder to remove the pile and/or to install replacement piles at positions selected by the Engineer, all at the cost of the Bidder.

(4) In-Situ Piles

Before commencing the piling, the Bidder shall submit details of the type and number of rigs to be used for in-situ 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 Bidder 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 500 mm above cut-off level. Concrete shall not normally be placed in or through water. In particular circumstances only, the Engineer may allow the Bidder at his own expense to place concrete (using suitable mix) through water by means of a termite pipe. If the Bidder's piling system does not normally exclude water during concreting, he should allow in his Bid for the use of compressed air or other method to keep the pile hole free from water whilst the concrete is being placed.

(5) Miscellaneous Piling Systems and Subsoil Improvement Method

The Bidder 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.

(6) Testing

The Bidder 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 Bidder 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%.
(7) Test Pile Load & Settlement Under Test Loads

The Bidder shall carry out preliminary trial pile tests on at least two set of piles for vertical, horizontal and pull-out tests in each type of pile to substantiate design parameters used in arriving at the load carrying capacity of the pile.

Constant rate of penetration and maintained load (ML) tests shall be carried out on piles. Piles tested using the ML test shall be required to be loaded up to three times working load. Such piles shall not form part of a load carrying pile group.

Cyclic Load Tests of vertical load test and horizontal load tests shall also be carried out on 0.5% of total working piles as directed to a maximum load of 1.5 x working load. The method that the Bidder proposes to use for carrying out tests on working piles shall be submitted in detail for approval by the Owner/Owner's Representative.

The high strain dynamic pile test for working piles shall be carried out 5% of total piles.

The low strain integrity (NDT) pile test shall be carried out 100% of working piles.

The following information will be required during pile testing:

- loading increment and frequency of loading up to working load
- length of time that working load is held and total & residual settlement of the head of the pile
- permanent settlement and recovery of pile after off-loading from working load
- increment of reloading to working load and increment of loading up to 1.5 x working load together with the frequency of loading
- length of time that 1.5 x working load is held and settlement of the head of the pile
- permanent settlement and recovery of pile after off-loading from 1.5 x working load:

In the case of preliminary tests the same cycle of loading and off-loading shall be required for 2, 2.5 and 3 times working load.

Where the maintained load method of testing is used, each increment of load shall be held until settlement has ceased, before applying the next increment of load.

The maximum load achieved at the end of each loading cycle shall be maintained for at least 12 hours after all settlement has ceased.

Likewise, the permanent settlement shall be observed for a period of at
least 12 hours after recovery has ceased.

Settlement and recovery shall be deemed to have ceased when a movement rate not exceeding 0.3 mm/hour is recorded. When 2 or 3 consecutive readings are same then settlement is deemed to be ceased. Then only shall the next increment be applied.

Where the constant rate of penetration testing is adopted, the Bidder shall indicate the rate at which he intends applying the loading and the method to be used to measure the settlement. The Bidder shall give a complete methodology for carrying out the test which shall confirm to BNBC or BS Standards and shall be approved by the owner before carrying out the test.

Should any failure of a working pile occur, the Bidder shall carry out at his own expense additional tests or install further piles to ensure that the total working load can be carried with a suitable factor of safety against failure.

Should a pile test be carried out in an unsatisfactory manner or contrary to the accepted method then at the discretion of the Owner/Owner’s Representative the test shall be repeated on another pile at the Bidder’s expense.

Pile failure shall be deemed to mean either excessive settlement of the pile under load or damage to the pile shaft.”.

On completion of each pile test the Bidder 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.

(8) Rejection of Piles

If any pile is in any case unsatisfactory to the Engineer he reserves the right to order the Bidder to install replacement piles at the locations selected by the Engineer at no extra cost.

(9) Settlement Criteria

The total settlement shall be restricted to the following:

Maximum allowable total settlement should be restricted to 25 mm for foundations (settlement sensitive) of all Main Plant structures like Main Power house, STG, HRSG and BFP, equipment foundation and all plant buildings.

Maximum allowable total settlement should be restricted to 40 mm for all other Foundations of non-plant structures and buildings.

20.4.3 FOUNDATION OF HRSG & STEAM TURBINE GENERATOR

Appropriate foundations shall be provided for the steam turbine generating units & HRSG. The steam turbine generating unit & HRSG shall be supported by the reinforced block foundation.
The Bidder 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 relevant code

The worst case shall be selected for the design of the gas turbine generating unit foundation as per relevant code and recommendation of equipment supplier.

20.4.4 FOUNDATION FOR BUILDING AND OTHER EQUIPMENT

Suitable pile foundations shall be provided for the elevated water tank, switchyard equipment, cooling tower civil works, overhead travelling crane, buildings, equipment, and miscellaneous structures.

20.4.5 HARDCORE

The Bidder shall place where required hardcore under the foundations of the equipment and below ground floor slab as per requirement. 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 Bidder 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

Bidder shall submit together with his Bid the outlined drawings and calculation sheet concerning the design of the steel sheet piling wall.

The Bidder 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. Design Mix concrete shall be used for all areas other than lean concrete work and plain cement concrete where nominal/volume mix can be permitted. Design mix shall be carried out as per concrete code. Mix design shall be developed by Reputed institute as per approval of BPDB. Specific approval of the Engineer shall be obtained regarding degree of quality control to be adopted for design mix.

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

Grade of Concrete

Minimum grade of concrete for all RCC work shall be C20 and actual grade shall be as per actual exposure condition at site. Lean concrete work shall be C10 grade. Strength of concrete grades shall be as per relevant British and American codes. The grades of concrete for some of the major structures and machine foundations are given in Table below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Minimum grade of concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chimney foundation</td>
<td>C30</td>
</tr>
<tr>
<td>2</td>
<td>TG foundation</td>
<td>C30</td>
</tr>
<tr>
<td>3</td>
<td>BFP foundations including deck</td>
<td>C25</td>
</tr>
<tr>
<td>4</td>
<td>All equipment foundation</td>
<td>C20</td>
</tr>
<tr>
<td>5</td>
<td>RCC piling works</td>
<td>C20</td>
</tr>
<tr>
<td>6</td>
<td>CW Pump House, CW Channel</td>
<td>C30</td>
</tr>
</tbody>
</table>
**Temperature Control of Concrete**

The temperature of fresh concrete used for machine foundations shall not exceed 25°C when placed. For maintaining the temperature of machine foundations, crushed ice shall be used in mixing water and cooling of aggregate.

**Admixture**

Plasticizer/super plasticizer admixture shall generally be added to concrete for promoting workability and pumping of concrete. In addition, plasticizer/super plasticizer-cum-retarder shall be added to retard the setting time for mass concreting work as required. Admixture shall conform to relevant code and from reputed manufacturer depending on the nature of admixture. In case of pumping, suitable pumping additive shall also be added to avoid segregation and increase flow ability. The slump shall generally be in the range given in the table below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Slump Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top decks of STG</td>
<td>125 mm to 150 mm</td>
</tr>
<tr>
<td>Block foundation</td>
<td>100 mm to 150 mm</td>
</tr>
<tr>
<td>Column</td>
<td>100 mm to 150 mm</td>
</tr>
<tr>
<td>Piling</td>
<td>125 mm to 150 mm</td>
</tr>
</tbody>
</table>

**Placing of Concrete**

General placement of all RCC work shall be by pumping as per the site condition and work requirement. Placement of concrete in piles shall be through tremie pipe. However, placement of non-structural concrete (PCC) such as flooring, plain / lean concreting can also be done by other means.

Top deck of machine foundations shall be cast in a single pour.

Adequate curing for required period shall be ensured using water or curing compound.

**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 Bidder.

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 Bidder 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 Bidder 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

Coarse and fine aggregates shall be well graded within the standard limits specified in relevant code
20.6.9 CONCRETE MIXING

All concrete shall be mixed in concrete batching plant of adequate capacity. 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 Bidder 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 surface 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 them 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 Bidder 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 Bidder shall at his own expense repair honeycombs, cracks, and irregularities promptly as directed by the Engineer.

The Bidder shall carry out all repair and rectification work of existing concrete work of building and equipment foundations of open cycle system area as per actual requirement to the satisfaction of project official.
(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 Bidder.

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 12m or more: 20 mm
   - For exposed columns, joint grooves and other conspicuous lines:
     - In 6 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 any bay or 6 m max.:
     - In 3 m: 5 mm
     - In 12m or more: 20 mm

   - In floors, invert:
     - In 6 m max.: 10 mm

   - In floors, invert, related position of walls:
     - In 12m or more: 15 mm

   - In the thickness of slabs and walls:
     - In 12m or more: 30 mm

   - In the thickness of slabs and walls:
     - In 12m or more: 30 mm

   - In the thickness of slabs and walls:
     - In 12m or more: 30 mm

   - In the thickness of slabs and walls:
     - In 12m or more: 30 mm

f. Variation in cross-section dimensions or columns, beams and in the thickness of slabs and walls:
   - minus: 10 mm
   - plus: 15 mm

f. Variation in steps:
   - In a flight of stairs:
     - Rise: 3 mm
     - Tread: 5 mm
   - In consecutive steps:
     - 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 Bidder 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

All reinforcement bars shall be TMT bars. 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 (fy) : more than 400 MPa

\( f_{y}/f_{u} \) greater than 1.25, where \( f_{u} \) is the ultimate tensile strength as per BNBC.

Reinforcement bars shall be stacked on the ground on sufficient sup-ports to prevent distortion of the bars. Prior to fabricating and placing the reinforcement, the Bidder 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, duets, 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 roads system shall provide vehicular access throughout the plant area including access to all building and structure etc. All major roads in Plant area shall be 7 m wide with 1.5 m wide hard shoulder on both sides of road. All secondary plant roads shall be 3.75 m wide provided with 1 m wide hard shoulders on both sides. This shall be applicable for peripheral road along the
boundary wall and access to plant auxiliary areas and buildings. Crown of the Road shall be minimum 250mm above the formation level.

The Bidder 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: 20 cm

#### 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 sub-grade to the desired elevations and cross section, and the whole shall be rolled until compacted thoroughly.

The Bidder shall perform CBR test and a load bearing test by a method to be instructed by the Engineer on the surface of the sub-grade and he shall design the thickness of sub-base as per requirement.

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 15cm 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 Bidder 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 wa-
20.7.1.4 Concrete Pavement

(1) Materials

(i) Cement and reinforcing steel will be furnished by the Bidder. The concrete to be used for concrete pavement shall be C20 grade concrete and shall have appropriate strength after at 28 days as per code. The concrete pavement shall be 20cm in thickness or as designed whichever is higher.

(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 75.

(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 75. 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 65°F to 135°F Fahrenheit. The asphalt should be completely dry before commencing 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 sealer 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 20 mm diameters shall be used for concrete pavements. In all contraction joints, 75cm long slip dowel bars of 20 mm 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 75 mm lean concrete over 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 cannot 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 Bidder, 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 Bidder. 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 Bidder 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 marring 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 Bidder shall remove such material as directed and at his expense.

(xi) Maintenance

The Bidder 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 Bidder 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 Bidder 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
The Bidder shall submit a detailed proposal on landscaping for the Site. Fruit 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. The area to be turfed shall be provided with a layer of 20cm top soil suitable for the growth of the lawn. The Bidder shall maintain and replace all dead turf at his own expense until the end of maintenance period.

Comprehensive landscaping & area development shall be provided included flower bed of seasonal flower for important area like Gate complex including entry location, Power House building, Administrative building, Residential buildings. The landscaping system shall include a routine maintenance program.

The ground cover areas shall be seeded with native grasses. Establishment of the cover areas shall include preparation of the soil surface, fertilizing, planting, covering and firming the seed to the soil, watering, and maintenance of the disturbed areas. Grasses for the ground cover shall be selected for drought tolerance and low maintenance.

A sufficient water and irrigation system shall be provided to service all landscaping and ground cover. Pathways shall be provided with interlocking paver block in suitable pattern and colour combination.

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 Bidder 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:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall intensity</td>
<td>100 mm/hr</td>
</tr>
<tr>
<td>Run-off coefficient for open area</td>
<td>0.6</td>
</tr>
<tr>
<td>Run-off coefficient for built up area</td>
<td>0.9</td>
</tr>
<tr>
<td>Manning’s roughness coefficient for concrete lined channel</td>
<td>0.013</td>
</tr>
</tbody>
</table>

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 Storm Water Drainage System

All storm water drainage shall generally be through open drains however all plant effluent drainage shall be through separate buried concrete pipes unless otherwise specifically required.

Open storm water drains shall be provided on both sides of the roads and shall be designed to drain the road surface as well as all the free and covered areas, etc.

Open RCC rectangular section shall be provided for all drains. RCC drains located within and along both sides of peripheral roads of the Power house area shall be covered with perforated precast RCC slabs of minimum 75mm thickness with provision of openable galvanised steel grating covers at about 4.0M intervals.

Similarly the drains along the periphery of building shall also have perforated precast RCC covers of minimum 75 mm thickness with provision of openable galvanised steel grating covers at about 4.0 m intervals. In areas where vehicular loads would be coming, precast RCC covers of suitable thickness without perforations and designed for the vehicular loading shall be provided. The thickness of side walls and bottom slab of RCC drains shall be minimum as per design considerations. RCC box/pre cast RCC pipe culverts shall be provided for road crossing.

All drains inside the building shall have minimum 40 mm thick grating covers. In areas where heavy equipment/ Vehicular loads would be coming, precast RCC covers shall be provided in place of steel grating.

Invert of the drains shall be decided in such a way that the water can easily be discharged to the natural water bodies above the high flood level. The invert of the in-plant and plant peripheral drains shall be kept such that water can be discharged by gravity to the main/ trunk drains under all conditions.

RCC manholes shall be provided at every 30m interval along the length, at connection points and at every change of alignment, gradient and diameter of pipeline.

Opening of drain at Boundary Wall location shall be provided with MS grating for security purpose.

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 Each pipe 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 C20

The Bidder 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 hunching 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 Supply System**

20.10.1 **Internal Water Supply System**

The water supply system shall be designed to serve potable water for domestic consumption.

20.10.2 **Water Requirement**

Potable water for the newly constructed buildings/facilities (such as electrical & control building, chemical building, store, workshop, admin building etc.) will be supplied from the existing potable water system or deep well water system (to be installed for cooling water & demi water source).

20.10.3 **Design Parameters and Standard**

The water supply 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 Bidder 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 – Not Applicable

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 Bidder 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 Bidder 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:

- Height: 2.4 metres
- Length: 5.0 metres
- Thickness: 0.25 metre

The Bidder 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 per approved general layout and as directed by the Engineer. The site boundary wall shall be of brick wall with RCC frame in accordance with relevant Standard and 2.40 m high and 0.25 m thickness.

The boundary wall along the sides of River Korotota (about two kilometres length approx.) generally get effected by rising water level of river during monsoon season. The lower part of boundary wall (Up to highest river water level shall be designed as RCC retaining wall against river water thrust and also to be protected by earthen embankment with boulder pitching on earthen embankment surface. The stability of wall and flood protection work against river water shall be decided vendor as per site condition.

Boundary walls of other side of project site shall be RCC framed construction with RCC columns at every 3.0 m intervals and RCC footings. RCC plinth beam is to be provided below the formation level and brick masonry is to be used for in filled walled panels. Surfaces of the wall shall be provided with cement sand plaster with water proof cement paint finish. Top of the wall is to be provided with RC coping. Over and above 2.5m height of the wall MS Y-angle post of 0.6 m height is to be provided with Galvanised Concertina. All structural steel members shall be painted with high performance chemical resistant paint as per the specifications. Boundary wall is to be structurally designed for all conditions including wind forces as per the Codal provisions. Expansion Joint shall be provided at a spacing of maximum 30.0m.
20.13 WATER INTAKE AND DISCHARGE FACILITIES

The Bidder shall take full responsibility for the suitability of water intake facilities and design for the platform for the pump station on the river side in accordance with the requirements of the specification.

The design of water intake facilities shall be submitted to the Engineer for approval.

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. It will be used for unloading heavy equipment to be brought to site through river. It shall be concrete / steel structure supported on pile foundation. The Jetty shall have loading / unloading and handling facility of heavy load (Up to 225 ton load capacity) as per mechanical requirement. The size of jetty and all components of the facility such as jetty, platform etc. shall be based on function requirement and adequately strong to handle/ support 225 load capacity. The component include Approach road and Jetty RCC platform, railing Tower crane, cable trench Electrical power and lighting facilities as required.
Section 21

Building Works
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan  December, 2016

Single - Stage: Two-Envelope
21 Building Works

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21. **Building Works**

21.1 **General**

The General Conditions, Bid Drawings, relevant Specifications on materials and workmanship described elsewhere in this Documents, shall be read in conjunction with this Specification.

21.1.1 **Bidder’s Responsibilities**

This is a turnkey contract which includes all building works and services. The Bid shall cover all requirements of the Bid 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 Bidder has over looked but are essential for the full completion of the Project in every respect.

The Bid shall include the building works proposal complete with out-line drawings indicating details he deems technically or financially justified.

The Bidder 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 Bidder 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-Bidder**

The Bidder may employ a building subBidder for building works. If the Bidder intends to subcontract the building works design and/or construction, his Bid shall include full details of comparable works carried out elsewhere by the subBidder, together with details of the financial stability and general efficiency of the proposed subBidder.

21.1.3 **Construction Schedule**

A preliminary building construction schedule showing the completion time for the building works shall be submitted by the Bidder based on the overall project implementation schedule. The Bidder 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 Bidder 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 Bidder
shall submit to the Engineer weekly reports of labour, plant and materials employed on the Site.

21.1.5 Samples Testing and Inspection

The Bidder 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 Bidder.

21.1.6 Temporary Services

The Bidder 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 Bidder.

21.2 Details 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.

The Administration Building design should follow sustainable design techniques so that easy access of natural air and lights to the building is to be confirmed.

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.

Solar system shall be provided in the roof of the building. For details refer as per cl.no.14.7.

21.3 Design of the Works

21.3.1 Designs and Drawings

The Bidder 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 Loading details and 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 Bidder 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 Bid submission.

As described elsewhere in the documents the Bidder shall indicate in his Bid the 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.

**Loading**

**Dead Loads**

Dead loads shall include the weight of complete structure with finishes, fixtures & partitions and shall be taken as per Stipulation of Building code.

**Imposed Loads**

Imposed (Live) loads shall consist of uniform live loads and equipment live loads, hang load and dust load. Floors and supporting members which are subject to heavy equipment live loads shall be designed on the basis of the weight of the equipment in addition to a uniform load of 5 kN/m², or specifically defined live loads, whichever is greater.

**Impact Loads**

Impact loads shall be added to other loads for components supporting reciprocating or rotating machines, elevators, hoists, cranes, or other equipment creating dynamic forces.

**Equipment Loads**

Equipment loads shall be specifically determined and located. For major equipment, structural members and bases shall be specifically located and designed to carry the equipment load into the structural system. Pipe hanger loads for the major piping systems, shall be specifically determined and located. Piping expansion and dynamic loads including thrust loads at bends shall be considered on an individual basis for their effect on the structural systems. Static and dynamic loading of major equipment including Turbine generator, boiler feed pumps, shall be obtained from manufacturer certified drawings of specific equipment. Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as developed from the crane weights and wheel loads.

**Pipe Hanger Loads**

Piping loads to account for miscellaneous piping systems shall initially be estimated as uniform loads per unit floor area based on the expected density and size of piping being supported in a specific floor area. These loads shall be carried to the columns and foundation as dead loads, but shall not be considered as reliable dead load for uplift

**Test Load**

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

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing in so far as possible. However, construction or crane access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

Wheel and Crawler Loads

Loads exerted on roadway pavements, parking and unloading areas, buried piping, box culverts, and embankments shall be reviewed and selected prior to design of the underlying items. The loads as recommended in relevant codes for moving load and live load shall be utilized for the design of roadways, and parking and unloading areas.

Dust Loads

All buildings/structures shall be designed for a dust load of 0.50 kN/m² on flat roof.

Crane Loads

Crane reaction loads shall be as per the crane manufacturer’s details, and same shall be analysed according to the provisions of codes for design.

Loads on Underground Structures

In addition to other loads, the following loads shall also be considered for underground structures:

a) Earth pressure – Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever as applicable).

b) Ground water pressure – Ground water pressure due to the highest water table as per recommendation of approved soil investigation Report shall be considered.

c) Surcharge load - Minimum surcharge load of 20 kN/m² shall be considered for the design of all underground structures located in the vicinity affected by vehicular traffic; including channels, sumps, cable & pipe trenches etc. to provide for increase in earth pressure due to vehicular traffic.

Hydrostatic Load and Buoyancy

Hydrostatic load is the load due to water pressure. The design of structures shall include hydrostatic loads where applicable. The buoyancy load is equal to the weight of the volume of displaced water. For working out such loads, water table shall be considered to appropriate level as per recommendation.
Dynamic Loads

Each structure shall be designed to withstand the effects of vibration and impact to which it may be subjected. Each structure and foundation supporting a compressor, turbine, pump, fan other machinery having significant dynamic unbalance shall be designed to resist the peak loads specified by the manufacturer. Vibration amplitudes of the supporting structure or foundation shall be kept within acceptable limits for dynamic forces that occur during normal machine operation.

For the design of individual structural components, realistic load combinations in accordance with the relevant design standards shall be considered. All loadings considered in the design shall be justified with supporting details.

Temperature Load

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The structure shall be designed to withstand stresses due to 50% of the total temperature variation. Suitable expansion joints shall be provided in the longitudinal direction wherever necessary.

Load Combinations

The different load combinations shall be taken as per stipulation of relevant codes Wind and seismic forces shall not be considered to act simultaneously. Lifted load of crane shall not be considered during seismic condition. Permissible stresses for different load combinations shall be taken as per relevant codes. Wind speed, seismic parameter and minimum live load to be considered are as follows:

**Basic Design Conditions for Building**

a. Design Wind Speed: "50.6 m/s" - as per BNBC 2015.

b. Coefficient for seismic force (horizontal) (GPA): As per Zone 3, Z = 0.28, "as per BNBC 2015"

Live Load

Live load of each floor shall be more than as follows:

- Auxiliary room: 500 kg/sq.m
- Cable spreading room: ditto
- Live load of ground floor area of Pump House Building: 1000 kg/m²

**21.3.3 Submission of Designs and Drawings**

The Bidder 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, seismic load and wind load. The Bidder 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 of the Bid Documents. Construction on the Site shall only commence after drawings are finally approved.

Notwithstanding the Engineer's approval, the Bidder 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

The requirement shall be as per description given in tender document.

Construction Control Room Building

(1) Main construction materials

Frame : Reinforced concrete
Roof : Reinforced concrete roof with lime concrete water proofing.
Exterior wall : Reinforced concrete and/or brick.
Partition wall : Brick
Floor : Concrete with plastic tile, ordinary tile, trowelled mortar finish, etc.
Foundation : the Bidder shall examine subsoil condition for design of foundation. Proper foundation shall be designed by the Bidder in accordance with the Specifications

(2) Windows:

Aluminum 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 Bidder may submit the layout to suit any particular requirement subject to the approval of the Engineer.
(6) Other Requirements:

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 shall be as per requirement of Mechanical specification. Details of the equipment proposed shall be submitted with the Tender proposal, 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

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 Bid.

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 G.I. pipe and 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.

21.5 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 otherwise specified or agreed in writing by the Engineer. Specification of Steel Structure for Building and Sub-station shall be provided in Separate Section. Design Methodology (Combination of Load) shall be followed as per section relevant ACI 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 Bidder 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 like yield point, tensile strength and elongation will be as per BNBC or ASTM or BS.

(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 be 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 Bidder 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 Bidder.

(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 Bidder. 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 Bidder 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 joined 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 the Engineer.

(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
c. 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 damages it shall be cleaned and re-painted following the procedures as approved by the Engineer. The manufacturer's instructions regarding inter-coat 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 Bidder 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 Bidder 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 Architectural Concepts for Buildings

The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, local norms, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall be conversant with all laws, by-laws, regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements and local norms. The Bidder shall provide the drawings and documents for such statutory approvals.

Roof Access

All roofs shall be provided with access thorough a suitable staircase or cage ladder as applicable.

Platforms and Walkways

Platforms shall be provided to all major equipment, not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. However, in case of space restriction, the minimum allowable clear width shall be 600 mm. Platforms in front of entry door etc. shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached.

Continuous walkway at least 600 mm wide shall be provided along the crane girder level with handrails, on both side of the building. Approach to EOT crane shall be ensured by cage ladder or staircase.
Stairs and Ladders

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm.

The vertical height between successive landings shall generally not to exceed 3m. Channels (min MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm (200 mm in exceptional cases).

Ladders shall be provided to platforms, walkways, instruments and equipment which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 5°. Ladders shall be of minimum 450 mm clear width with 20 mm diameter MS rungs spaced at 300 mm (maximum).

Ladders shall be provided with a safety cage of minimum 750 mm diameter clear when the top of ladder is more than 4.5 m above the landing level. However, safety cages shall start at 2.5 m above the lower landing level.

All RCC stairs shall have maximum riser of 150 mm and a minimum tread of 250 mm. However, for administrative building riser shall be limited to 150 mm and tread width of 300 mm. Minimum width of RCC stairs shall be 1500 mm generally. All stairs normally shall have not more than 15 risers in one flight. Aluminium angle nosing with minimum 50 x 25 x 3 angle shall be provided for edge protection of RCC stairs wherever required.

Handrails

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors / roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) suitably galvanised. Hand railing shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Hand railing shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. However, Stainless Steel handrails of appropriate Grade shall also be provided for important area like operating floor of turbo generated building as per requirement.

For RCC stairs, hand railing with 20 mm² MS bar balustrade with suitable MS flat and Aluminium handrail shall be provided, unless specifically mentioned otherwise. The overall provision of this component shall be aesthetically impressive.
Edge Protection

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. The grade of concrete shall be C25. All concrete edges, where breakage of concrete corners are expected shall be provided with angles of minimum size L 50x50x6 with lugs for edge protection e.g. all-round the cut-outs/ openings in floor slabs, edges of drains supporting grating covers, edges of RCC cable / pipe, trenches supporting covers, edges of manholes supporting covers and supporting edges of precast covers etc.

Anchor Bolts and Insert Plates

Anchor bolts shall be designed for working stress, in tension and shear, for embedded length of the anchor bolts and pipe sleeves. Shear and crushing strength of concrete shall also be checked. Increase in allowable stress for loading including seismic and wind loads shall not be permitted in design of anchor bolts.

Insert plates shall be designed and checked for shear and bending moment as per the provisions of relevant codes

Vertical Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified.

a) Finished floors to ceiling (buildings) .................................................. 3000 mm
b) Doors, Walkways, Platforms, Stairs etc. .............................................. 2100 mm
c) False ceiling of office areas ................................................................. 2400 mm
d) Above false ceiling (Other than AC duct area) .................................. 1000 mm
   (Other than AC duct area)
a) Safety cage for ladders ..................................................................... 2500 mm
b) Access for fork lift trucks ................................................................. 3000 mm
c) Main roads crossings & crane access ................................................. 8000 mm
d) Other plant roads and truck access .................................................. 5000 mm
e) Cable & Pipe rack(except at road and rail crossing) ......................... 3000 mm

Expansion and Construction Joints

Expansion and construction joints shall be provided wherever required. All expansion and construction joints of water retaining structures in RCC shall be made water tight using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops may be used for the base slabs and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 6 mm and minimum width 225 mm. For other than expansion joints these shall be 150 mm wide. For deep underground structure of coal handling plant etc. copper water stops shall be provided as specified under coal handling system.
Bitumen sealing compound can be used. Preformed bitumen impregnated fibre board shall be used as joint filler.

Brick Masonry and Parapet Wall

All masonry works shall be designed in accordance with Building code of Bangladesh and other relevant codes as applicable.

All walls shall be non-load bearing in filled panels walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, change rooms, first aid rooms and toilets which may be half brick thick. RCC bands shall be provided wherever necessary.

50 mm thick DPC (1:1.5:3) with water proofing admixture and bitumen coating on top shall be provided at plinth level before starting masonry work.

Minimum 50 kg/cm² compressive strength bricks shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick walls and 1:4 for half brick thick walls shall be used.

All up stands and parapet walls on roof shall be of RCC or brickwork construction. Minimum height of parapet walls shall be 750 mm and thickness 125 mm / 230 mm (for brick wall) with aesthetics of architectural designs as approved by the owner.

Water Proofing of Underground Structures

All underground structures like basements, pump houses, water retaining structures etc., shall have plasticiser cum waterproofing cement additives conforming to relevant standard. The concrete surface of these structures in contact with aggressive soil shall be provided with minimum two coats of bituminous painting of grade 85/25 @ 1.7 kg/m² (Minimum) for water and damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that water proofing grouting can be injected later in case of leakage.

Anti-Termite Treatment

Pre-constructional anti-termite treatment shall be given to all vulnerable areas susceptible to termite attack and shall include column pits, wall trenches, foundations filling below the floors as per requirement.

The rate of application for foundation bed and side of excavation shall be 5 L/m². The rate of application for foundation concrete surface shall be 7.5l/m².

Plinth level

Finished ground floor level (plinth level) of Power House building, pump houses and all other Plant buildings, Non- Plant and Residential buildings shall be minimum 500 mm above the finished formation level.

All cable vaults shall be located above ground level i.e., vaults shall not be provided as basements in the buildings.

Finished floor levels of HRSG area, transformer area yard paving shall generally be kept 150 mm lower than the finished floor level of turbine building.
Provisions of safety, health and welfare according to Factories act shall be complied with at design stage. These shall include provision of continuous walkway (minimum 600 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape, locker room for workmen, pantry, toilets, rest rooms etc.

Floor Finish

Total thickness of floor finish (including under bed of Cement Mortar or PCC and top finish) shall be 50 mm. Height of matching skirting shall be minimum 150 mm and height of dado shall be minimum 2200mm for toilets and up to bottom of false ceiling for other area if required.

In general following type of floor finish shall be adopted for different area as per functional requirement. However, Bidder shall prepare a comprehensive scheme of floor finish with complete plan and details of the material to be used for the approval of the Owner before the execution of the work.

a) Vitrified Ceramic Tiles with or without mirror polish

b) This shall be homogeneous and compact throughout the entire body and fully vitrified. The minimum compressive strength and modulus of the tile shall be 700 kg/cm² and 300 kg/m² respectively and MOH hardness not less than 6 (unpolished).

c) Following sizes of the tiles shall generally be provided based on the area of application.
   - 400mm x 400mm x 8mm (nominal)
   - 600mm x 600mm x 9mm (nominal)

d) Heavy duty cement concrete tiles

Size of the tiles shall be 300mm x 300mm x 25mm and conforming to local code. Top wearing coat shall be made of white cement mixed with pigment and abrasion resistant carborundum / quartz stone chips of different colours. Tile shall be laid as per prudent practice.

a) Cement concrete flooring with metallic or non-metallic hardener topping.

This shall consist of 12mm thick metallic hardener topping with OPC. In case of non-metallic hardener finish, ready-mix non-metallic hard granules shall be spread directly over concrete base at a rate of 5kg/m².

b) Cement concrete flooring with neat cement finish.

Ordinary grey cement finish shall be applied over green concrete at the rate of 2.5 kg/m² and finished smooth.

c) Cement concrete flooring with epoxy resin finish

This shall be laid with acid, alkali and oil resistant high build, solvent free, self-smoothing, seamless epoxy resin floor finish. Total Dry Film Thickness (DFT) of the coating (excluding primer) shall be minimum 300 micron.

d) Interlocking Concrete Paver Block
This shall be provided as per building and Road work codes.

e) Granite Stone flooring

Pre polished Granite stone of minimum 18mm thickness shall be provided and nominal size of a single slab shall not be less than 0.4 m².

f) Marble Stone flooring

The Marble of 18mm thickness shall be plain white marble with coarse grain predominantly showing mica particles giving reflection in bright light.

g) Acid and Alkali resistant lining

- Acid and Alkali resistant lining for DM plant, CPU regeneration complex including neutralisation pit, acid battery area etc shall conform to the following:-

- Bitumen Primer and Bitumastic compound shall conform to British code

- Where the height of Bitumastic layer on vertical surface is more than 2.0 meter, the Bitumastic layer shall be reinforced with diamond pattern expanded metal steel sheets.

- A.R. Bricks / Tiles shall conform to British code.

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 Bidder 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 of this building shall be RCC slab with water proofing treatment. The Bidder 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

Water proofing treatment to the roof slab shall be provided with high solid content liquid applied urethane based elastomeric membrane of joint less dry film thickness of minimum 1.5mm conforming to ASTM C 836 and C 898. Wearing course on the top of membrane shall consists of 25mm thick PCC of grade C25 cast in panel of maximum 1.5mx1.5m size and reinforced with galvanised chicken wire mesh including panel joint sealing. Wherever required, chequered concrete tile flooring minimum 22mm thick of approved colour and shade shall also be provided.

(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 Bidder 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 fitting 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 Bidder 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

<table>
<thead>
<tr>
<th>Part</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame and Stile Plates</td>
<td>more than 2.3 mm thick</td>
</tr>
<tr>
<td>Stile and Panel</td>
<td>more than 1.6 mm thick</td>
</tr>
<tr>
<td>Thickness</td>
<td>80 mm</td>
</tr>
<tr>
<td>Size</td>
<td>double door 2.0 x 2.0 m</td>
</tr>
<tr>
<td></td>
<td>single door 1.0 x 2.0 m</td>
</tr>
<tr>
<td></td>
<td>other sizes as shown on the approved drawing</td>
</tr>
</tbody>
</table>

b. Wooden doors

<table>
<thead>
<tr>
<th>Part</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plywood for panel</td>
<td>more than 5 mm thick</td>
</tr>
<tr>
<td>Thickness</td>
<td>40 mm</td>
</tr>
<tr>
<td>Size</td>
<td>0.9 x 2.0 m or other sized as</td>
</tr>
<tr>
<td></td>
<td>shown on the approved drawing</td>
</tr>
<tr>
<td></td>
<td>Hollow flush door shall be painted 2 coats of rust resistant paint and finish coat. Hollow flush door shall be of the waterproof type.</td>
</tr>
</tbody>
</table>

c. Aluminium window

<table>
<thead>
<tr>
<th>Part</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>70 mm</td>
</tr>
<tr>
<td>Finishing</td>
<td>Aluminate</td>
</tr>
<tr>
<td>Size</td>
<td>double window 0.9 x 1.8 m</td>
</tr>
<tr>
<td></td>
<td>single window 0.9 x 0.9 m or other sizes as shown on the approved drawing</td>
</tr>
</tbody>
</table>

Glass (tinted) : 6mm
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 different 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 a 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 manufacturer 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 surface. 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 of 2 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 waterproof 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 Bidder 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 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 Bidder 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 Bidder 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 grid 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 Bidder 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 Codes and 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>Metal</th>
<th>Wood</th>
<th>Concrete</th>
<th>Brick</th>
</tr>
</thead>
<tbody>
<tr>
<td>First paint (Rust inhibitive paint)</td>
<td>0.14</td>
<td>0.09</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Second paint</td>
<td>0.08</td>
<td>0.11</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Finishing paint</td>
<td>0.04</td>
<td>0.09</td>
<td>0.13</td>
<td></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
21.6.6 Storage

The Bidder 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.

21.6.6 Finishing Schedule

Interior and Exterior Finishes shall be as given in following two tables :-

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of Area</th>
<th>Flooring</th>
<th>Wall Finish over Cement Plaster</th>
<th>Ceiling Finish over Cement Plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operating / Maintenance areas of workshop, Pump houses, Compressor house</td>
<td>RCC with Metallic hardener topping for general area</td>
<td>Oil bound distemper</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For Control room area-Mirror polished vitrified Ceramic tiles</td>
<td>For Control room Acrylic emulsion paint over plaster of Paris</td>
<td>For Control room Pre-coated (colour) Aluminium false ceiling in approved pattern</td>
</tr>
<tr>
<td>2</td>
<td>General storage areas</td>
<td>RCC with Metallic hardener topping</td>
<td>Oil bound distemper</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>3</td>
<td>Cable Vault / Cable spreader</td>
<td>-do-</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>4</td>
<td>Chimney and HRSG area paving</td>
<td>RCC with Metallic hardener topping to be laid over 250 mm thick compacted stone filling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Equipment / Vehicle movement area</td>
<td>RCC with Metallic hardener topping</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Balance area</td>
<td>Concrete Paving Block</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Power house building (Main Plant Building)</td>
<td>a) Ground Floor</td>
<td>RCC with Metallic hardener topping</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) Main trailer entrance area</td>
<td>Oil bound distemper</td>
<td>Oil bound distemper</td>
</tr>
</tbody>
</table>

c. Oil painting

Three coats on woodwork

Two coats on elsewhere
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of Area</th>
<th>Flooring</th>
<th>Wall Finish over Cement Plaster</th>
<th>Ceiling Finish over Cement Plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>(ii) Balance area including passage</td>
<td>RCC with metallic hardener topping</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>b) Mezzanine floor (excluding grating area)</td>
<td>Heavy duty concrete tiles</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>c) Deareator floor</td>
<td>RCC with metallic hardener topper</td>
<td>-do-</td>
<td>Metal deck</td>
</tr>
<tr>
<td></td>
<td>d) Operating floor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Operating area, Laydown area,</td>
<td>18mm thick polished granite stone (1st quality) with combination of 10 mm polished vitrified ceramic tiles and heavy duty concrete tiles.</td>
<td>Acrylic emulsion paint over plaster of Paris (except cladding area)</td>
<td>Oil bound distemper (except metal deck area)</td>
</tr>
<tr>
<td></td>
<td>ii) General circulation and movement areas</td>
<td>10mm thick vitrified ceramic tiles in combination of mirror polished and unpolished tiles.</td>
<td>Oil bound distemper over plaster of Paris (except cladding area)</td>
<td>-do-</td>
</tr>
<tr>
<td>6</td>
<td>a) MCC room</td>
<td>10mm thick vitrified ceramic tiles (unpolished)</td>
<td>Oil bound distemper over plaster of Paris</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td></td>
<td>b) Switchgear room</td>
<td>RCC with metallic hardener topping</td>
<td>Oil bound distemper</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>7</td>
<td>a) Control room area including Central control room, Computer room and Control equipment room. (False flooring area may be restricted in control room)</td>
<td>10mm thick mirror polished vitrified ceramic tiles. False flooring area with Pre laminated over high density particle board</td>
<td>Mirror polished Vitrified ceramic tiles up to false ceiling height.</td>
<td>Precoated colour) / Al. Lineal false ceiling in approved pattern With combination of Gypsum board for area requiring profiled shape</td>
</tr>
<tr>
<td></td>
<td>b) Conference room, Senior executive room</td>
<td>Mirror polished Vitrified tiles</td>
<td>Acrylic emulsion paint over plaster of Paris.</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>c) Record room</td>
<td>Mirror polished Vitrified tiles</td>
<td>Oil bound distemper over plaster of Paris</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description of Area</td>
<td>Flooring</td>
<td>Wall Finish over Cement Plaster</td>
<td>Ceiling Finish over Cement Plaster</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------</td>
<td>----------</td>
<td>--------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>d) Locker room</td>
<td>Mirror polished Vitrified tiles</td>
<td>Oil bound distemper over plaster of Paris</td>
<td>Oil bound distemper</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Toilet area</td>
<td>Unpolished Vitrified Ceramic tiles</td>
<td>Coloured ceramic tiles up to 2.2m with border tiles wherever required and oil bound distemper over plaster of Paris for balance height</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>9</td>
<td>Pantry Area</td>
<td>i) 10mm thick vitrified ceramic tiles in combination of mirror polished and unpolished tiles ii) 18mm thick polished granite stone for counter platform</td>
<td>Coloured ceramic tiles up to 1.2m and oil bound distemper over plaster of Paris for balance height</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>10</td>
<td>Office Room, Staff Room</td>
<td>Mirror Polished vitrified ceramic tiles</td>
<td>Acrylic emulsion paint over plaster of Paris</td>
<td>Precoated (colour) Al. Lineal false ceiling in approved pattern</td>
</tr>
<tr>
<td>11</td>
<td>Chemical building</td>
<td>RCC with metallic hardener topper and painted with chemical resistant paint.</td>
<td>Oil bound distemper over cement plaster surface</td>
<td>Oil bound distemper over cement plaster</td>
</tr>
<tr>
<td>12</td>
<td>Laboratory area</td>
<td>10mm thick vitrified ceramic tiles in combination of mirror polished and unpolished tiles</td>
<td>Acrylic emulsion paint over plaster of Paris</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>13</td>
<td>RCC Stair case</td>
<td>Combination of 18mm thick marble and kota stone (first quality) for tread &amp; riser respectively</td>
<td>Coloured ceramic tile matt finish up to 1.2m ht &amp; 1.2mm thick Resin bonded granular texture finish for balance height.</td>
<td>Oil bound distemper over plaster of paris on underside of staircase</td>
</tr>
<tr>
<td>14</td>
<td>Entrance lobbies and Lift areas</td>
<td>18mm thick polished granite stone</td>
<td>1.2 mm thick resin bonded granular textured finish. Mirror polished vitrified ceramic tiles on lift facia.</td>
<td>Precoated (colour) Al. Lineal false ceiling in approved pattern</td>
</tr>
</tbody>
</table>
| 15     | Passages and General circulation | 18mm thick Marble stone (first | Oil bond distemper over plaster of | -do-
### Technical Requirements

#### Sl. No. Description of Area

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of Area</th>
<th>Flooring</th>
<th>Wall Finish over Cement Plaster</th>
<th>Ceiling Finish over Cement Plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Battery Room</td>
<td>20mm thick acid resistant tiles over bitumen primer.</td>
<td>20mm thick acid resistant tiles over bitumen primer up to 1.2 m height and chemical resistant paint for balance height</td>
<td>Chemical resistant paint.</td>
</tr>
<tr>
<td>17</td>
<td>Oil canal, oil room, oil purification tank and other areas where oil spillage is likely to occur.</td>
<td>Oil resistant paint (epoxy based amine cured) 150 micron over primer on CC flooring</td>
<td>Oil resistant paint up to 1.2m height and Oil bound distemper for balance height.</td>
<td>Oil bound distemper except oil canal area.</td>
</tr>
<tr>
<td>18</td>
<td>Re-generation and other areas requiring acid / alkali resistant treatment.</td>
<td>Acid &amp; Alkaline resistant bricks, tiles with applicable mortar</td>
<td>Oil bound distemper above acid resistant skirting</td>
<td>Oil bound distemper</td>
</tr>
<tr>
<td>19</td>
<td>Covered parking area</td>
<td>Interlocking cement concrete blocks</td>
<td>-</td>
<td>Pre coated metal sheet</td>
</tr>
<tr>
<td>20</td>
<td>Pathways including equipment installation area on top of roof</td>
<td>22mm thick concrete chequered tiles.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### Notes

- a) All wall and roof areas above false ceiling shall be plastered and white washed.
- b) For wall finishing shall be provided above 150mm height matching skirting.
- c) The colour and pattern of finish shall be as per approved details.
- d) All material shall be of reputed and established brand approved by Owner.
- e) Wherever alternative materials are specified, the final selection rests with the Owner.
- f) This finishing schedule shall also be applicable to similar functional areas for all other buildings and facilities.
- g) All the finishing materials shall be applied / provided as per manufacturer specification and guidelines under the supervision & guidelines of manufacturer.
- h) Requirement given above are suggestive and minimum. Bidder is free to suggest alternative scheme conforming to design & functional requirement.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of Area</th>
<th>Walls and Projections</th>
<th>Soffit of Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Turbine building</td>
<td>i) Initial height of 3m (nominal) permanent finish using bricks cladding in cement mortar, finished with plastering, smooth finish and 2.5mm thick resin and polymer bounded granular textured coat.   ii) Approved colour / colour combination of colour coated metal cladding for balance height.</td>
<td>i) Two coats of water proof cement based paint over primer coat.  ii) Approved colour / colour combination of colour coated metal cladding.</td>
</tr>
<tr>
<td>2</td>
<td>Building with concrete framework, fire walls, Residential buildings etc.</td>
<td>2.5mm thick resin and polymer bounded granular textured coat.</td>
<td>Two coats of water proof cement based paint over primer coat.</td>
</tr>
<tr>
<td>3</td>
<td>Steel structures, trestles etc.</td>
<td>High performance chemical resistant painting system having UV resistant top coat with approved colour and shade as per requirement of corrosion protection.</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Chimney</td>
<td>Top 10 m painting using polyurethane with colour band for aviation requirements as per technical specification. The balance portion shall receive two coats of synthetic enamel paint.</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Cooling tower</td>
<td>Two coats of water proof cement based paint over the primer coat.</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Boundary wall</td>
<td>Two coats of water proof cement based paint over the primer coat applied on plaster surface.</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:

a) The colour and pattern of finish shall be as finalized by the Owner.

b) All materials shall be of reputed and established brand approved by the Owner.

c) All the finishing work shall be carried out as per manufacturer specifications and of approved colour.
Section 22

Spare Parts
SPARE PARTS

22 Spares during Warrantee Period
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan December, 2016

Single - Stage: Two-Envelope
22. **SPARE PARTS**

**Spares & consumables during Defect Liability period**

The Bidder shall submit a list & supply accordingly Essential spare parts with OEM part No. (as per Vol. 2, Schedule-F) to be necessary for maintenance of Gas Turbine Generating Unit, Steam Turbine Generating unit, HRSG and other plant equipment inclusive of routine, scheduled as well as emergency use that takes place in the course of operation of the plant during defect liability period (24 months) which are mandatory.

It may be mentioned that Bidder must quote in Schedule-F in full quantity and also additional items & quantity necessary as stated in Tender Document, otherwise Tender shall be rejected.

During the defect liability period of 24 months, the Bidder shall supply all necessary equipment, spare parts, materials/consumables etc. at his own cost and whether it is listed or not in in Schedule-F, Vol. 2 of 2 Part B Tender Documents. In preparation of the list the Bidder have to consider plant factor as 80%.

During the defect liability period the Bidder have to conduct (providing all required spare parts and service) at least 1(One) CI for Gas Turbine and at least one Inspection for other equipment and any other maintenance work for force outage. 1 (One) HGPI Spare is also included. Spare parts & consumables to be supplied for defect liability period under the Contract must be made available at site before start of testing.

**SCOPE OF FIRST INSPECTION (CI):**

The first inspection(CI) have to be conducted but not limited to the followings:

1. Opening and inspection of gas fuel nozzles, combustion liners, cross flame tubes and transition pieces.
2. Opening of the axial compressor upper half casing, visual checking of the compressor blades and their clearances.
3. Opening the upper halves of turbine and generator bearings and checking of their clearances.
4. Visual check of the load gear by removing the inspection window.
5. Visual check of the clutch.
7. Cleaning and checking of the gas turbine rotor buckets by non-destructive testing and checking of their clearances.
8. Checking of first and second stage nozzles by taking them out, cleaning them thoroughly and checking the same for any cracks, by non-destructive testing.
9. Removal of both the end shields of the generator for cleaning purposes and checking of the insulation resistance between phase and phase and earth.
10. Check the quality and quantity of transformer oil.
11. Checking and cleaning of the exciter rotor.
12. Calibration of GT control system.
13. Checking of the fire protection system, various temperature and pressure switches.
14. Tightening of the foundation bolts of the equipment.
15. Checking of the hydraulic ratchet system.
17. Checking of the over-speed trip
Section 23

Environmental Requirements
23  Environmental Requirements
   23.1  General
   23.2  Air Emission
   23.3  Water Pollution
   23.4  Soil Contamination
   23.5  Permissible Noise Levels
   23.6  Environmental and Social Impact Assessment (ESIA)
   23.7  Labour and Working Conditions
   23.8  Occupational and Public Health and Safety
   23.9  Stakeholder Engagement Plan
   23.10 Traffic Management
   23.11 Security Management
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
Environmental Requirements

23.1 General

32.1.1 The bidder will be required to design, construct, commission and operate the Plant in accordance with the applicable national (Bangladesh) environmental laws and standards and international requirements and guidelines of European Investment Bank (EIB) (European Union (EU) environmental requirements). Bidders are responsible for familiarising themselves with the legal requirements in this regard.

32.1.2 Where EU standards are more stringent than national standards, the Project shall comply with the more stringent EU standards if practical and feasible (i.e. affordability, local conditions, international best practice)

32.1.3 The Bidder shall apply for an Environmental Clearance from the Directorate of Environment following the completion of Environmental and Social Impact Assessment (ESIA) study. The Bidder shall identify and apply for all additional environmentally-related consents and permits required for the Project. An ‘in principal’ approval has been obtained by BPDB from the Directorate of Environment, Rajshahi Division (dated 08/01/2015), a copy of which is attached as Appendix 24.12 to the RFP.

32.1.4 The Bidder will be required to provide monitoring equipment to demonstrate ongoing compliance with the relevant environmental standards (continuous online flue gas monitoring systems and online wastewater discharge monitoring for flowrate, pH, temperature, salinity). Monitoring programme for both construction and operational phases shall comply with both national and EIB requirements.

32.1.5 The Plant shall be designed to ensure compliance with all applicable laws and standards and environmental, construction and operating consents, This shall include all relevant national Bangladeshi standards and guidelines as well as EU standards as required by the EIB. An illustrative, non-exhaustive list of regulations is listed below:


23.1.5.2 Environment Court Act of 2000 and its subsequent amendment of 2002

23.1.5.3 The Ground Water Management Ordinance of 1985

23.1.5.4 The Forest Act of 1927 and subsequent amendments in 1982 and 1989

23.1.5.5 Bangladesh Wildlife (Preservation) Act of 2012

23.1.5.6 The Protection and Conservation of Fish Act 1950 and its subsequent amendments in 1982

23.1.5.7 Natural Water Bodies Protection Act of 2000
23.1.5.8  The Embankment and Drainage Act of 1952
23.1.5.9  Antiquities Act of 1968
23.1.5.10 The Land Acquisition Act of 1894
23.1.5.11 The Acquisition and Requisition of Immovable Property Ordinance of 1982 and subsequent amendments in 1994, 1995 and 2004
23.1.5.12 Bangladesh Labour Law 2006
23.1.5.13 The Factories Act of 1965
23.1.5.14 Bangladesh Constitution Article 11: Democracy and Human Rights
23.1.5.15 EIB Environmental and Social Handbook, 2013
23.1.5.16 Applicable EU environmental policies and directives
23.1.5.17 Applicable International Labour Organisation (ILO) Conventions and labour standards
23.1.5.18 International Finance Corporation (IFC) General Environmental, Health and Safety (EHS) Guidelines and Thermal Power EHS Guidelines
23.1.5.19 IFC and EBRD Guidance Note on Workers’ Accommodation: Processes and Standards (2009)

23.1.5 The Bidder shall include in their Bids details of all environmental mitigation measures and Best Available Techniques (BAT) proposed to control environmental emission and contamination.

23.2 Air Emission

23.2.1 The Bidder shall design the Plant to ensure compliance with the more stringent air emission standards of Bangladesh or EIB. EIB requires that the Plant should be designed in accordance with the principles of “Best Available Technique” (BAT) and a BAT assessment may be required to demonstrate emission limits meet these requirements.

23.2.2 Applicable emission standards based upon BAT will be determined through the environmental assessment process and will be based on the predicted impacts and existing baseline pollutant concentrations. The EU’s ambient air quality standards will be referred to and the project should be designed to not cause an exceedance of these standards. If existing ambient standards are above the EU’s ambient air quality standards the project should be designed so that it does deteriorate existing air quality.

23.2.3 The Bidder shall carry out air quality modelling to determine the necessary stack heights and for adequate dispersion and to determine project
impacts to confirm the appropriate emission standards.

23.2.4 The determination of the stack height should be based on Natural Gas firing. When determining overall air quality impacts back up fuel should also be considered.

23.2.5 The height of the exhaust gas stacks shall comply with the requirements of the environmental standards and outcomes of air dispersion modelling study but shall be at least:

23.2.5.1 Fifty (50) meters above ground level for the main stack/HRSG stack as per the local EIA.

23.2.6 The plant shall be equipped with CEMS as specified in section 11.8.

23.2.7 Periodic (annual) monitoring of stack emissions will be undertaken by an accredited third party stack emission monitoring company using reference methods (or equivalent) for all parameters monitored by the CEMS equipment specified in section 11.8. The results will be used to demonstrate compliance with emission standards and to review reliability of CEMS equipment.

23.3 Water Pollution

23.3.1 The Bidder shall design the Plant to ensure compliance with the relevant effluent discharge standards of Bangladesh and EIB, whichever value is more stringent.

23.3.2 The standards for disposal of liquid effluents from industrial units or projects to inland surface water (river environment) as issued within The Environment Conservation Rules (1997) by the Ministry of Environment and Forest is attached within Appendix 24.7 of this Bidding Document.

23.3.3 The Bidder shall carry out thermal and hydrodynamic modelling studies that assess the impacts of thermal and pollutant plumes on the river environment against applicable national and international (EU) standards. The background ambient water quality and the discharge of other sources, if any, shall be taken into consideration for the modelling and the design of the intake and outfall of the Project.

23.3.4 The Bidder shall carry out plume dispersion and sediment transport modelling that assesses the impacts of construction activities (such as dredging and construction of intake, outfall and jetty/loading-unloading facilities on the surrounding water) on ecology and local stakeholders.

23.3.5 The ESIA shall assess the impacts associated with the water abstraction and water discharge to/from the river on the water quality, ecology and stakeholders upstream (if any) and downstream.

23.3.6 The ESIA shall assess the impacts associated with the groundwater abstractions from local deep tube wells during the drought season on the water quality including impacts on water provision for consumption and irrigation.
23.3.7 The domestic and sanitary wastewater shall be collected separately and shall be treated and disposed of in accordance with applicable environmental regulations.

23.3.8 Both domestic and industrial wastewater consist of many compounds which could contaminate surface water, ground water and soil. Special attention is required to be paid by the Bidders during their investigation of the collection area to guarantee that all wastewater streams are considered and will be segregated and collected and/or discharged in a wastewater collecting system. This also includes all sanitary and other domestic wastewater from canteens, laundries, offices, and workshops; and the industrial wastewater such as backwash water, rinse water and other process wastewater which cannot be used in other ways (for example blow-down water).

23.3.9 All domestic and sanitary wastewater streams discharged into the sewer shall be free of toxic and inhibitory compounds concerning the process of biological clarification or compounds that can influence the further use of sewage sludge.

23.3.10 Special regard is required to be paid by Bidders to the contamination of the several streams and the adequacy and suitability of treatment processes. Wastewater streams with similar contamination can be combined and mixed before treatment. Oil-contaminated water shall be treated in oil separators.

23.3.11 All chemical loaded wastewater (out of storage areas, acid cleaning, cleaning of GT compressors) has at least to be neutralised and detoxified.

23.3.12 The ESIA will also demonstrate that site drainage is designed such that no flooding of the Project or adjacent facilities will result from construction or operation of the Project.

23.3.13 Wastewater discharge monitoring shall meet the requirements of national regulator, EU and international best practices.

23.4 Soil Contamination

23.4.1 The entire Plant must be designed, constructed, operated and maintained in such a way to prevent any soil contamination.

23.4.2 The Bidder shall satisfy themselves that the ground and groundwater conditions are free of contamination. Testing for an appropriate suite of potential contaminants shall be undertaken for soil and groundwater to establish the baseline conditions. The Bidder will treat the groundwater to acceptable levels if used during construction or operational phases during the drought seasons. Contaminated soil/material excavated during construction and dewatering water, if any, shall be disposed off appropriately as per national regulations, EIB requirements and international best practices.

23.5 Permissible Noise Levels
23.5.1 The Bidder shall ensure that the Project is designed, constructed, and operated to avoid, prevent or reduce negative effects associated with environmental noise emitted from the Project.

23.5.2 The Bidder shall design the Plant to ensure compliance with the more stringent national standards or EIB (EU) noise emission requirement.

23.5.3 It is expected that the maximum permissible noise pressure levels will be as follow:

Table 23.4: Permissible noise levels

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Noise Pressure Level, dB(A)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>At one (1) metre outside the Plant fence/boundary when all equipment is running</td>
<td>60</td>
</tr>
<tr>
<td>At one (1) metre away from open air installations</td>
<td>85</td>
</tr>
<tr>
<td>Within the central control room</td>
<td>45</td>
</tr>
<tr>
<td>Within the turbine halls (outside operational areas)</td>
<td>90</td>
</tr>
<tr>
<td>Within other machine rooms, workshop, etc</td>
<td>85</td>
</tr>
</tbody>
</table>

(*) the actual permissible noise pressure levels will be confirmed in the ESIA Study

23.5.4 The sound levels shall be measure according to the procedures described within ISO standards (e.g. ISO 1996 ‘Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels’).

23.5.5 EIB requires that the Plant should be designed in accordance with the principles of BAT and a BAT assessment may be required to demonstrate emission limits meet these requirements. The Plant is required to be equipped with noise attenuation features or techniques identified and recommended for BAT.

23.5.6 To meet the noise level requirements, the Plant is required to be equipped with standard noise attenuation features. The noise from all machinery which exceeds the permissible noise limits shall be reduced using Best Available Techniques for the control of noise which may include silencers, lagging or specially designed acoustic enclosures.

23.5.7 Noise levels during the construction phase shall be monitored and assessed:

23.5.7.1 In accordance with the basic procedures for noise measurement as set out in:


23.5.7.1.2 Annex G of the British Standard 5228 ‘Code of Construction Practice for the Control of Noise and Vibration
23.5.7.2 At monthly intervals throughout construction, but not at pre-arranged times

23.5.7.3 As and when required, during critical phases of construction, i.e. when possible exceedance of the project noise criteria during construction (see Table 23.5) is anticipated

23.5.7.4 In response to reasonable noise complaints being received;

23.5.7.5 At locations representative of sensitive receptors in the vicinity

23.5.8 With reference to the British Standard 5228 Part 1 (2009+A1:2014), noise impacts measured during construction should not exceed the levels presented in Table 23.5, or result in a maximum increase in ambient noise levels of 5 dB.

Table 23.5 – Project noise criteria during construction to be evaluated by monitoring

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Daytime 07:00 – 22:00</th>
<th>Night-time 22:00 – 07:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential, commercial, institutional, place of worship, buildings in health and/or community use</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Industrial commercial</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

23.5.9 Criteria for industrial and commercial receptors may be reviewed as appropriate if especially sensitive to noise (e.g. performance spaces, recording studios and radio stations).

23.5.10 Criteria for long-term operational noise impacts and the frequency of measurements during commissioning and operation shall be confirmed as part of the ESIA study.

23.6 Environmental and Social Impact Assessment (ESIA)

23.6.1 An Environmental and Social Impact Assessment (ESIA) shall be carried out by the Bidder in accordance with the requirements and regulations of People’s Republic of Bangladesh and EIB Environmental and Social Handbook and Standards. The ESIA shall be consistent and aligned with EU environmental and social standards and shall adhere to international best environmental and social practices.

23.6.2 The organisation commissioned to prepare the ESIA must have appropriate experience to undertake EIB compliant ESIA studies.
23.6.3 The ESIA shall assess the environmental and social impacts associated with the Project and its associated infrastructure facilities such as loading-unloading facility, Jetty, intake pipeline, outfall channel, and if any, transmission and distribution networks, and substations.

23.6.4 The ESIA shall include a labour assessment in accordance with EIB Standard 8 on Labour Standards.

23.6.5 The ESIA shall include a review of the completed land acquisition process undertaken by the DC Office Sirajgonj for the Project, including an assessment of whether forced evictions (as defined by EIB) were carried out. The land acquisition review shall include a gap analysis of the process against EIB Standard 6 requirements on Involuntary Resettlement.

23.6.6 The ESIA study shall assess the cumulative impacts associated with existing plants in the vicinity of the Project.

23.6.7 An Environmental and Social Management Plan (ESMP) shall be developed as part of the ESIA. The Bidder shall expand on the ESMP Framework, a copy of which is attached to Appendix 24.13, to develop detailed ESMPs for both construction and operational phases prior to the commencement of each respective phase.

23.6.8 The ESMPs shall include a detailed environmental and social monitoring programme that is in compliance with the national legal and EIB requirements.

23.6.9 The ESMP shall include mitigation measure and management plans to address the decommissioning of above ground structure that exist on site and rehabilitation work planned for the Project, including a retrenchment plan.

23.7 Labour and Working Conditions

23.7.1 Prior to construction, the Bidder shall undertake a labour assessment which incorporates the principles of the core International Labour Standards including EIB Standard 8: Labour Standards on non-discrimination and equality, freedom of association and collective bargaining, compliance with national labour and employment laws and with internationally recognised labour standards as defined by the ILO, particularly its Core Labour Standards, protection of all workers, including vulnerable categories (workers engaged by primary contractors and first-tier/direct suppliers, from unacceptable forms of labour and employment practices, exploitation and violation of the core labour rights; avoiding the use of forced and child labour.

23.7.2 The Bidder shall prepare a human resources (HR) policy and procedures which in conformance with EIBs standards on labour and working condition. The Bidder shall ensure that the Project’s primary contractors and first tier suppliers to the Project\(^1\) also have similar HR policy and procedures in place.

\(^1\) First-tier (or direct suppliers) sell directly to BPDB.
23.7.3 The Bidder shall undertake regular monitoring of labour rights in accordance with EIB Standard 8 requirements. The Bidder shall monitor its workforce and the Project’s primary contractors and first tier suppliers.

23.7.4 Should it be required; the Bidder shall prepare a worker accommodation plan, in accordance with international guidelines and provide temporary workers’ accommodation in accordance with the approved plan.

23.8 Occupational and Public Health and Safety

23.8.1 The Bidder shall complete HAZIDs (hazardous identification studies) and a HAZOP (hazard and operability study) completed for the Project which employ internationally-accepted methodologies. These studies will form the basis of subsequent health and safety management plans.

23.8.2 The Bidder shall prepare an occupational health and safety plan (OHSP), in accordance with applicable environmental permit conditions, national regulations and international standards, including EIB Standard 9: Occupational and Public Health, Safety and Security.

23.8.3 The Bidder shall prepare a community health and safety plan (CHSP), and in accordance with applicable environmental permit conditions, national regulations and international standards, including EIB Standard 9.

23.8.3 The Bidder shall prepare an emergency preparedness plan (EPP) in accordance with applicable environmental permit conditions, national regulations and international standards.

23.7.5 Should it be required; the Bidder shall prepare an influx management plan which will identify ways to manage Project-induced migration risks, including a disease prevention strategy in accordance with EIB Standard 9.

23.10 Security Management

23.10.1 The Bidder shall prepare a security management plan in accordance with applicable environmental permit conditions, national regulations and international standards, including EIB Standard 9: Occupational and Public Health, Safety and Security.

23.11 Stakeholder engagement plan (SEP)

23.11.2 The Bidder shall prepare a SEP in accordance with applicable environmental permit conditions, national regulations and international standards including EIB requirements on stakeholder engagement and information disclosure.

---

3 To include consideration of international guidelines such as the International Finance Corporation’s (IFC) general and industry specific environmental, health and safety guidelines.
Section 24

Annexes
24 Annexes
24.1 Site Layout
24.2 Grid Network
24.3 Key Electrical Single Line Diagram
24.4 Fuel Analysis
24.5 Seismic Zone Map of Bangladesh
24.6 Basic Wind Speed Map
24.7 Environmental Standards
24.8 Additional Documents Requirements
24.9 Overhauling Scope of Works
24.10 Additional Drawings
24.11 Condition Assessment of Existing GT Power Plant
24.12 EIA Approval
24.13 Environmental and Social Management Plan (ESMP) Framework
24.1 Site Layout
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan
December, 2016
Single Stage: Two-Envelope
24.2 Grid Network
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan
December, 2016
Single Stage: Two Envelope
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan
December, 2016
Single – Stage: Two-Envelope
24.3 Key Electrical Single Line Diagram
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
24.4 Fuel Analysis
### Technical Requirements

<table>
<thead>
<tr>
<th>TESTS</th>
<th>METHOD</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Density at 15 °C, kg/L</td>
<td>ASTM D 1298</td>
<td>Min. 0.820, Max. 0.870</td>
</tr>
<tr>
<td>2 Colour, ASTM</td>
<td>ASTM D 1500</td>
<td>Max. 3.0</td>
</tr>
<tr>
<td>3 Neutralization Value</td>
<td>ASTM D 664/</td>
<td>Nil</td>
</tr>
<tr>
<td>Strong Acid No, mg KOH/g</td>
<td>ASTM D 974</td>
<td>Max. 0.2</td>
</tr>
<tr>
<td>Total Acid No, mg KOH/g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Ash, % mass</td>
<td>ASTM D 482</td>
<td>Max. 0.01</td>
</tr>
<tr>
<td>5 Carbon Residue (Conradson) on 10% bottom</td>
<td>ASTM D 189</td>
<td>Max. 0.2</td>
</tr>
<tr>
<td>% mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Cetane Number</td>
<td>ASTM D 613</td>
<td>Min. 45</td>
</tr>
<tr>
<td>7 Cetane Index (Calculated)</td>
<td>ASTM D 976</td>
<td>Min. 45</td>
</tr>
<tr>
<td>8 Pour Point, °C</td>
<td>ASTM D 97</td>
<td>Max. 9 (<em>Winter</em>), Max. 12 (<em>Summer</em>)</td>
</tr>
<tr>
<td>9 Copper Strip Corrosion (3 hours at 100 °C)</td>
<td>ASTM D 130</td>
<td>Max. No. 1</td>
</tr>
<tr>
<td>10 Flash Point PM (co)/ Abel, °C</td>
<td>ASTM D 93/</td>
<td>Min. 32</td>
</tr>
<tr>
<td>IP 170</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Kinematic Viscosity at 38 °C, cSt</td>
<td>ASTM D 445</td>
<td>Max. 9.0</td>
</tr>
<tr>
<td>12 Sulphur, % mass</td>
<td>ASTM D 1552/</td>
<td>Max. 0.5</td>
</tr>
<tr>
<td>ASTM D 4294</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Sediment, % mass</td>
<td>ASTM D 473</td>
<td>Max. 0.01</td>
</tr>
<tr>
<td>14 Water Content, % vol.</td>
<td>ASTM D 95</td>
<td>Max. 0.1</td>
</tr>
<tr>
<td>15 Distillation: 90% vol. recovery, °C</td>
<td>ASTM D 86</td>
<td>Max. 375</td>
</tr>
</tbody>
</table>

* Winter shall be the period from November to February (both months inclusive) and rest of the months of the year shall be called as summer.
**Calorific value of HSD:**

Eastern Refinery Ltd.
Chittagong.

For: Director [O & P]
Bangladesh Petroleum Corporation
Chittagong.

Fax no. 88-031-720147
Date: 05.10.2009

Calorific Value of:

1. Gas Oil : Btu Per lb : 19,200 (Min)
2. HSF0 : K.Cal Per Kg : 10,250 (Min)

Best regards
## 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 (CH(_4))</td>
<td>92 to 97 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>b. Ethane (C(_2)H(_6))</td>
<td>0 to 6.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>c. Propane (C(_3)H(_8))</td>
<td>0 to 1.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>d. Butane (C(_4)H(_4))</td>
<td>0 to 1.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>e. Pentane (C(<em>5)H(</em>{12})) &amp; higher HC</td>
<td>0 to 2.00 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>f. Hydrogen Sulphide (H(_2)S)</td>
<td>0.5 grains per 10 S. Cu. ft.</td>
</tr>
<tr>
<td></td>
<td>g. Carbon Dioxide (CO(_2))</td>
<td>0 to 0.80 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>h. Nitrogen (N(_2))</td>
<td>0 to 0.60 Percent by volume</td>
</tr>
<tr>
<td></td>
<td>i. Oxygen (O(_2))</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>900 Btu/ S. Cu. ft.</td>
</tr>
<tr>
<td></td>
<td>b. Temperature Range</td>
<td>15(^0)C to 60(^0)C</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>Not less than 150 Psig</td>
</tr>
</tbody>
</table>
24.5 Seismic Zone Map of Bangladesh
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
24.6 Basic Wind Speed Map
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two- Envelope
24.7 Environmental Standards
**Updated Environmental regulation**

SCHEDULE-1

[REGULATION 5(2)]

AREA-BASED NOISE STANDARD

<table>
<thead>
<tr>
<th>Area</th>
<th>Standard (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
</tr>
<tr>
<td>Quiet Area</td>
<td>50</td>
</tr>
<tr>
<td>Residential Area</td>
<td>55</td>
</tr>
<tr>
<td>Complex Area (Complex of residential, commercial and industrial area)</td>
<td>60</td>
</tr>
<tr>
<td>Commercial Area</td>
<td>70</td>
</tr>
<tr>
<td>Industrial Area</td>
<td>75</td>
</tr>
</tbody>
</table>

Note 1: Day is 6 a.m. to 9 p.m.
Note 2: Night is 9 p.m. to 6 a.m.
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameters</th>
<th>Standard press unit of mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Particulate</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>(a) Power plant with capacity of 200 Megawatt or above.</td>
<td>150</td>
</tr>
<tr>
<td>1</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>
<tr>
<td></td>
<td>Lowest height of stack for dispersion of sulfuric acid (in meter).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Coal based power plant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) 500 Megawatt or above</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>(2) 200 to 500 Megawatt</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>(3) Less than 200 Megawatt</td>
<td>14(Q)^0.3</td>
</tr>
<tr>
<td></td>
<td>(b) Boiler</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) Steam per hour up to 15 tons Steam</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>(2) per hour more that 15 tons [Q = Emission of Sulfur dioxide (kg/hour)].</td>
<td>14(Q)^0.3</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>---</td>
<td>------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>9.</td>
<td>Oxides of Nitrogen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Nitric acid production</td>
<td>3 kg/ton ac</td>
</tr>
<tr>
<td></td>
<td>(b) Gas Fuel based Power Plant</td>
<td>50 ppm</td>
</tr>
<tr>
<td></td>
<td>(l) 500 Megawatt or above</td>
<td>50 ppm</td>
</tr>
<tr>
<td></td>
<td>(2) 200 to 500 Megawatt</td>
<td>40 ppm</td>
</tr>
<tr>
<td></td>
<td>(3) Below 200 Megawatt</td>
<td>30 ppm</td>
</tr>
<tr>
<td></td>
<td>(c) Metallurgical oven</td>
<td>200 ppm</td>
</tr>
<tr>
<td>10.</td>
<td>Kiln soot and dust</td>
<td>mg/Nm³</td>
</tr>
<tr>
<td></td>
<td>(a) Blast Furnace</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>(b) Brick Kiln</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>(c) Coke oven</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>(d) Lime Kiln</td>
<td>250</td>
</tr>
</tbody>
</table>
## EFFLUENT STANDARD

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Unit</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nitrogen including ammonia (N molecule)</td>
<td>Mg/l</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Ammonia (Free ammonia)</td>
<td>Mg/l</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Arsenic (As)</td>
<td>Mg/l</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>BGD&quot;20°C C</td>
<td>Mg/l</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Boron</td>
<td>Mg/l</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Cadmium (Cd)</td>
<td>Mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>7</td>
<td>Chloride</td>
<td>Mg/l</td>
<td>600</td>
</tr>
<tr>
<td>8</td>
<td>Chromium (Total Cr)</td>
<td>Mg/l</td>
<td>0.5</td>
</tr>
<tr>
<td>9</td>
<td>COD</td>
<td>Mg/l</td>
<td>200</td>
</tr>
<tr>
<td>10</td>
<td>Chromium (Hexavalent chromium)</td>
<td>Mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>11</td>
<td>Copper (Cu)</td>
<td>Mg/l</td>
<td>0.5</td>
</tr>
<tr>
<td>12</td>
<td>Dissolve Oxygen (DO)</td>
<td>Mg/l</td>
<td>4.5-8</td>
</tr>
<tr>
<td>13</td>
<td>Conductance</td>
<td>Micromho/cm</td>
<td>1.200</td>
</tr>
<tr>
<td>14</td>
<td>Total soluble matters</td>
<td>Mg/l</td>
<td>2.100</td>
</tr>
<tr>
<td>15</td>
<td>Fluoride (F)</td>
<td>Mg/l</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>Sulfide (S)</td>
<td>Mg/l</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>Iron(Fe)</td>
<td>Mg/l</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>Total Kjeldahi nitrogen (N)</td>
<td>Mg/l</td>
<td>100</td>
</tr>
<tr>
<td>19</td>
<td>Lead (Pb)</td>
<td>Mg/l</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>Manganese (Mn)</td>
<td>Mg/l</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>Mercury (Hg)</td>
<td>Mg/l</td>
<td>0.01</td>
</tr>
<tr>
<td>22</td>
<td>Nickel (Ni)</td>
<td>Mg/l</td>
<td>1.0</td>
</tr>
<tr>
<td>23</td>
<td>Nitrate (N molecule)</td>
<td>Mg/l</td>
<td>10.0</td>
</tr>
<tr>
<td>24</td>
<td>Grease</td>
<td>Mg/l</td>
<td>10</td>
</tr>
<tr>
<td>25</td>
<td>Phenol compound (C₆H₅OH)</td>
<td>Mg/l</td>
<td>1.0</td>
</tr>
<tr>
<td>26</td>
<td>Dissolve phosphorus (P)</td>
<td>Mg/l</td>
<td>8</td>
</tr>
<tr>
<td>27</td>
<td>Radio active substance : Defined by Bangladesh nuclear Committee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>P⁴⁺</td>
<td>Mg/l</td>
<td>6-9</td>
</tr>
<tr>
<td>29</td>
<td>Selenium</td>
<td>Mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>30</td>
<td>Zinc(Zn)</td>
<td>Mg/l</td>
<td>5.0</td>
</tr>
<tr>
<td>31</td>
<td>Total dissolve evaporation residue</td>
<td>Mg/l</td>
<td>2.100</td>
</tr>
<tr>
<td>32</td>
<td>Temperature</td>
<td>Celsius</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td></td>
<td>04</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Suspended solid (55)</td>
<td>Mg/l</td>
<td>150</td>
</tr>
<tr>
<td>34</td>
<td>Cyanide (CN)</td>
<td>Mg/l</td>
<td>0.1</td>
</tr>
</tbody>
</table>
24.8 Additional Documents Requirements
The Bidder shall submit with its Technical Bid the following additional documents:

i) Design criteria for structures and foundations.

ii) Schematic diagrams of the following systems showing design flows, pressures, temperatures, line sizes, valves, strainers, controls and equipment.
   - Fuel supply system (Since shifting of Gas RMS is required)
   - Cooling system.
   - Water supply and Fire fighting system.
   - Lube oil system.
   - Compressed Air system
   - Condensate, Feed Water, steam system
   - Power Plant drainage system

iii) Electrical schematic diagrams of the following.
   - Generator protection system.
   - Generator excitation system.
   - All instruments and controls of the plant.

iv) Electrical single line diagram showing all equipment, ratings, current and potential transformer ratios, metering and relaying.

v) Project schedule in bar chart form as well as Critical Path Method.

vi) Description of training program including curriculum and training aids.

vii) Description of expatriate camp facilities (if any).

viii) Capacities, numbers and mobilisation schedule of construction equipment.

ix) Manpower mobilization schedule.

x) List of sources, quantities and unit costs of construction materials.

xi) Local material delivery schedule.

xii) Description of Site Laboratory facilities during construction (if any).

xiii) Description of proposed method of transportation and unloading of equipment at the Site.

xiv) De-rating curves of power output and fuel consumption VS ambient temperature, ambient pressure, humidity etc for simple cycle as well as combined cycle mode.

xv) A list of plant equipment, material etc. which the Bidder intend to re-export or sale in Bangladesh after the completion of the contract.
xvi) A list of special tools and equipment for maintenance and overhauling of the machine/equipment to be handed over to Board
24.9 Overhauling Scope of Works
23.9.1 GT Generator Overhauling
Modification / renovation / inspection / overhauling of GT Unit, as described below, will be done by the Owner. However, Bidder shall check and ensure the completeness of the activities, listed below, and operability of GT Unit after overhauling by the Owner. Bidder has to carry out necessary condition assessment tests of GT Unit, after overhauling by the Owner, and take corrective / preventive measures, if required, to ensure smooth running of GT Unit.

Supply of Retaining Rings (2 nos), dismantling of existing retaining rings, engineering, installation, testing, commissioning of new Retaining Ring on Turn Key basis also supply required consumables/materials for engineering, installation, testing, commissioning work of the Generator.

The scope of works have been furnished below but not limited to the followings:

A. Rotor

1) Measuring and recording the internal electrical parameters of the rotor winding.
2) Withdraw the rotor from the Generator.
3) Uniformly heating and removal of both the retaining rings.
4) Separating the retaining ring from the centering rings.
5) Measuring the shrink fit dimensions of the retaining rings.
6) Machining the new retaining rings as per the required shrink fit dimension.
7) Checking the Centering Ring with necessary NDT & DPT test.
8) Fitting the centering rings in the new retaining rings.
9) Inspecting and testing the overhangs (en windings) of the rotor.
10) Insulating the end winding of the rotor with “F” class insulation.
11) Uniformly heating the retaining rings and shrink fitting the retaining rings in position.
12) Locking the rings.
13) Testing the electrical parameters of the rotor winding.
14) Treating the rotor with anti track varnish.
15) Installing the rotor into Generator.
16) Necessary installation work for complete start up the unit.
17) Required test (i.e. Rotor insulation test, etc.) as per international standard before starting the machine.

B. Stator

1) Visual inspection of the dismantled baffles and wirers.
2) Recording of assembled baffles diameters.
3) Recording of shaft journals diameters.
4) Recording of journal bearings bare diameters.
5) Preservation and storage of disassembled parts.
6) Visual inspection of magnetic core rear.
7) Removal of stator slot wedging.
8) Visual inspection of stator bars.
9) Visual inspection of disassembled slot wedging components.
10) Visual inspection of the stator bars lateral faces.
11) Refurbishment of slot lateral wedging upon results of contact coefficient measurements.
12) Slot radial wedging installation.
13) Checking of stator slot radial wedging.
14) Visual check of the base of the stator frame.
15) Search for presence of oil leaks inside generator compartments and piping flanges.
16) Visual check of the joint faces on the end shields.
17) Visual check of the joint faces of the air gauges.
18) Visual inspection of the medium voltage cell.
19) Visual inspection of the bearing insulating components.
20) Visual inspection of the shaft earthing brush.
21) Stator end windings visual inspection.
22) Stator insulation resistance measurement and polarization index on each phase.

C. **Exiter Inspection:**

1) Visual inspection of exciter field system and armature.
2) Insulation resistance measurement of armature and polarization index.
3) Insulation resistance measurement of exciter field system and polarization index.
4) Checking of the ohmic resistance of the diodes.
5) Checking of the rotor earth fault system operation.
6) Checking of lack of clearance on the stator base plate bolting arrangement shimming.
D. Tests to be conducted:

1) Visual check and dye penetrant test of bearing journals white metal.

2) Ultrasonic testing of bearings journals white metal upon results of visual inspection and dye penetrant test.

3) Natural frequency measurements of end windings structures and hoods.

4) Contact coefficient measurements between stator bars and magnetic core.

5) Core laminations short circuit detection using ELCID technology.

6) Partial discharges measurement of stator winding.

7) Dielectric strength test of stator winding.

8) Continuity and insulation check of stator temperature probes.

During execution of work, if it is observe that, Centering Ring is unusable, than Bidder have to replace centering ring with the new one within the quoted price.

During execution of work, if any other work is required to be done and/or additional spares / materials/hardware/consumables are required for successful completion of overhauling of Generator Rotor and Stator, the Bidder has to perform the supply of the materials/ items/ spares whether it is listed or not and execute the work, in all respect within the quoted price.

23.9.2 GTG's Step- up Transformer (11/132kV, 3 x 37.5/50MVA, 1-Ph Unit) Overhauling

Following minimum tests shall be carried out on GSUT for condition assessment:

1) Visual checking for any damage.

2) Thermal modelling.

3) Dissolved Gas analysis (DGA).

4) Frequency response analysis (FRA or SFRA).

5) Partial discharge analysis (PD).

6) Winding resistance measurement in all taps.

7) Measurement of load loss and Impedance voltage.

8) Turns ratio test in all taps.

9) Excitation/Magnetizing current test.

10) Insulation resistance (IR) measurement with 5kV Motorised Megger.

11) Testing of power and control wiring between different equipment / devices

12) mounted on the transformer and it’s marshalling kiosk.
23.9.3 GTG's Station Service Transformers (6.9/0.415kV, 2x1600kVA) Overhauling

Following minimum tests shall be carried out on UT for condition assessment:

1) Visual checking for any damage.
2) Thermal modelling.
3) Tan Delta.
4) Winding resistance measurement in all taps.
5) Measurement of load loss and Impedance voltage.
6) Turns ratio test in all taps.
7) Excitation/Magnetizing current test.
8) Insulation resistance (IR) measurement with 5kV Motorised Megger.
9) Testing of power and control wiring between different equipment / devices mounted on the transformer and it's marshalling kiosk.

23.9.4 GTG’s Unit Auxiliary Transformers (11/6.9kV, 5MVA) Overhauling

Following minimum tests shall be carried out on GSUT for condition assessment:

1) Visual checking for any damage.
2) Thermal modelling.
3) Dissolved Gas analysis (DGA).
4) Frequency response analysis (FRA or SFRA).
5) Partial discharge analysis (PD).
6) Winding resistance measurement in all taps.
7) Measurement of load loss and Impedance voltage.
8) Turns ratio test in all taps.
9) Excitation/Magnetizing current test.
10) Insulation resistance (IR) measurement with 5kV Motorised Megger.
11) Testing of power and control wiring between different equipment / devices mounted on the transformer and it's marshalling kiosk.
23.9.5 Switchgear for Voltages above 1 kV Overhauling

The complete installation shall be tested at site as follows:

1) Dielectric test
2) Visual inspection
3) Contact resistance/torque test of bus bar joints
4) CT’s, VT’s ratio, magnetisation characteristic and burden measurement
5) HV test
6) Mechanical functioning test
7) Test of the functional sequence
8) Testing of all interlocks
9) Testing of all protection relays and circuits by primary/secondary injection and functional tests of the arc protection
10) Testing of high speed transfer systems
11) Testing of all alarms (local and remote)

23.9.6 LV switchgear (AC and DC) Overhauling

The complete switchgear and the individual apparatus shall be tested on site as follows:

1) Visual inspection
2) Dielectric test
3) Contact resistance/torque test of bus bar joints
4) CT’s, VT’s ratio, magnetisation characteristic and burden measurement
5) Testing of all interlocks
6) Setting and testing of all protection relays and circuits by primary/secondary injection. Test
7) Kit of adequate rating to be provided
8) Testing of automatic change over devices
9) Testing of all alarms (local and remote)
10) Functional test
11) Test of the functional sequence

Setting and functional test of protection devices (primary injection method). However, test plugs and socket facilities for secondary injection tests shall also be made available. Tests kits of adequate ratings shall be made available for the tests.
23.9.7 Earthing

The complete earthing and lightning protection systems shall be tested as follows:

1) The earthing system as a whole shall be tested and verified before putting any major equipment into operation.

2) Visual inspection of exposed elements.

3) Measurement of the earth electrode potential UE by the voltmeter/ammeter method, test current 100 - 300 A or an equivalent, approved method if above will be proved to be not feasible.

4) Measurement of the touch potential UB.

5) Measurement of step potential.

23.9.8 Site Tests on Electrical Equipment for Overhauling

The following tests or measurements must be made during and after erection but before any item of equipment is put on trial operation:

1) Design and visual checks.

2) Screwed connections for correct assembly.

3) Terminals and terminal connections for correct assembly.

4) Checking of earthing connections and testing of earthing resistances.

5) Measurement of insulation values (didactic tests).

6) Verification of earthing conditions.

7) Fire-proof partitioning.

8) Marking, inscription, provision of designation plates.

9) Rotating-field measurement.

10) Phase coincidence with 2 half-busbars.

11) Voltage checks.

12) Polarity checks.

13) Fuses, overcurrent trips, short circuit trips, time settings, relay settings.

14) Oil levels.

15) Status indication, alarm and trip signals.
16) checks on wiring and cabling for conformity with the constructional circuit drawings and plans

17) high voltage tests

18) current and voltage transformer circuits

19) functional test of all protection relays including winding and oil temperature monitoring as well as Buchholz protection etc.

20) interface with the DCS and SCADA.

The tests shall be carried out according to relevant standards.

The Bidder shall submit for each test of all equipment a method statement, with relevant diagrams explaining the procedure of the tests and test criteria supported by relevant standards and test methods.

All major equipment shall have a separate test package. All high voltage tests shall be carried out at 50 Hz. Equipment for which DC tests are proposed shall be justified and approved by Employer/ Engineer. HV tests of switchgears shall be carried out with the relevant circuit breakers in open and closed positions.

Unless otherwise agreed, all erection and civil works related to the equipment shall be completed before starting any site tests.
24.10 Additional Drawings
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
24.10 Additional Drawings

1. DCS Configuration for Combined Cycle Power Plant
2. DCS Control Hierarchy Model Block Diagram
3. Schematic Diagram for CEMS
4. Schematic Diagram DCS – LDC
1. DCS Configuration for Combined Cycle Power Plant
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single Stage: Two Envelope
2. DCS Control Hierarchy Model Block Diagram
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
3. Schematic Diagram for CEMS
4. Schematic Diagram DCS – LDC
24.11 Condition Assessment of Existing GT Power Plant
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single - Stage: Two-Envelope
Condition Assessment
for
Baghabari 100MW GT Power Plant


Introduction:
The consultants have visited the site, discussed with the O&M people and collected the
available information and documents, inventory of strategic spares (Major items), inventory of existing infrastructure.

Findings:
Maintenance Record since commissioning of the unit has been analysed. 3CIs, 2 HGPI &
MI have been completed.
As per Original Equipment Manufacturers (OEM)s maintenance guide-line the mainte-
nance interval should be as follows:-
Cl- after every 8,000 Running hours.
HGPI-after every 24,000 Running hours.
MI-after every 48,000 Running hours.

Comments :
(a) Overhauling and Rehabilitation / MI (major inspection) of existing GTG along with auxil-
iaries (Replacement of Exhaust Diffuser and Exhaust Assembly) with supply of all neces-
sary new and unused spare parts and consumables by the EPC contractor.
(b) 1st CI & HGPI - are included in Bid document including Supply of spares (List
enclosed below):
Mandatory, Defect Liability & Consumable and Recommended Spare Parts
One CI & one HGPI Spares for Gas Turbine as per manufacturer’s guideline

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The spares required for other upcoming inspection like CI, HGPI & MI during next 15 years have to be procured time to time. List of Recommended spares for different types of inspections are available in the power station.
PDB has to procure spares for the particular type of inspection just before the inspection as per recommended list of spares.

**To procure all the spares at a time for next 15 years would not be cost effective.**

**Refurbishment:**
Every capital parts have different life (e.g. 48000 hours, 72000 hours or 96000 hours). During every CI, HGPI & MI the capital parts like- Fuel nozzles, Cross fire tubes, Cap and liners, Transition pieces, Bull horn, 1st, 2nd and 3rd stage Nozzles, Buckets and shroud etc. have to be replaced by new/refurbished set of spares and the old ones which are taken out from the GT have to be refurbished.
So, double set capital spares should be in hand (1(one) set in the GT and another set in pipeline for refurbishment).

**New spares:**
OEM recommended security spares have to be kept at stock.

**Renovation/ Inspection/ Overhaul of Existing Gas Turbine Generating Unit & its Auxiliaries:**

At present existing one 100 MW Open Cycle, Single Shaft, Heavy Duty Industrial Package type Gas Turbine unit was used as a combined cycle operation. Tenderer have to renovate/ inspect the existing Gas turbine & its Auxiliaries (i.e Gas Turbine Generating Unit, Transformers, Gas Booster Compressors (3 nos), electrical system including AVR & Excitation System, all electrical equipment, Protection and Control system, EDG, UPS, Battery charger system etc.) and capable the existing Gas Turbine to 100 MW capacity for using as a Gas turbine of combined cycle operation.

**A Upgradation:**

Tenderer have to renovate/ inspect the existing Gas turbine & its Auxiliaries (i.e Gas Turbine Generating Unit, Transformers, Gas Booster Compressors (3 nos), electrical system, EDG, UPS, Battery charger system, protection and control system etc.) and capable the existing Gas Turbine to 100 MW capacity for using as a Gas turbine of combined cycle operation.

**Upgradation / Rehabilitation comprise:**

i) Dry Low NOx combustion system for the existing GT.

ii) NOx abatement of existing GT emissions.

iii) Rehabilitation measures of the existing Plant Auxiliary systems & BOP.

iv) Overhauling of accessory gear

v) New central control room common for GTG, STG & their associates.

vi) Overhauling and Rehabilitation / MI (major inspection) of existing GTG along with auxiliaries (Replacement of Exhaust Diffuser and Exhaust Assembly) with supply of all necessary new and unused spare parts and consumables by the EPC contractor.

ix) Rehabilitation of VIGV with Rack & pinion have to be done

x) Upgrade of existing gas turbine control system Mark V to Mark VIe, along with associated accessories like control cables along with other cables etc..

Since the plant is 10-15 years old, the need for any upgradation with respect to existing of I&C System shall be suggested / recommended in consultation with Owner/Owner’s Engineer.

**Recommendations:**

1) 2 sets of capital parts have to be kept in hand.

2) Advance Capital parts with extended life (Manufactured by GE) may be used by which PDB may avoid CIs after every 8000 running hours. Instead after 32000 and 62000 running hours HGPI and after 96000 running hours MI have to be done.

3) PDB has to operate the GT at ideal condition.

4) Preventive schedule maintenance have to be ensured.
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan							December, 2016

Single Stage: Two Envelope
24.12 EIA Approval
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan
December, 2016
Single - Stage: Two- Envelope
LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan

December, 2016

Single Stage: Two-Envelope
24.13 Construction Environmental and Social Management Plan (ESMP)
1. **Overview**

Bangladesh Power Development Board (BPDB – the “Proponent”) is intending to convert the existing Baghabari 100MW simple cycle gas turbine power plant to a 150MW combined cycle plant with the addition of a heat recovery steam generator and steam turbine units (the “Project”). This upgrade will be located on an area of approximately 13.6 acres which will be acquired alongside the existing 28 acres currently developed by the plant. The existing plant is located at 24°08'3.0'' N, 89°35'46.0''E, in Selachapri Mouza in Rupabati union, Shahjadpur upazila of the Sirajgonj district.

Using combined cycle technology, the power plant will generate an additional 50MW of power for the national grid without consuming any extra fuel or generating extra emissions. The plant will be designed in such a way to ensure minimum environmental pollution and meet all standards of the Bangladeshi Department of Environment (DoE) and the European Investment Bank (EIB) - the “Lender” for the Project.

To obtain the environmental clearance for the Project (received 08 January 2015) from the DoE an environmental impact assessment (EIA) was completed in October 2014 by the Centre for Environmental and Geographic Information Services (CEGIS 2014).

In order to meet the national Bangladeshi laws and regulations and EIB’s requirements, a site-specific environmental and social management plan (ESMP) must be developed for the Project for both construction and operational phases.

This document is a construction environmental and social management plan (CESMP) framework, which is based on the EIA (CEGIS 2014), the Project’s environmental permit conditions and current knowledge of the Project and environment. This document is designed to enable the bidding engineering, procurement, construction, commissioning and operations (EPCCO) contractors to consider their construction phase environmental and social commitments during the tendering stage, and to guide the development of a detailed CESMP by the successful EPCCO contractor. The subsequent detailed CESMP will need to include any further commitments resulting from the international standard environmental and social impact assessment (ESIA) that is planned to be carried out for the Project.

2. **Purpose of the CESMP**

The primary objective of an ESMP is to safeguard the environment, site staff and the local population from site activity which may cause harm or nuisance. This CESMP framework is intended to be used as a guide to ensure transparent and effective monitoring, prevention, minimisation, mitigation, compensation and offsetting measures to address the environmental and social impacts associated with construction of the Project. The mitigation measures described within this CESMP framework must be applied to the Project and developed in more detail based on the findings of the planned ESIA. The resulting document should form the basis of the environmental and social protection measures implemented by the EPCCO contractor that will be commissioned to undertake the work.

To develop the detailed CESMP document, the EPCCO contractor will be required to produce standalone mitigation and monitoring plans. The resulting CESMP will
need to identify responsibilities, actions, control/mitigation measures and monitoring, auditing, reporting and training requirements during the construction phase in order to:

- Achieve compliance with relevant national environmental laws, regulations and standards, international guidelines and good international industry practice
- Eliminate or minimise potential environmental and social impacts associated with the construction activities.

3. Content of Construction Environmental and Social Management Plan (CESMP)

The EPC Construction Environmental and Social Management Plan (CESMP) shall comprise the following chapters:

- Project Description, including:
  - Location overview and site layout
  - Scope of works
  - Key Plant information (for existing and proposed plant):
    - plant type and configuration
    - quantity of water required
    - source of water
    - gas consumption
    - net power output
  - Associated facilities
  - Site preparation requirements
  - Workforce

- Legal Framework, Standards and Regulations, including:
  - Relevant national legislation and regulations
  - Relevant international agreements
  - Parameter-specific national and international standards related to:
    - Water quality
    - Air quality
    - Soil and groundwater
– Noise

➢ Environmental and Social Baseline, including:
  • Key local baseline conditions
  • Physical and ecological environment
  • Socio-economic environment
  • Key sensitive receptors

➢ Indicative Register of Environmental and Social Impacts and Risks

➢ Environmental and Social Management Plan, including:
  • Environmental, social and H&S policy statements
  • EPC Contractor role and responsibility
  • EPC Contractor Organisational structure
  • Inspections and audits
  • Environmental and social training requirements
  • Internal and external communications protocols and addressing complaints
  • CESMP changes management
  • Documentation procedures

➢ Environmental and Social Mitigation and Monitoring Plan, including:
  • Air quality management plan
  • Water use and quality management plan
  • Biodiversity protection management plan
  • Construction site waste management plan
  • Noise and vibration control plan
  • Construction materials handling and storage plan
  • Construction transport and traffic management plan
  • Landscape and visual amenity management plan
  • Human resources policy
  • Workers’ code of conduct
- Workers’ grievance mechanism
- Workers accommodation plan
- Occupational health and safety (OHS) plan
- Security management plan
- Resettlement action plan (RAP) or livelihood restoration plan (LRP)
- Stakeholder engagement plan (SEP)
- Community grievance mechanism
- Local content strategy
- Community health and safety plan
- Chance finds procedure
- Emergency preparedness and response plan (EPRP)
- Incident preparedness and response plan

4. **Key Bangladeshi laws and regulations**

A summary of the key Bangladeshi laws and regulations that are potentially applicable for the Project are presented in below table:

<table>
<thead>
<tr>
<th>Act/rule/law/ ordinance</th>
<th>Responsible agency</th>
<th>Key features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh Energy Regulatory Commission Act, 2003</td>
<td>Ministry of Power</td>
<td>Governance of power generation and management system</td>
</tr>
<tr>
<td>Power System Master Plan, 2006</td>
<td>Bangladesh Power Development Board (BPDB) and Ministry of Energy and Power (MoEP)</td>
<td></td>
</tr>
<tr>
<td>Power System Master Plan, 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Energy Policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum Act, 1934</td>
<td>Bangladesh Agency of Petroleum Exploration (BAPEX)/ Petrobangla</td>
<td>Gas exploration and quality management</td>
</tr>
<tr>
<td>Law/Ordinance</td>
<td>Ministry/Department/Agency</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fatal Accidents Act, 1855</td>
<td>Health Department/Ministry of Labour and Manpower/Ministry of Home Affairs</td>
<td>Health and safety</td>
</tr>
<tr>
<td>Imports and Exports (Control) Act, 1950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Safety Ordinance, 1953</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire prevention and Extinguish Act, 2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Public Procurement Regulations, 2003 and Revisions</td>
<td>Procurement in Bangladesh</td>
<td></td>
</tr>
<tr>
<td>The Vehicle Act, 1927; The Motor Vehicles Ordinance, 1983; The Bengal Motor Vehicle Rules, 1940</td>
<td>Bangladesh Road Transport Authority (BRTA)</td>
<td>Exhaust emission; vehicular air and noise; road safety</td>
</tr>
<tr>
<td>Water Supply and Sanitation Act, 1996</td>
<td>Ministry of Local Government, Rural Development and Cooperatives</td>
<td>Management and control of water supply and sanitation in urban areas</td>
</tr>
<tr>
<td>The Ground Water Management Ordinance 1985</td>
<td>Upazila Parishad</td>
<td>Management of ground water resources; tube well shall not be installed in any place without the license granted by Upazila Parishad</td>
</tr>
<tr>
<td>The Forest Act, 1927 and subsequent amendments in 1982 and 1989</td>
<td>Ministry of Environment and Forest</td>
<td>Reserve forests; protective forests; village forests</td>
</tr>
<tr>
<td>The Private Forests Ordinance Act, 1959</td>
<td>Regional Forest Officer, Forest Department</td>
<td>Conservation of private forests and for the afforestation on wastelands</td>
</tr>
<tr>
<td>The Protection and Conservation of Fish Act 1950 and subsequent amendments in 1982</td>
<td>Ministry of Fishery</td>
<td>Protection and conservation of fish in government owned water bodies</td>
</tr>
<tr>
<td>Natural Water Bodies Protection Act 2000</td>
<td>Rajdhani Unnayan Karpakkha/Town Development Authority/ Municipalities</td>
<td>According to this act, the character of water bodies i.e. rivers, canals, tanks, or floodplains identified as water bodies in the master plans or in the master plans formulated under the laws establishing municipalities in division and district towns shall not be changed without approval</td>
</tr>
<tr>
<td>The Embankment and Drainage Act 1952</td>
<td>Ministry of Water Resources and FCD</td>
<td>An act to consolidate the laws relating to embankment and drainage and to make better provision for the construction, maintenance, management, removal and control of embankments and water courses for the better drainage of lands and for their protection from floods, erosion and other damage by water.</td>
</tr>
</tbody>
</table>

LOT-1: Conversion of 100 MW Baghabari Gas Turbine Power Plant to 150 MW Combined Cycle Power Plant

Procurement of Plan: December, 2016
Single - Stage: Two- Envelope
5 Relevant International Agreements

This section provides a brief introduction to the relevant international agreements that Bangladesh are signatory to.

Rio Declaration on Environment and Development 1992

Declaration by member states to cooperate with respect to the interests of all whilst protecting the integrity of the global environmental and development system. The declaration includes 27 principles for the member states to achieve the objective of the agreement. For example: “The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations”.

Convention on Biological Diversity

Dedicated to promoting sustainable development through commitment of member states to maintain the world’s ecology during economic development. The convention establishes three main goals:

- The conservation of biological diversity
- The sustainable use of its components
- The fair and equitable sharing of the benefits from the use of genetic resources.

Bangladesh implements it commitments to the Convention on Biological Diversity through its National Biodiversity Strategy and Action Plan which contains 16 strategies focusing on valuation, ecosystem, species and genetic resource conservation, restoration and rehabilitation, invasive alien species, access and benefit-sharing, awareness-raising and capacity-building, traditional knowledge, institutional development and cooperation, protected areas management, wetlands, participatory mechanisms (including private sector, civil society, local communities), legislation and policy, monitoring and reporting, innovative and sustainable financing, synergies with other multilateral environmental agreements, mainstreaming in national development planning. A total of 128 action programmes were identified for implementation of these strategies in the short, medium
and long terms.

**Ramsar Convention 1971**

The convention’s mission is the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world. Bangladesh ratified the convention in 1992 and currently has two sites (Sundarbans Reserved Forest and Tanguar Hoar) designated as wetlands of international importance with a total surface area of 611,200 hectares.


An international convention which defines the rights and responsibilities with respect to the use of the world’s oceans, establishing guidelines for businesses, the environment and the management of marine natural resources. Bangladesh ratified the convention in 2001. As a signatory to UNCLOS Bangladesh are duty-bound to cooperate to achieve the following:

Conservation and management of living resources in the areas of the high seas

Protection and preservation of the marine environment

Prevention, reduction and control of pollution of the marine environment

**The Montreal Protocol on Substances that Deplete the Ozone Layer**

A protocol to the Vienna Convention for the Protection of the Ozone Layer. The Montreal Protocol is an international treaty designed to protect the ozone layer by phasing out the production of substances that are responsible for ozone depletion. The treaty includes most ozone depleting substances and provides a timetable for the cessation of production and use.

Bangladesh ratified the Montreal Protocol in 1990.

**The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal**

An international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. The convention is also intended to minimize the amount and toxicity of wastes generated, to ensure their environmentally sound management as closely as possible to the source of generation, and to assist less developed countries in environmentally sound management of the hazardous and other wastes they generate.


**United Nations Framework Convention on Climate Change**

The United Nations Framework Convention on Climate Change is an international treaty negotiated at the Earth Summit in Rio de Janeiro in June 1992, then entered into force in March 1994. The treaty’s objectives are:

Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.
Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.

Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The framework sets no binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. Instead, the framework outlines how specific international treaties (called "protocols" or "agreements") may be negotiated to set binding limits on greenhouse gases.

The Paris Agreement is the latest agreement under the framework, which deals with greenhouse gases emissions mitigation, adaptation and finance starting in the year 2020. For the agreement, each country proposed a non-binding nationally determined contribution of greenhouse gases, which has to be ambitious and progressive over time, with the view to achieving the goal of the agreement. Contributions are to be reported every five years.

Bangladesh ratified the framework in 1994 and signed the Paris Agreement in 2016 with a nationally determined contribution of 0.27% of the world’s greenhouse gas emissions.

6 Parameter-specific national and international standards

Water quality

Bangladeshi standards

The Project should take into consideration relevant national legislation relating to water quality, in particular the Environment Conservation Rule 1997, and its amendments – Schedule 3.

Table below presents the ambient river water quality standards for Bangladesh

<table>
<thead>
<tr>
<th>Best practice based classification</th>
<th>pH</th>
<th>BOD mg/I</th>
<th>DO mg/I</th>
<th>Total coliform number/100ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of drinking water for supply only after disinfecting</td>
<td>6.5-8.5</td>
<td>2 or less</td>
<td>6 or above</td>
<td>50 or less</td>
</tr>
<tr>
<td>Water usable for recreational activity</td>
<td>6.5-8.5</td>
<td>3 or less</td>
<td>5 or above</td>
<td>200 or less</td>
</tr>
<tr>
<td>Source of drinking water for supply after conventional treatment:</td>
<td>6.5-8.5</td>
<td>6 or less</td>
<td>6 or above</td>
<td>5,000 or less</td>
</tr>
<tr>
<td>Water usable by fisheries</td>
<td>6.5-8.5</td>
<td>6 or less</td>
<td>5 or above</td>
<td>-</td>
</tr>
<tr>
<td>Water usable by various process and cooling industries</td>
<td>6.5-8.5</td>
<td>10 or less</td>
<td>5 or above</td>
<td>5,000 or less</td>
</tr>
<tr>
<td>Water usable for irrigation</td>
<td>6.5-8.5</td>
<td>10 or less</td>
<td>5 or above</td>
<td>1,000 or less</td>
</tr>
</tbody>
</table>

Source: ECR 1997
Table below presents the wastewater discharge standards to the river environment and national sewer system.

<table>
<thead>
<tr>
<th>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</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>*</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Arsenic (As)</td>
<td>*</td>
<td>0.2</td>
<td>0.05</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>BOD5 at 20°C</td>
<td>*</td>
<td>50</td>
<td>250</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Boron</td>
<td>*</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Cadmium (as Cd)</td>
<td>*</td>
<td>0.5</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</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Chemical oxygen demand (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</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Copper (as Cu)</td>
<td>*</td>
<td>0.5</td>
<td>3</td>
<td>3</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>Electrical conductivity (EC)</td>
<td>micro mho/cm</td>
<td>1200</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>14</td>
<td>Total dissolved solids (TDS)</td>
<td>mg/l</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</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</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>Nitrate (as elementary N)</td>
<td>mg/l</td>
<td>10</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 C6H5OH)</td>
<td>*</td>
<td>1</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></td>
<td>To be specified by Bangladesh Atomic Energy Commission</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>*</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>31</td>
<td>Temperature</td>
<td>°C</td>
<td>40</td>
<td>40</td>
<td>40-Summer</td>
</tr>
</tbody>
</table>
### International Standards

Annex I-C of Directive 91/271/EEC on Urban Waste Water Treatment mentions that industrial wastewater entering collecting systems and urban wastewater treatment plants shall be subject to pre-treatment in order to ensure that effluent discharges do not adversely affect the people, the surrounding environment, or the water quality of the receiving water body. No numerical standards have been set in this regard hence national compliance with the Bangladeshi standards on water quality will apply.

#### Air quality

**Bangladeshi standards**

Schedule 2 of the ECR (1997) specifies the following ambient air quality standards. Table below displays the Bangladesh standards for air emissions.

<table>
<thead>
<tr>
<th>Categories of area</th>
<th>Suspended particulate matter ($\leq 10\mu m$) $\mu g/m^3$</th>
<th>Sulphur dioxide $\mu g/m^3$</th>
<th>Carbon monoxide $\mu g/m^3$</th>
<th>Oxides of nitrogen $\mu g/m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial and mixed use</td>
<td>500</td>
<td>120</td>
<td>5000</td>
<td>100</td>
</tr>
<tr>
<td>Commercial and mixed</td>
<td>400</td>
<td>100</td>
<td>5000</td>
<td>100</td>
</tr>
<tr>
<td>Residential and rural</td>
<td>200</td>
<td>80</td>
<td>2000</td>
<td>80</td>
</tr>
<tr>
<td>Sensitive</td>
<td>100</td>
<td>30</td>
<td>1000</td>
<td>30</td>
</tr>
<tr>
<td>WHO</td>
<td>50**</td>
<td>20**</td>
<td>-</td>
<td>200*</td>
</tr>
</tbody>
</table>

Source: ECR 1997 – Sensitive areas include monuments, health centres, archaeological sites, educational institutions and government designated areas. Industrial units located in areas not designated as industrial areas shall not discharge pollutants which may contribute to the exceedance of the standard for the surrounding area. Note: averaging time is not provided. WHO Ambient Air Quality Guidelines - *averaging time of 1 hour ** averaging time of 24 hours.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Standard limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulates - electric power plants of $\geq 200$ MW</td>
<td>$mg/Nm^3$</td>
<td>150</td>
</tr>
<tr>
<td>Particulates - electric power plants of &lt;200 MW</td>
<td>$mg/Nm^3$</td>
<td>350</td>
</tr>
<tr>
<td>Chlorine</td>
<td>$mg/Nm^3$</td>
<td>150</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>$mg/Nm^3$</td>
<td>350</td>
</tr>
<tr>
<td>Total fluoride</td>
<td>$mg/Nm^3$</td>
<td>25</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>$mg/Nm^3$</td>
<td>50</td>
</tr>
<tr>
<td>Lead</td>
<td>$mg/Nm^3$</td>
<td>10</td>
</tr>
<tr>
<td>Mercury</td>
<td>$mg/Nm^3$</td>
<td>0.2</td>
</tr>
<tr>
<td>Oxides of nitrogen - gas fuel-based power plant</td>
<td>ppm</td>
<td>50</td>
</tr>
</tbody>
</table>

$\geq 500$MW
Parameter | Unit | Standard limit
--- | --- | ---
200 to 500MW | ppm | 40
<200MW | ppm | 30

Source: ECR 1997

International standards

The design and construction of the Project is expected to contribute in meeting the objectives set out in the EU Thematic Strategy on Air Pollution and Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention and Control). Emission limits for gas turbines including combined cycle are listed in Annex V – Technical Provisions Relating to Combustion Plants of Directive 2010/75/EU. The relevant standards for this project are (calculated at 0°C, 101.3kPa, 15% oxygen and after correction for water vapour content):

Nitrogen dioxide – 50mg/Nm³
Carbon monoxide – 100mg/Nm³

Emissions must be monitored continuously to check for compliance with the standards.

**Soil and groundwater**

Bangladeshi standards

There is currently no national legislation specific to soil and groundwater quality in Bangladesh.

International standards

The design and construction of the Project is expected to contribute in meeting the objectives set out in EU Thematic Strategy on Soil Protection, EU requirements on Water Protection and Directive 2006/118/EC on the Protection of Groundwater against Pollution. Annex – Groundwater Quality Standards of Directive 2006/118/EC specifies the quality standards for the following parameters:

Nitrates – 50mg/L
Active substances in pesticides including their metabolites, degradation and reaction products – 0.1µg/L and 0.5µg/L (total)

Environmental quality standards for other parameters other than the above have not been specified and it is unlikely that the Project will exceed the guidelines above as no pesticide use will be required in the construction of the Project.

**Noise**

Bangladeshi standards


<table>
<thead>
<tr>
<th>Category</th>
<th>Day time</th>
<th>Night time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6am-9pm</td>
<td>9pm-6am</td>
</tr>
<tr>
<td>Silent zone</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>Residential zone</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>
### Category | Day time | Night time
--- | --- | ---
Mixed zone | 60 | 50
Commercial zone | 70 | 60
Industrial zone | 75 | 70

Source: ECR 1997

**International standards**

Directive 2002/49/EC on the Assessment and Management of Environmental Noise mentions that an environmental noise assessment ($L_{den}$ and $L_{night}$) shall be undertaken according to sound assessment methods but does not in itself specify ambient noise limits. Noise exposure limits have been specified under Directive 2003/10/EC but this is in relation to occupational health and safety. Directive 2003/10/EC on the Minimum Health and Safety Requirements Regarding Exposure of Workers to Risk Arising from Physical Agents (Noise) specifies the noise exposure limit as provided in table below.

<table>
<thead>
<tr>
<th>Exposure limit values</th>
<th>$L_{den}$ dB(A)</th>
<th>$P_{peak}$ Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure limit values</td>
<td>87</td>
<td>200</td>
</tr>
<tr>
<td>Upper exposure action values</td>
<td>85</td>
<td>140</td>
</tr>
<tr>
<td>Lower exposure action values</td>
<td>80</td>
<td>112</td>
</tr>
</tbody>
</table>

Source: Directive 2003/10/EC

### References

- Directorate of Environment (2015) EIA approval of Beobo, Dhaka for Conversion of Shahjibazar 2x35MW GT to 105MW CCPP project
- EIB (2013) Environmental and Social Handbook
- IFC EHS Guidelines (general and sector specific)
- IFC EBRD (2009) Worker’s accommodation: Processes and Standards