# BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS GROUP
TRANSMISSION BUSINESS ENGINEERING MANAGEMENT
NEW DELHI

<table>
<thead>
<tr>
<th>DOCUMENT No.</th>
<th>TB-300-316-001</th>
<th>Rev No.</th>
<th>00</th>
<th>Prepared</th>
<th>MK</th>
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<tbody>
<tr>
<td>TYPE OF DOC.</td>
<td>TECHNICAL SPECIFICATION</td>
<td>TITLE</td>
<td>TECHNICAL SPECIFICATION FOR GAS INSULATED SUBSTATION</td>
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</tr>
<tr>
<td>CUSTOMER/CONSULTANT</td>
<td>NHPC Limited</td>
<td>PROJECT</td>
<td>4×130 MW Parbati-III Hydroelectric Project</td>
<td></td>
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</tbody>
</table>

## CONTENTS

<table>
<thead>
<tr>
<th>Sec. No.</th>
<th>Description</th>
<th>No. of Sheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Scope Specific Technical Requirement and Quantities</td>
<td>6</td>
</tr>
<tr>
<td>2.</td>
<td>Equipment Specification (customer’s Specification)</td>
<td>26</td>
</tr>
<tr>
<td>3.</td>
<td>General Technical Requirement</td>
<td>32</td>
</tr>
<tr>
<td>4.</td>
<td>Guaranteed Technical Particulars</td>
<td>14</td>
</tr>
<tr>
<td>5.</td>
<td>Enclosures</td>
<td>65</td>
</tr>
</tbody>
</table>

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**Revision Details**

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</table>
1.1 SCOPE

Scope of work covers Design, manufacture, Testing, Delivery at site, supervision of installation and commissioning including site testing along with necessary equipment, training of BHEL and NHPC personnel and guarantee for Two years for 420 kV Gas Insulated Substation(GIS) as per the specification complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

This section covers the scope and quantities of 420 kV GIS. The Specific Technical Requirements for the above item as specified by the customer (NHPC Ltd.) are given in Section-2. The offered equipment shall also comply with the General Technical Requirements for the project as detailed under section-3 of this specification.

In case of any discrepancies between the requirements mentioned under Section-1/Section-2 and those specified in the Section-3, the specifications given under Section-1/Section-2 shall prevail and shall be treated as binding requirements.

The equipment is required for the following project:

Name of the Customer : NHPC Limited
Name of the Project : Parbati Hydroelectric Project Stage-III(H.P.) India

1.2 SPECIFIC TECHNICAL REQUIREMENT

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Technical Parameter</th>
<th>420 kV GIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>SYSTEM PARAMETERS</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Type of GIS</td>
<td>Indoor Type</td>
</tr>
<tr>
<td>2</td>
<td>Location</td>
<td>Indoor</td>
</tr>
<tr>
<td>3</td>
<td>Scheme</td>
<td>Double Busbar Arrangement</td>
</tr>
<tr>
<td>4</td>
<td>Maximum ambient temperature</td>
<td>46°C</td>
</tr>
<tr>
<td>5</td>
<td>Minimum ambient temperature</td>
<td>-4°C</td>
</tr>
<tr>
<td>6</td>
<td>Design ambient temperature</td>
<td>50°C</td>
</tr>
<tr>
<td>7</td>
<td>Nominal voltage class, kV rms</td>
<td>400 kV</td>
</tr>
<tr>
<td>8</td>
<td>Rated voltage, kV</td>
<td>420</td>
</tr>
<tr>
<td>9</td>
<td>Rated frequency, Hz</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>Number of phases</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Number of bus bars</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>Rated normal current at 50 Hz,a,rms</td>
<td>4000 A</td>
</tr>
<tr>
<td>13</td>
<td>Rated short circuit current at rated maximum voltage, not less than, ka, rms (symmetrical)</td>
<td>63 kA</td>
</tr>
<tr>
<td>14</td>
<td>Lightning impulse withstand voltage (phase to phase and phase to earth)at minimum operating gas pressure</td>
<td>1425 kVp</td>
</tr>
<tr>
<td>15</td>
<td>Switching impulse withstand voltage</td>
<td>1050 kVp</td>
</tr>
<tr>
<td>16</td>
<td>1 minute power of frequency withstand voltage, to</td>
<td>520 kV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Rated peak withstand current, kA</td>
<td>157.5 kA</td>
</tr>
<tr>
<td>16</td>
<td>Material of bus bar</td>
<td>Al</td>
</tr>
<tr>
<td>17</td>
<td>Insulation medium</td>
<td>SF6</td>
</tr>
<tr>
<td>19</td>
<td>Leakage rate of SF6 per annum for each compartment</td>
<td>1 % individual section and 0.5% on overall basis per phase</td>
</tr>
<tr>
<td>20</td>
<td>Partial Discharge of switchgear assembly at highest voltage for equipment, pc</td>
<td>&lt;5</td>
</tr>
<tr>
<td>21</td>
<td>Rated Auxiliary Supply voltage</td>
<td>220 V DC</td>
</tr>
<tr>
<td>22</td>
<td>GIS Connection  - Transformer bay (GIS to Transformer)  - Line Bay</td>
<td>420 kV SF6 Bus Duct (Bidder’s scope) 400 kV XLPE Cable (Not in Bidder’s scope; bidder to make provision for connection of Cable Sealing End)</td>
</tr>
<tr>
<td>23</td>
<td>Implemented technology for control shall be digital and Local Control Unit shall incorporate bay control unit for integration to plant SCADA system through local control board for GIS</td>
<td></td>
</tr>
</tbody>
</table>

### Circuit Breaker

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type</td>
</tr>
<tr>
<td>2</td>
<td>Description</td>
</tr>
<tr>
<td>4</td>
<td>First-pole-to clear factor</td>
</tr>
<tr>
<td>5</td>
<td>Rated short circuit breaking capacity, kA (r.m.s)</td>
</tr>
<tr>
<td>6</td>
<td>Rated short circuit making capacity, kA (peak)</td>
</tr>
<tr>
<td>7</td>
<td>Rated line charging breaking current capacity, A</td>
</tr>
<tr>
<td>8</td>
<td>Rated cable charging breaking current capacity, A</td>
</tr>
<tr>
<td>9</td>
<td>Duty Cycle</td>
</tr>
<tr>
<td>9.1</td>
<td>- Line Breakers</td>
</tr>
<tr>
<td>9.2</td>
<td>- Generator feeder and bus coupler breaker</td>
</tr>
<tr>
<td>10</td>
<td>Closing Time</td>
</tr>
<tr>
<td>11</td>
<td>Breaking Time</td>
</tr>
<tr>
<td>12</td>
<td>Small inductive current breaking capability (without producing excessive over voltages)</td>
</tr>
<tr>
<td>13</td>
<td>Operating Mechanism</td>
</tr>
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</table>

### Disconnector

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type</td>
</tr>
<tr>
<td>2</td>
<td>Operation</td>
</tr>
<tr>
<td></td>
<td>Rated withstand voltage across isolating distance</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>3.1</td>
<td>Power frequency</td>
</tr>
<tr>
<td>3.2</td>
<td>Lightening Impulse</td>
</tr>
<tr>
<td>4</td>
<td>Rated capacitive current make and break capacity</td>
</tr>
<tr>
<td>5</td>
<td>Rated Bus Transfer Current</td>
</tr>
<tr>
<td>6</td>
<td>Rated Bus Transfer Voltage</td>
</tr>
</tbody>
</table>

**Earthing Switch**

|   | Making Capacity kA (peak) | 157.5 kA |
|   | Rated short-time current | 63kA |
| 3 | Rated Induced Current/Voltage for Electromagnetic coupling(rms) | 160 A / 10kV |
| 4 | Rated Induced Current/Voltage for Electrostatic coupling(rms) | 18A/20kV |

**Current Transformers**

<table>
<thead>
<tr>
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<th>Current ratio</th>
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<tbody>
<tr>
<td>2</td>
<td>Generator/Bus coupler</td>
</tr>
<tr>
<td>3</td>
<td>Line bay</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Accuracy class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- For protection</td>
</tr>
<tr>
<td></td>
<td>- For metering</td>
</tr>
</tbody>
</table>

**Surge Arrester**

<table>
<thead>
<tr>
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<th>Type</th>
<th>Gapless metal Oxide station type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Rated arrester voltage</td>
<td>336 KV rms</td>
</tr>
<tr>
<td>3</td>
<td>Nominal discharge Current (8/20μs wave)</td>
<td>20 KA</td>
</tr>
<tr>
<td>4</td>
<td>Energy dissipation capability</td>
<td>Not less than 10 KJ/kV</td>
</tr>
<tr>
<td>5</td>
<td>Partial Discharge at highest level</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

**Bus Voltage Transformer**

<table>
<thead>
<tr>
<th></th>
<th>Type</th>
<th>Inductive type, single phase, two core</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Location</td>
<td>R,Y,B phase</td>
</tr>
<tr>
<td>3</td>
<td>Purpose</td>
<td>Synchronising, and Metering</td>
</tr>
<tr>
<td>4</td>
<td>Voltage ratio</td>
<td>(400/√3) kV/ (110/√3) V/ (110/√3) V</td>
</tr>
<tr>
<td>5</td>
<td>Accuracy class</td>
<td></td>
</tr>
<tr>
<td>Sl. No</td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>0.2</td>
<td>Metering</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>Voltage factor</td>
<td>1.5 for 30 s, 1.2 for continuous</td>
</tr>
<tr>
<td></td>
<td>SF6 Gas (Contents of SF6 Gas shall conform to following limits)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Water</td>
<td>≤ 5 ppm by weight</td>
</tr>
<tr>
<td>2</td>
<td>Carbon Tetra Fluoride</td>
<td>&lt; 250 ppm by weight</td>
</tr>
<tr>
<td>3</td>
<td>Air</td>
<td>&lt; 250 ppm by weight</td>
</tr>
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### 1.3 BILL OF QUANTITIES

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>420 kV GIS (As per SLD NH/DEM/PBT-III/CP/03) as follows:</strong></td>
<td>1</td>
<td>Set</td>
</tr>
<tr>
<td></td>
<td><strong>1.1 GIS with Double busbar scheme comprising</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Four (4) Generator Transformer Bays including Gas Insulated bus duct for interconnection between GSU transformer and respective unit bays of GIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Two (2) 400kV Line Bays</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- One (1) Bus Coupler Bay (Local Control Unit shall house bay control unit to be supplied by the bidder.) (Details of bay equipment referred in Section 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td><strong>Mandatory Spare parts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>SF6 gas for use during operation and maintenance in non-returnable cylinders.</td>
<td>10% of total quantity in 40 kg cylinders</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>One pole of complete Interrupter unit of circuit breaker with operating mechanism and tie rod etc.</td>
<td>1</td>
<td>Set</td>
</tr>
<tr>
<td>2.3</td>
<td>Complete drive mechanism including motor for disconnector switches and earthing switches</td>
<td>1</td>
<td>No.</td>
</tr>
<tr>
<td>2.4</td>
<td>Complete drive mechanism including motor for fast acting earthing switches</td>
<td>1</td>
<td>No.</td>
</tr>
<tr>
<td>2.5</td>
<td>Trip coils for circuit breakers</td>
<td>6</td>
<td>Nos.</td>
</tr>
<tr>
<td>2.6</td>
<td>Closing coils for circuit breakers</td>
<td>6</td>
<td>Nos.</td>
</tr>
<tr>
<td>2.7</td>
<td>Complete set of rupture disc</td>
<td>2</td>
<td>Set</td>
</tr>
<tr>
<td>2.8</td>
<td>Pressure switch/gas pressure transmitter</td>
<td>2</td>
<td>Sets of each used type</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>2.9</td>
<td>Pressure gauge</td>
<td>2</td>
<td>Sets of each used type</td>
</tr>
<tr>
<td>2.10</td>
<td>Gas density relay</td>
<td>2</td>
<td>Sets of each used type</td>
</tr>
<tr>
<td>2.11</td>
<td>Gas tight bushing of each type used</td>
<td>2</td>
<td>Nos. of each type used</td>
</tr>
</tbody>
</table>

3. Special Tools

3.1 Gas processing unit and filling units, along with tools and spares to handle gas quantity in at least two largest gas sections, with provision to check SF₆ moisture and acidity content | 1 | Set |

3.2 Set of handling devices and tools for assembling and dismantling of bays / complete GIS modules | 1 | Set |

3.3 Set of handling devices and tools for assembling and dismantling each type of operating mechanism of circuit breakers, disconnectors and earthing switches. | 1 | Set |

4. Testing Instruments

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<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Air / gas humidity tester</td>
<td>1</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>Gas, purity detector for SO₂, H₂O, CF₄, AIR etc.</td>
<td>1</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>Gas leakage tester</td>
<td>1</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>Breaker timing measurement kit</td>
<td>1</td>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>Equipment for pressure measurement and gas tightness testing</td>
<td>1</td>
<td>Set</td>
<td></td>
</tr>
</tbody>
</table>

5. Supervision of Erection and Commissioning inclusive of all testing equipments/instruments for GIS( equipment used by the bidder for testing can be taken back, unless otherwise specified.) | 1 | Lot |

6. Training at supplier’s works for 45 man-days | 1 | Lot |

Note:-
1) All mounting hardware is in bidder scope.
2) Tentative layout plan and section of GIS is enclosed.
3) Bidder shall give dimensional GIS building layout and sectional elevation drawing along with bid showing all details as follows:
   a) Location of GIS
   b) Maintenance space required
   c) Location of local control cabinet
   d) Height of EOT crane and building with matching as given NHPC drg.
   e) All embedded parts drawing
   f) Trench layout drawing
   g) Routing of GIS Bus duct
4) For transport limitation please refer to clause 3.1(e) of Section 3.
1.4 TYPE TESTING

Bidder shall submit valid type test reports (as per relevant latest IEC Standard) for approval. The type test reports submitted shall be of tests conducted within last 5 years prior to the date of bid opening. The bidder should have conducted type test on identical or similar equipment/components to those offered. In case type test reports are found to be technically unacceptable to BHEL/NHPC, the type tests shall be conducted without cost and delivery implication to BHEL.

1.5 Drawings / Documents

The drawings / documents submitted shall be project and product specific and shall incorporate all project details and title block and numbering scheme of the customer as detailed in Section 3.
Section - 2

CUSTOMER’S EQUIPMENT SPECIFICATION

10. GAS INSULATED SWITCHGEAR

10.1. Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, installation, commissioning, performance testing, acceptance testing, training of Employer’s personnel, handing over to NHPC and guarantee for two years of 420 kV GIS System as per the specifications hereunder, complete with all accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system covering all supply and services including but not be limited to following:

10.1.1. 420 kV GIS

Indoor metal-enclosed phase segregated type SF₆ gas insulated switchgear system rated for 420 kV, 3 phases, 50 Hz consisting of following major items:

i) Two (2) 3-phases, 4000 A SF₆ gas insulated metal enclosed bus bars complete in all respects, comprising of:
   - Six (6), individual bus bars enclosures running the length of the switchgear,
   - Six (6) single-phase surge arrestors,
   - Six (6) single-phase, 2-core voltage transformers,
   - Six (6) single-phase disconnector complete with manual and motor driven operating mechanisms, for isolation of voltage transformer,
   - Six (6) single-phase safety earthing switches complete with manual and motor driven operating mechanisms, with each single-phase disconnector.

ii) One (1) bus-coupler bay modules, each comprising of:
   One (1), 3-pole SF₆ gas insulated circuit breaker, complete with dedicated operating mechanism,
   4-core, multi ratio, 3-pole current transformers,
   Two (2), 3-phase, single-pole group-operated disconnector complete with manual and motor driven operating mechanisms,
   Two (2), 3-phase, single-pole group-operated safety earthing switches complete with manual and motor driven operating mechanisms,
   One (1), local control cubicle for control of coupler bay, bus bar VT and disconnector including bay controller.

iii) Four (4) generator bay modules, each comprising of:
   One (1), 3-pole SF₆ gas insulated circuit breaker, complete with dedicated operating mechanism for each pole,
   One (1), 5-core, multi ratio, 3-pole current transformer,
   Three (3) single-phase surge arrestors,
   Three (3), 3-phase, single-pole group-operated disconnector, complete with manual and motor driven operating mechanisms,
   Three (3), 3-phase, single-pole group-operated safety earthing switches, complete with manual and motor driven operating mechanisms,
Three (3), SF6 / SF6 bushings,
One (1), local control cubicle for control including bay controller.

iv) Two (2) transmission line bay modules, each comprising of:
One (1), 3-pole SF6 gas insulated circuit breaker, complete with individual
operating mechanism,
One (1), 5-core, multi ratio, 3-pole current transformer,
Three (3), 3-phase, single-pole group-operated disconnectors, complete with
manual and motor driven operating mechanisms,
Two (2), 3-phase, single-pole group-operated safety earthing switches, complete
with manual and motor driven operating mechanisms,
One (1), 3-phase, single-pole group-operated high-speed earthing switch,
complete with manual and motor driven operating mechanism,
Three (3), SF6 / air bushings for outdoor connections,
One (1), local control cubicle for control including bay controller.

v) Gas insulated bus duct (GIB) for interconnection between GSU
transformers and respective unit bays of GIS,

vi) All necessary terminal boxes, SF6 gas filling, interconnecting power and
control wiring, earthing connections, gas monitoring equipment and piping
support structures etc.,

vii) The first filling of SF6 gas for the equipment supplied plus an additional
quantity sufficient for conducting all tests on equipment at the site before
placing it into successful operation. SF6 gas shall be supplied in returnable
cylinders. In addition about 10% spare gas (of total used for GIS) by weight
shall be supplied in 40 litre non returnable cylinders,

viii) Continuous on-line monitoring and diagnostic systems to monitor gas
density, gas pressure, leakage, moisture (offline) etc., operating parameters
such as current, voltage, temperature etc. complete with sensors,
control/processor units, wiring/cabling in all respect and integration of the
systems with plant SCADA system,

ix) Coordination and provision of necessary contacts and/or ports integration with
plant SCADA system,

x) One (1) set of spare parts in accordance to clause 10.8 “Spare Parts” of this
section,

xi) One (1) set of tools and instruments in accordance to clause 10.9 “Tools and
Instruments” of this section.

Any other item(s) not mentioned specifically but necessary for the satisfactory
completion of scope of work defined above, as per accepted standard(s) / best
international practices.

10.2. Specific Parameters and Layout Conditions

10.2.1. Layout and General Arrangement
The Contractor shall follow the duct layout arrangement as shown in equipment
arrangement drawings to develop the actual layout.
EOT crane of 10T capacity for handling and installation of GIS shall be provided
and its hook height has been shown in the drawing. Bidder to conform to suitability
of the above crane for GIS and its accessories in their design.
The switchgear shall have double bus bar arrangement. The rated capacity of switchgear including bus bar and all feeders shall be 4000 A. 420 kV SF6 gas insulated switchgear shall be installed at EL 984.00M. The interconnection between main GSU transformers and respective unit bays shall be through GIB. The interconnection between pot yard and outgoing line bays of the 420 kV GIS switchgear shall be through 400 kV XLPE cable laid in cable-cum-ventilation tunnel. The single line diagram for 420 kV GIS is given in drawing no. NH/DEM/PBT-III/CP/01, NH/DEM/PBT-III/CP/02 and NH/DEM/PBT-III/CP/03.

10.2.2. Design Consideration

The power evacuation system of the Parbati H.E. Project, Stage-III shall be designed to cater the combined power generation of Parbati H.E. Project, Stage-II and Parbati H.E. Project, Stage-III i.e., 1620 MVA of power. For evacuation of this power two nos. of transmission line shall be provided. Each bus and line shall be capable to handle the entire power.

10.3. Rating and Functional Characteristics

<table>
<thead>
<tr>
<th>System Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Indoor</td>
</tr>
<tr>
<td>Scheme</td>
<td>Double Bus bar arrangement</td>
</tr>
<tr>
<td>No. of Bays</td>
<td>7</td>
</tr>
<tr>
<td>System Requirement</td>
<td></td>
</tr>
<tr>
<td>Rated voltage kV</td>
<td>420 KV</td>
</tr>
<tr>
<td>Rated frequency, Hz</td>
<td>50</td>
</tr>
<tr>
<td>Rated withstand Voltage to earth</td>
<td></td>
</tr>
<tr>
<td>- Power Frequency</td>
<td>520kV</td>
</tr>
<tr>
<td>- Lightening Impulse (peak value)</td>
<td>1425kV</td>
</tr>
<tr>
<td>- Switching Impulse</td>
<td>1050kV</td>
</tr>
<tr>
<td>Rated short time withstand current (r.m.s) for 1 Sec</td>
<td>63kA</td>
</tr>
<tr>
<td>Rated Peak withstand current</td>
<td>157.5kA</td>
</tr>
<tr>
<td>Rated normal current, A, r.m.s</td>
<td>4000A</td>
</tr>
<tr>
<td>Control voltage DC</td>
<td>220 V + 10% / -10% for trip coils -20% for trip coils</td>
</tr>
<tr>
<td>Auxiliary AC supply, 3 phase</td>
<td>415 ± 10% V</td>
</tr>
<tr>
<td>Partial discharge of switchgear assembly at highest voltage for equipment, pc</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Maximum Gas leakage rate (%) of the respective volume, per year</td>
<td>1 % individual section and 0.5% on overall basis per phase</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Circuit Breaker</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>SF₆</td>
</tr>
<tr>
<td>Description</td>
<td>Three separate pole equipped with single pole operating mechanism</td>
</tr>
<tr>
<td>First-pole-to clear factor</td>
<td>1.3</td>
</tr>
<tr>
<td>Rated short circuit breaking capacity, kA (r.m.s)</td>
<td>63kA</td>
</tr>
<tr>
<td>Rated short circuit making capacity, kA (peak)</td>
<td>157.5kA</td>
</tr>
<tr>
<td>Rated line charging breaking current capacity, A</td>
<td>400A</td>
</tr>
<tr>
<td>Rated cable charging breaking current capacity, A</td>
<td>400A</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td></td>
</tr>
<tr>
<td>- Line Breakers</td>
<td>O-0.3s-CO-3 min–CO</td>
</tr>
<tr>
<td>- Generator feeder and bus coupler breaker</td>
<td>O-3min-CO-3 min–CO</td>
</tr>
<tr>
<td>Closing Time</td>
<td>Less than or equal to 100 ms</td>
</tr>
<tr>
<td>Breaking Time</td>
<td>Less than or equal to 50 ms</td>
</tr>
<tr>
<td>Small inductive current breaking capability (without producing excessive over voltages)</td>
<td>10 A</td>
</tr>
<tr>
<td>Disconnector</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Three separate pole mechanically coupled and group-operated</td>
</tr>
<tr>
<td>Operation</td>
<td>Motor as well as manual</td>
</tr>
<tr>
<td>Rated withstand voltage across isolating distance</td>
<td></td>
</tr>
<tr>
<td>- Power frequency</td>
<td>610kV</td>
</tr>
<tr>
<td>- Lightening Impulse (Peak)</td>
<td>1425kV</td>
</tr>
<tr>
<td>Rated capacitive current make and break capacity</td>
<td>0.50A</td>
</tr>
<tr>
<td>Rated Bus Transfer Current</td>
<td>80% of rated normal current</td>
</tr>
<tr>
<td><strong>Rated Bus Transfer Voltage</strong></td>
<td>20V r.m.s</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Earthing Switch</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Making Capacity kA (peak)</strong></td>
<td>157.5 kA</td>
</tr>
<tr>
<td><strong>Rated short-time current</strong></td>
<td>63kA</td>
</tr>
<tr>
<td><strong>Rated Induced Current/Voltage for Electromagnetic coupling(rms)</strong></td>
<td>160 A / 10kV</td>
</tr>
<tr>
<td><strong>Rated Induced Current/Voltage for Electrostatic coupling(rms)</strong></td>
<td>18A/20kV</td>
</tr>
<tr>
<td><strong>Current Transformers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Current ratio</strong></td>
<td></td>
</tr>
<tr>
<td>Generator/Bus coupler</td>
<td>2400-1200-300/1A</td>
</tr>
<tr>
<td>Line bay</td>
<td>2400-1200-300/1A</td>
</tr>
<tr>
<td><strong>Accuracy class</strong></td>
<td></td>
</tr>
<tr>
<td>- For protection</td>
<td>PS</td>
</tr>
<tr>
<td>- For metering</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Surge Arrester</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Gapless metal Oxide station type</td>
</tr>
<tr>
<td><strong>Rated arrester voltage</strong></td>
<td>336 KV rms</td>
</tr>
<tr>
<td><strong>Nominal discharge Current (8/20µs wave)</strong></td>
<td>20 KA</td>
</tr>
<tr>
<td><strong>Energy dissipation capability</strong></td>
<td>Not less than 10 KJ/kV</td>
</tr>
<tr>
<td><strong>Partial Discharge at highest level</strong></td>
<td>&lt;10</td>
</tr>
<tr>
<td><strong>Bus Voltage Transformer</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Inductive type, single phase, two core</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>R,Y,B phase</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Synchronising, and Metering</td>
</tr>
<tr>
<td><strong>Voltage ratio</strong></td>
<td>(400√3) kV/ (110√3) V/ (110√3) V</td>
</tr>
<tr>
<td><strong>Accuracy class - Metering - Protection</strong></td>
<td>0.2 3P</td>
</tr>
<tr>
<td><strong>Voltage factor</strong></td>
<td>1.5 for 30 s, 1.2 for continuous</td>
</tr>
</tbody>
</table>

10.4. Performance Guarantee
The GIS system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

Contractor shall state and guarantee the following:

The maximum yearly gas loss in every monitored compartment. In the event of loss of gas exceeding 1.0 percent in any section measured in the first two years after commissioning of GIS the manufacturer shall submit a procedure for the approval of Employer and based on agreed QA plan carry out necessary rectification or replacement to reduce the gas leakage shall be carried out by the manufacturer at no cost to Employer. Necessary outage however shall be provided by Employer,

Number of mechanical and fault current operation of circuit breaker interrupter unit before it is opened for inspection and maintenance,

Number of operation of operating mechanism before it is opened for inspection and maintenance.

10.5. Design and Construction

10.5.1. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IEC 62271(All Parts)</td>
<td>“High voltage switchgear and control gear”,</td>
</tr>
<tr>
<td>4</td>
<td>IEC 60694 1996 Edition</td>
<td>Common Clauses for high-voltage switchgear and control gear standards</td>
</tr>
</tbody>
</table>

10.5.2. General

It is understood that each manufacturer has its own particular design concept and it is not the purpose of this specification to impose unreasonable restrictions. However, in the interest of safety, reliability and maintainability, the switchgear offered shall meet
the following minimum modular concept and design requirements:

- Fail safe inter and intra bay interlocking scheme,
- Maintenance of one bus bar with the other bus bar in service,
- Interchangeability of similar parts,
- Future extension of bays, with maximum one bus outage at a time,
- Possible to remove and replace the fully assembled parts of circuit breaker,
- Pressure relief device for each pressurised section,
- Gas density monitoring device for each isolated section/module.

All mechanical parts, which are outside of gas filled compartment, must be externally accessible and serviceable without disconnecting the main bus bar or feeder circuits.

All current carrying components of the equipment specified shall be capable of continuous operation at the specified rated current without exceeding the maximum temperature rises specified in the relevant IEC standards.

10.5.3. Arrangement and assembly

The arrangement shall be single-phase enclosed. The assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to personnel or adjacent sections in the event of a failure occurring within the equipment. Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors provide protection for the operating personnel. In order to achieve maximum operating reliability, no internal relief devices shall be installed because adjacent compartments would be affected. Modular design, complete segregation, arc-proof bushings and “plug-in” connection pieces shall allow ready removal of any section and replacement with minimum disturbance of the remaining pressurized switchgear.

10.5.4. Metal enclosed Bus bar

The bus bars shall be single-phase segregated metal-enclosed type. The enclosure design shall essentially be based on following considerations

- Temperature and solar radiations,
- Thermal cycling, vibration, shock and seismic,
- Design Pressure on normal and abnormal conditions.

Conductors and live part shall be mounted on moulded epoxy resin insulators specially made for the EHV application. The conductors shall be made of tubular aluminium. Silver plated finger contacts at the ends of conductor or mounted on support insulators shall be provided to form sliding contact permitting the conductor to expand axially on a temperature rise, without imposing any mechanically stresses on the supporting insulators. Metal bellows compensators shall be provided on enclosure for permitting longitudinal expansion. The enclosure shall be dimensioned for the full return current. Compensators shall be bypassed by copper straps.

10.5.5. Circuit breakers

The circuit breaker shall be designed to minimize switching over voltages and also to be suitable for out-of-phase switching. The specified arc interruption performance must be consistent over the entire operating range, from line-charging currents to full short-circuit currents. The complete contact system (fingers, clusters, jets, SF6 gas) shall be designed to withstand at least twenty (20) operations at full short-circuit rating without the necessity to open the circuit breaker for service or maintenance.
The interrupter and operating drive should be simple and sturdy conforming to C2 & M2 class complying with $T_{100}$ & $L_{75}$ without maintenance respectively as per IEC 62271-100.

The operating mechanism shall be spring / spring or hydraulic / spring type.

The circuit breakers shall comprise three single-phase metal clad breakers poles. The circuit breaker shall have double break interrupter unit per pole. However, single break interrupter per pole may also be considered provided minimum 24 bays are under successful operation at the time of award of contract. Each pole shall consist of the operating mechanism, interrupter unit and the enclosure with basic supporting structure. The mechanism shall be trip free mechanically or electrically with anti pumping device. Grading capacitors shall be provided to ensure uniform voltage distribution between interrupting elements. SF$_6$ circuit breakers shall conform to IEC-62271-100. Auxiliary contacts of the breakers shall be provided for the local and remote indications, the performance of various control and protection schemes and the interlocking scheme. Alarm and cut-off contacts for mechanism faults and gas pressure loss shall also be provided. The circuit breaker shall be capable of being operated locally or from remote.

10.5.6. Current transformers

The current transformers shall be of single phase inductive type and shall have multi core with multi ratio, which shall be changeable by means of taps on secondary side. Independent cores shall be used for different purposes as per drawing NH/DEM/PBT-III/CP/02 of protective relaying and metering diagram.

10.5.7. Voltage transformers

The voltage transformers shall be of single phase inductive type with secondary windings as shown in drawing NH/DEM/PBT-III/CP/02. Independent cores shall be used for different purposes as per drawing No.NH/DEM/PBT-III/CP/02 of protective relaying and metering diagram.

The voltage transformer shall be located in a separate module and shall be connected phase to ground to the phase buses.

10.5.8. Disconnector

The three-phase disconnector shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms.

The disconnector shall have provision for visual indication of switching position. Disconnector shall conform to IEC 62271-102. Sufficient auxiliary contacts shall be provided for indications (local and remote), interlocking schemes and the performance of various control and protection schemes.

10.5.9. Earthing switch

The 3-phase earthing switch shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms.

Each earthing switch shall be electrically and mechanically interlocked with its associated disconnector and circuit breaker. Sufficient auxiliary contacts for indications
10.5.10. High speed earthing switch

The three-phase high-speed make-proof type-earthing switch shall comprise of three separate pole and all the three poles shall be mechanically coupled via robust mechanical link. All three poles shall be group-operated manually as well as through motor driven mechanisms. It shall be used to discharge the respective charging current in addition to their safety earthing functions.

Each earthing switch shall be electrically and mechanically interlocked with its associated disconnector and circuit breaker. Sufficient auxiliary contacts for indications and interlocking shall be provided. Inspection window shall be provided in the enclosure.

10.5.11. Surge arrester

The surge arrester shall be of gap-less heavy-duty station type and the live part shall comprise of non-linear metal oxide resistors without spark gap. Provision shall be made for measurement of leakage current and connection of discharge counter.

The arrestors shall be either the plug in construction or the disconnect link type and be attached to the GIS in such a manner that they can be readily disconnected during the dielectric tests. The metal housing of the arrester should be connected to the metal enclosure of the GIS through the flanged or bolted joints.

10.5.12. Termination arrangements

The Contractor shall co-ordinate the interface arrangement and scope of supply of respective manufacturers for 420 kV GIS termination on 400 kV side of transformers and 400 KV XLPE cable.

10.5.13. Name Plate

Each auxiliary control cubicle must be identified with the feeder designation to which it is assigned.

Each instrument transformer must have its own rating plate with the information as required in IEC 60044-1 and IEC 60186.

10.5.14. Earthing

The enclosures of all the GIS shall be grounded at several points so that there shall be a grounded gauge around all live parts. All conduits and cables sheaths shall be connected to the ground bus, to be provided, in the control cubicles and the marshalling boxes. All steel structures shall be grounded. The manufacturer shall recommended earthing requirements during engineering in the first submission of drawings

All wirings to GIS shall be shielded and grounded at both ends. Subassembly to subassembly ground conductors shall be provided to assure safe voltage gradients.

10.5.15. SF₆ GAS
The gas shall generally conform to IEC 60376 – 2005 edition but for following

- Water < 5 ppm by weight
- Carbon Tetra Fluoride < 250 ppm by weight
- Air < 250 ppm by weight

10.5.16. On-line monitoring

Continuous on line monitoring system shall be provided to monitor conditions such as gas density, gas pressure, gas leakage, moisture (offline) etc. and operating parameters such as current, voltage, temperature etc. of GIS for smooth operation and detection of any changes in insulation at an early stage during normal operation to take appropriate remedial action.

Each system shall be complete with sensors, input/output module, control/processor unit, relays, junction boxes, cabling and associated accessories for measuring, monitoring and data acquisition of intended parameters to be monitored.

10.5.16.1. Gas monitoring system

Each gas-filled compartment shall have its own SF₆ gas density / pressure monitoring system, each comprising of a temperature compensated SF₆ gas density monitoring unit and pressure gauge having alarm/trip contacts.

Gas pressure and density shall be continuously monitored and displayed by a suitable temperature compensated instrument, which will provide an alarm signal in case of pressure drop before the allowable minimum pressure is reached.

10.5.17. Local control cubicle

The Local control cubicle shall contain all the equipment required for controlling and monitoring the bay. Each bay’s local control cubicle shall have at least the following main function:

- The mimic diagram with control switches for electrically operated circuit breakers, disconnector and earthing switches as well as the position indication of all components provided with auxiliary switches,
  - Alarm facia with indicating lamps for monitoring of gas density,
  - Trip circuit healthiness,
  - Electric interlocking between devices,
  - Interface between central control and the switchgear,
  - Interior lighting, safety shrouding, heating to prevent condensation etc.

All the switchgear bay module shall be supplied with a local control cubicle of the floor standing type. The cubicle shall have full height, hinged, gasket lockable double doors. One door shall have safety glass window through which various controls can be viewed without opening the door. The cubicle shall be utilized as both the switchgear bay local control module and as the terminating centre for all power supply, control, annunciation and supervisory wiring interfacing with the system. Adequate no. of potential free contact shall be made available for providing necessary input/output interface.

Implemented technology for control shall be digital and local control cubicle shall incorporate bay control unit for integration to plant SCADA system through local control Board for GIS.
10.6. Drawings, Documents and Design Calculations

10.6.1. Design memorandum

The Contractor shall submit to Employer a design memorandum for the proposed equipment/system fulfilling the contract specification/requirement for approval prior to submission of dragwings and documents.

10.6.2. Drawings and documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in Section 3 –General Technical Requirements.

10.6.3. Design calculation

The Contractor shall submit the design calculation in accordance to the system requirement to the satisfaction of the customer.covering at least the following, for review / acceptance.

- Calculation of power requirement for operating mechanism of breakers, disconnector and earthing switches,
- Data/calculations in regard to the loads under severe short circuit conditions to be transferred to civil structures for designing of GIS hall accordingly.

10.7. Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning requirement of the project schedule.

10.8. Spare Parts

Recommended spare parts shall be as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SF6 gas for use during operation and maintenance in non-returnable cylinders</td>
<td>10% of total quantity in 40 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cylinders</td>
</tr>
<tr>
<td>2</td>
<td>One pole of complete Interrupter unit of circuit breaker with operating mechanism and tie rod etc.</td>
<td>one phase</td>
</tr>
<tr>
<td>3</td>
<td>Complete drive mechanism including motor for disconnector switches and earthing switches</td>
<td>1 no.</td>
</tr>
<tr>
<td>4</td>
<td>Complete drive mechanism including motor for fast acting earthing switches.</td>
<td>1 no.</td>
</tr>
<tr>
<td>5</td>
<td>Trip coils for circuit breakers</td>
<td>6 nos.</td>
</tr>
<tr>
<td>6</td>
<td>Closing coils for circuit breakers</td>
<td>6 nos.</td>
</tr>
<tr>
<td>7</td>
<td>Complete set of rupture disc</td>
<td>2 sets</td>
</tr>
<tr>
<td>8</td>
<td>Pressure switch/gas pressure transmitter</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Pressure gauge</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>10</td>
<td>Gas density relay</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>11</td>
<td>Gas tight bushing of each type used</td>
<td>2 sets of each used type</td>
</tr>
</tbody>
</table>

One set would be applicable for one phase of one feeder bay.

10.9. Tools and Instruments

The Contractor shall supply all necessary tools and instruments etc. for installation, repair and maintenance.

10.9.1. Special tools

The Contractor shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), to be accepted by the Employer.

The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s):

- One (1), gas processing unit and filling units, along with tools and spares to handle gas quantity in at least two largest gas sections, with provision to check SF₆ moisture and acidity content,
- One (1), set of handling devices and tools for assembling and dismantling of bays / complete GIS modules,
- One (1) set of handling devices and tools for assembling and dismantling each type of operating mechanism of circuit breakers, disconnectors and earthing switches.

10.9.1.1. Testing instruments

The Contractor shall propose the list of testing instruments including their make and detailed specification to be accepted by the Employer.

Proposed list shall include following mandatory items:

- One (1) no. air / gas humidity tester,
- One (1) no. gas. purity detector for SO₂, H₂O, CF₄, AIR etc.,
- One (1) no. gas leakage tester,
- One (1) no. breaker timing measurement kit,
- One (1) set of equipment for pressure measurement and gas tightness testing.
10.10. Quality Assurance and Testing
The Contractor shall follow the quality assurance and testing requirements specified separately in “Quality assurance and Testing Specifications (QTS)” which is given below:

“Quality assurance and Testing Specifications (QTS)”.

1. INSPECTIONS AND TESTS

1.1. General
In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedules for inspections and tests the following stipulations shall apply:

Approval of assemblies, tests, inspections, related procedures etc. and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Contractor of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

Three (3) sets of all test records, test certificates, performance curves, tables etc. of all inspections and tests, whether or not attended by the Engineer shall be supplied soonest after performance of each inspection or test. After completion of all testing two (2) sets of the above-mentioned documents shall be supplied properly bound in books.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer.

In addition, the following references shall be entered in the top right-hand corner:

i) Employer's name
ii) Project title
iii) Plant's (stage's) name
iv) Number of Contractor's drawing
v) Date

1.2. Manufacture and Supply
All material furnished shall be of tested quality and all work performed shall be subjected to rigid inspection as specified in relevant International or Indian Standards and no articles or material or supplies shall be dispatched until the dispatch instructions are issued by the Employer, which shall be issued only after all test's analysis and shop inspection have been completed or certified copies of reports or, results of tests and analysis have been accepted by the Employer.

Duplicate copies of manufacturer tests certificate shall be submitted to the engineer in charge as soon as the tests are completed. In case test certificates are not available for any of materials, the same shall be tested if requested by the employer and only those materials, which fulfil the requirements of the specifications, shall be used.

1.2.1. Steel Casting
Castings shall be sound and free from blowholes, porosities, shrinkage holes, cracks or any other defects, Surfaces of castings which do not undergo machining and which are exposed to view in the installation shall be dressed for good appearance and for painting. The location of existing defects shall be determined, and all defects, which impair the strength or utility of the casting, shall be removed.
to sound metal. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting will be a cause for its rejection.

1.2.2. Welding

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Edges shall be shaped according to DIN 8551. Design of welded joints and selection of weld filler metal shall be in accordance with approved standards and shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects such as laminations or defects caused by cutting operation at least 30 mm back from the edge of the weld, and free from rust, oil, grease, and other foreign matter.

The qualification of welding procedures, welders, and welding operators for all welding, including weld repairs, shall conform to DIN 8560, DIN 8563, EN 287, or to the requirements of the ASME Boiler and Pressure Vessel Code Section VIII and IX. The Contractor shall perform qualification tests of his welders and welding operators and submit evidence of this to the Engineer in-charge.

Weld-fabricated pressure-containing parts shall be designed, fabricated, inspected and tested, unless otherwise specified, in accordance with approved standards and shall be stress relieved as a unit prior to final machining.

1.2.3. Workmanship

i) Electric Welding

All welds shall be made continuous and watertight. The minimum size of fillet welds shall be 6 mm measured on the leg. All butt welds shall be full penetration welds welded from both sides.

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds, which require nondestructive examination, shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination method. All butt welds in the flanges and webs of beams and girders shall be radio-graphically inspected. The fillet welds between flanges and webs shall be tested by the magnetic particle method.

ii) Machine work

All tolerances, allowances, and gauges for metal fits between plain (nonthreaded) cylindrical parts shall be indicated. Sufficient machining stock shall be allowed on parts to be machined to ensure true surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished, and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. No machining shall be done on working surfaces of self-lubricating bushings or washers.

iii) Finished Surfaces
All surfaces that are so indicated on the drawings or those that require machining for their intended function, or those that are usually machined according to good workshop practice shall be machined. Surface finish qualities shall be adequate for the intended use and shall be indicated on the Contractor's Drawings. Suitable measuring device such as Scatter meter or other acceptable measuring device will be used to determine compliance with specified surface.

iv) Unfinished Surfaces

So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces they shall be chipped and ground smooth, or machined, to secure proper alignment. If surfaces not designated as finished in the Contract Documents require machining to obtain the tolerances or straightness specified or needed for correct function, such machining shall be performed by the Contractor.

1.2.4. Dimensional Checks and Visual Inspection

Dimensional checks shall be performed on all major parts, components and partial assemblies, especially when close tolerances and fits are involved (tolerance of shafts, between stationary and moving parts, connecting dimensions for the assembly with other supplies, etc.). If the dimensional checks show discrepancies in measurement, which may affect the fit, assembly or dismantling of the respective part or component, the same have to be corrected correspondingly. Such correction or modification shall, however, in no way lead to sacrifices with respect to reliability of operation or inter-changeability, and shall be performed only after the agreement of the Engineer in-charge has been obtained. If the correction or modification cannot be carried out in accordance with the terms mentioned above, the part or component concerned may be subject to rejection. Faulty machine parts or equipment shall by no means be delivered.

Castings shall be inspected visually at the foundry after they are cleaned and while defects are being removed. Castings shall also be inspected after repairs and after heat treatment. Radiographic or other nondestructive tests will be required as specified under non-destructive testing and as directed by Engineer in-charge when granting permission to repair major defects. The Engineer in-charge reserves the right to require conducting non-destructive tests at the Contractor's expense to determine: the full extent of defects; that area is properly prepared for welding that the repairs are satisfactory.

1.2.5. Impact and Bend Tests

Steel products for all principal turbine and shut-off valve parts shall be tested for impact resistance using the ISO V-notch specimen. Both longitudinal and transverse impact tests shall be performed on plate steel. Bend tests shall be performed on specimens of all major steel castings and forgings in accordance with the applicable DIN standards. The nil ductility transition temperature shall be the temperature at which the impact resistance is at the values specified above.

1.2.6. Non-Destructive Testing

1.2.6.1. Examination of Welds
Unless otherwise indicated in these Contract Documents, non-destructive tests shall be in accordance with approved standards. Radiographic examination of welds shall be in accordance with the technique and acceptance standards of IIW (International Institute of Welding). The Contractor's Drawings shall indicate the type and extent of nondestructive examination as it applies to each component or weld.

Weld examination shall be by the ultrasonic, dye penetrant, or magnetic particle methods, supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretation of other methods is unclear, or where the integrity of the weld is doubtful. The Employer shall have the right to request the Contractor to make random spot-check examination of welds, including radiographic examination, as part of his inspection of the equipment. The Contractor's detailed program for non-destructive examination of welds shall be submitted for review.

1.2.6.2. Examination of Casting

The turbine runner casting shall be given complete non-destructive examination including radiographic examination of the most critical areas. The Contractor shall submit Quality Sheets (Specification for inspection of steel casting for hydraulic machines), with his recommendation and specify special precautions to be taken for the casting of the turbine runner and other important casting components. The Quality Sheets submitted shall define the area and extent of the various non-destructive examinations to be performed on castings.

1.2.6.3. Examination of Forging

Shafts, stems and coupling bolts made of forgings shall be given complete ultrasonic examination and other applicable non-destructive test, to determine that they are sound. Non-destructive examination of other forgings shall be in accordance with accepted good practice to assure their soundness. The structure of forgings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging will be a cause for its rejection.

1.2.7. Pressure Tests

Unless specifically mentioned otherwise in the Contract Documents, equipment, vessels and tanks under internal pressure during service shall be subject to hydrostatic pressure testing. The test pressure shall be 1.5 times the maximum design pressure of the respective equipment, vessel or tank.

Unless otherwise specified, the test pressure shall be applied for a period of 1/2 hour without showing leaks or drop in pressure.

1.3. Workshop Inspections and Shop Tests

As far as practicable, quality of materials, workmanship and performance of all items of the Works to be furnished under this Contract shall be inspected at the places of manufacture.

Free and unrestricted access to the Contractor's factory and shops (including
those of his Subcontractors) shall be granted to the Engineer also and upon reasonable notice by the Engineer if deemed necessary by the same for additional witnessing of assembly work or inspections and tests.

Should an agreed inspection not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state, which does not correspond to the proposed procedure or is clearly not acceptable such an inspection shall be repeated. The cost incurred by the Employer for repeated inspections shall be fully borne by the Contractor.

The Contractor shall state the plan of manufacture, testing and inspection of the various works in the contract, and the representative of engineer in-charge shall also be entitled to access to manufacturer's or, subcontractor's work at any time during working hours for the purpose of inspecting the manufacture of equipment and materials.

All the required tests as per standard/specifications shall be carried out at Contractor’s expenses. If any component of the equipment fails in the specified test, the same shall be replaced/ rectified and again offered for inspection.

Shop Tests specified in respective section shall be carried out in Employer’s presence. The tests not specifically mentioned but recommended in the relevant standards for such equipment and/or good engineering practice shall also be carried out.

The factory test equipment and the test methods used shall conform to the recommendations of the relevant IEC Publications and shall be subject to approval of the Engineer in-charge.

1.3.1. Material Tests

Unless otherwise specified, the quality of materials shall be verified generally by:

i) Chemical analysis

ii) Mechanical tests (yield point, tensile strength, elongation, Transverse Contraction and notch impact.)

iii) Welding tests (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.)

iv) Non-destructive tests (X-rays, Ultrasonic, Magnetic Particle tests, Liquid Penetration inspection, etc.).

v) Electrical tests (voltage, losses, tan delta, insulation, magnetic properties etc.) For the notched bar impact test, the impact value shall be obtained at plus (+) 20°C ambient temperature unless mentioned otherwise. The material tests shall be performed as per relevant ASTM unless approved otherwise. Certified mill test reports of plates will be acceptable when these comply with the requirement of specifications. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent. Castings and forgings shall be tested in the rough state in order to detect flaws in good time thus avoiding delays. Magnetic particle inspection of important castings shall cover the whole surface of the casting. After partial machining further tests can be conducted. Load tests on crane hooks, steel wire ropes, chains and other lifting devices, etc. shall be considered as material tests.
1.3.2. Checking of Dimensions

The dimensions, especially clearances and fits, which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

i) Run out and roundness tolerances of shafts, pistons, etc., to be measured on single parts as well as (wherever possible) on the assembled components,

ii) Fits and clearances of bearings, servomotor pistons, valves, guiding, distributing and actual actuating elements, etc.,

iii) Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves, etc.,

iv) Dimensions of couplings or connections for assembly with other deliveries from the Contractor, Sub-contractors or other contractors.

1.3.3. Workshop Assembly

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Works to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specifications, that the delivery is complete, and that no work remains to be done at Site, which reasonably can or should be done in the shop.

Where applicable, each item of the Works shall be assembled completely prior to painting.

Field joints shall be temporarily connected.

All parts shall be properly match marked, identified and doweled where practicable, to facilitate correct and quick field assembly and alignment. Where necessary, suitable dowels shall be provided for insertion after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed.

During workshop assembly all instruments, control devices and piping shall be fitted.

If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these shall be eliminated. If required, design alterations or corrective measures can be executed provided that reliability of operation or interchangeability are not reduced and provided that the agreement of the Engineer has been obtained.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer. Faulty parts or Works shall by no means be delivered.

The assembled parts shall subsequently be subject to tests as per applicable standards or required by the Engineer.

1.3.4. Pressure and Leakage Tests

All parts subject to internal or external pressure or containing any liquids or gases temporarily or permanently during operation shall be tested prior to painting. As far as practicable, these tests shall be done in the shop but can be repeated at site.
Parts exposed during operation to hydraulic pressure, to gas pressure or to any liquid without pressure, shall be treated distinctively.

As far as practicable and required, the influences of temperatures and temperature differences to which the part will be exposed during operation shall be considered in the performance of the tests.

1.3.4.1. Parts Exposed to Hydraulic Pressure

Unless otherwise specified or required, the following shall apply: the hydraulic pressure tests shall be carried out using the liquid to be used during operation or a liquid with less viscosity.

The hydraulic test pressure shall be 1.5 times the maximum operating pressure (except for spiral distributor) and shall be maintained for a period of eight hours or longer if required by the applicable standards. Afterwards the test pressure shall be reduced to the operating pressure.

1.3.4.2. Parts Exposed to Gas Pressure

Parts which will be subjected to gas pressure during operation for example pressure tanks, pressure air tanks and others, shall be inspected and tested according to the official regulations with respect to design, construction, fittings, etc.

The pressure test shall be executed by applying the test pressure in accordance with the relevant standards and specifications.

1.3.4.3. Parts Exposed to Liquids without Overpressure

Parts which shall not be closed and which are exposed to only small pressures of any liquid during operation e.g., bearing housings, oil containers, etc.) Shall be subjected to a tightness test with a suitable liquid of low viscosity. The testing-period shall not be less than 8 hours, unless otherwise agreed.

1.3.5. Functional Tests

Functional tests shall be defined as tests of the function of assemblies, sub-assemblies or parts of the Works under no load conditions. Functional tests shall be performed on all Works prior to the execution of operational tests.

1.3.6. Operational Tests

As far as practicable operational tests shall be carried out on all Works, simulating operating conditions.

Parts to be delivered by sub suppliers shall be tested either at the premises of the sub supplier or of the Contractor, as agreed by the Engineer.

Before testing the Contractor shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the Works to be tested and on the test facilities and equipment.

Testing of the electrical Works shall be performed in accordance with applicable Standards; they shall include but not be limited to tests of heating, loading,
overloading, losses.

Operational tests of lifting equipment and other machinery shall include tests under nominal load and 125 % of nominal load unless otherwise specified.

1.3.7. Electric Tests

Electrical Works shall be tested in accordance with applicable Standards and agreed test programs and procedures.

1.3.8. Model Tests

Model tests for certain parts of the work or Works shall be carried out as specified or agreed between Contractor and Engineer.

1.4. Quality Control and Assurance

To ensure quality during each stage of work, the Contractor shall establish a system defining quality assurance plan/procedures during various stages of work.

The Contractor shall maintain quality control during manufacturing of equipment as per the approved quality assurance plan. The model quality assurance plan for equipment / components for each section are given hereafter. Final quality assurance plan (QAP) for manufacturing shall be approved during detailed engineering.

The Bidder shall submit the detailed Quality Assurance Plan for the complete equipment/materials along with the bid for approval and acceptance by the Employer. This shall form integral part of the contract. The QAP shall include inspection and tests proposed to be conducted on raw material/bought out items at the time of induction in the process of manufacturing and at final stage of assembly.

Based on the test certificate, inspection report dispatch clearance shall be issued by the employer. The materials/equipment/items shall only be dispatched after issue of material dispatch clearance certificate (MDCC).

Detail Model Quality Assurance Plan is attached here with of each and every equipment/ auxiliaries. These are to be strictly observed /followed by the Manufacturer / Contractor/ Sub – Vendor.

Inspections and tests shall be carried out by the Contractor as per approved QAP with due regard to stipulations in “Section 3 - Inspection and Tests” of “General Technical Requirements” at various stages of manufacturing for assuring the full compliance of supply with the requirements of specification.

The Contractor shall follow approved site quality assurance plan and installation procedures. The Contractor shall maintain the quality records during site installation and commissioning which shall be produced to engineer in charge for approval at defined stages.

Inspection and tests shall be carried out at site by contractor during installation and commissioning as described in relevant clauses.

1.4.1. Type Tests
Type tests shall verify that all components of the equipment perform satisfactorily, both electrically and mechanically, at the rating assigned. All equipment proposed according to the specification shall be type tested at typical units in accordance with the relevant standards specified in respective sections.

The type tests for equipment, except wherever mentioned specifically as mandatory in respective section, may not be mandatory if similar typical units of equipment have been type tested and test certificate(s) for relevant tests are accepted by the Employer.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Employer, of all test certificates/results and hand over these documents to the Employer in due time for review and acceptance as required.

All cost associated with the mandatory type tests shall be included in contract price. Also, the Contractor shall conduct the type test(s) at his own cost for which certificate(s) are not acceptable.

1.4.2. Routine Tests

Routine tests shall be conducted on various equipment/components as elaborated in respective section and/or approved quality assurance plan. (QAP).

1.5. Field Tests

During erection, commissioning and trial operation, the Contractor shall perform at suitable intervals all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract.

Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor shall delegate his experts to perform the tests at site.

The Engineer reserves the right to have checked at his own expenses the Contractor’s instruments to be used or having been used for any tests by an independent, officially acknowledged institution.

The Contractor’s testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

For the procedure of inspections and test at site, notice to the Engineer, reports, commissioning, trial runs and trial operation, and acceptance tests refer to General Conditions of Contract.

All field tests including tests during installation, pre-commissioning, commissioning, performance and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer. Procedure to be adopted for conducting these tests shall be submitted well in advance, before start of relevant testing, for approval of the Employer.

All test equipment and instruments shall be furnished by the Contractor and will remain the Contractor’s property after the fulfilment of all field tests.

The Contractor shall prepare written test certificates in a form agreed upon by the Contractor and Employer of all tests results and hand them over to the Employer in
due time.

1.5.1. Tests During Installation, Pre Commissioning And Commissioning

Immediately upon termination of commissioning of a part or section of the Permanent Works, which can operate as an independent unit a “Certificate of Suitability for Operation”, shall be issued by the Engineer.

This document shall be signed by an authorised representative of the Employer, the Engineer and the Contractor.

This Certificate shall state:

i) The supplier of the Works concerned,

ii) The quantity and type of Works concerned,

iii) The conditions of commissioning,

iv) The names of the participants,

v) The date of commencement of trial run,

vi) The list of minor defects, if any, which has to be corrected by the Contractor.

During the trial run the Contractor shall make familiar the Employer's personnel with the equipment, the operation and maintenance of the Works and its auxiliaries to such an extent that thereafter the duties can be assigned to the Employer's trained personnel.

If any defects or irregularities affecting the safety or reliability of the Works should arise during the trial run, the trial run shall be interrupted and started again after such defects or irregularities have been corrected by the Contractor.

The tests during installation, pre-commissioning and commissioning shall be conducted at site in accordance with provision in respective sections and/or in applicable Indian/International testing standards for the system and system components. However, following generic tests shall be essentially performed on all installation/system:

Visual inspection of the equipment/components,

Pressure test of all field installed piping at 1.5 times of the design pressure,

Operational and functional tests of components, sub-assemblies, auxiliaries, piping system etc,

Control logic field tests to prove control logic scheme for operation and interlocks of system components, including annunciation and shutdown scheme,

Calibration Test - All instruments, gauges, sensors, switches, relays, and similar equipment shall be calibrated and adjusted after installation, wherever practical. Where not practical, the calibration and adjusting shall be done just prior to
installation,

Operational Tests For Protection - Field tests for verification of correct operation of protective relays shall be conducted,
Dielectric and insulation resistance test, continuity test, starting current measurement of each motor,
Any other checks/tests to ensure that requirements of the specifications are being met.

1.5.2. Performance Testing

If nothing unusual has been observed in load run and load rejection tests, the test service period of 72 hours shall follow. During this test service period, the unit must operate continuously at rated condition without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the test service period.

During this test service period, all the system/installations must perform satisfactorily.

The Contractor shall be responsible for the equipment during test service and also for the way it is operated. However, Employer will operate the equipment under the Contractor's guidance during test service period.

1.5.2.1. Field Acceptance Tests

The taking-over testing of any part or section of the Permanent Works which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the "General Conditions of contract, and as per the test procedure agreed upon between Engineer and Contractor.

Immediately upon termination of any such testing of a part or section of the permanent Works a "Protocol of Acceptance" which shall be deemed to be the Test Certificate required by General Conditions of Contract shall be issued by the Engineer.

This document shall be signed by an authorised representative of the Employer, the Engineer and the Contractor and shall form an integral part of the later "Taking-Over Certificate".

This "Protocol of Acceptance" shall state:

i) The date of testing,
ii) The quantity and type of Works concerned,
iii) Statement of all minor defects and/or irregularities, which have to be corrected by the Contractor,
iv) Confirmation that the guaranteed data have been proven,
v) Confirmation that all contractual documents have been submitted,
vi) Confirmation that the Employer's personnel have been familiarised with the Works and that they will be able to operate and maintain the Works. If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Contractor's responsibility, this part of the acceptance shall be
stated in the "Protocol of Acceptance" and be postponed for a mutually agreed period.

10. GAS INSULATED SWITCHGEAR

10.1. Type Tests

The contractor is required to carry out all type tests as per relevant IEC / International Standards on one apparatus of each type of similar rating and shall submit the reports to the Employer. The type test may not be mandatory if similar equipment has been type tested and test certificate(s) for relevant tests are accepted by the Employer.

10.2. Shop Tests

The GIS shall be routine tested as per relevant IEC with latest amendments. Following shop tests shall be carried out at the manufacturers works :-

i) Test on Enclosures as per IEC: 60517
   Pressure Test,
   Gas leakage test.

ii) Test on Circuit Breaker as per IEC: 60056
   Test on Auxiliary and Control circuit:
       Wiring Check,
       HV Test,
       IR Measurement.

       Mechanical Operation Test:
       5 Open and 5 Close Operations at Minimum supply voltage and Minimum Pressure.
       5 Open and 5 Close Operations at Maximum supply voltage and Maximum Pressure.
       5 Open and 5 Close Operations at rated supply voltage Pressure.
       Measurement of operation time.

   Electrical test
   Power Frequency Voltage Dry Test on Main Circuit,
   Measurement of Contact Resistance of Main Circuit,
   Measurement of Resistance of Circuit Breaker Closing and Trip Coils,
   Partial Discharge Measurement,
   Measurement of Power Consumption of Motor Operated Mechanism at Rated Supply Voltage,
   Operational and Interlocks Check,
   Operational Check of Pressure Density Monitoring Switches.

iii) Tests on Disconnect Switches and Ground Switches as per IEC: 60129
   IR, HV and wiring Check on Auxiliary and Control Circuit,
   Mechanical Operation Test,
   Electrical Test:
   Power Frequency Voltage Tests of the Main Circuit and Partial Discharge
Measurement,
Measurement of the Resistance of Main Circuit,
Operation and Interlock Check,
IR Measurement,
• Measurement of Power Consumption of Motor.

iv) Test on Current Transformer as per IEC: 60044-1 and 60185
Verification of Terminal Marking,
Inter-Turn Over voltage Test,
Test for Accuracy,
Composite Error Test,
Power Frequency Withstand Tests on Primary Winding and Partial
Discharge Measurement,
Power Frequency Withstand Between Sections of Primary and Secondary
Winding and on Secondary Winding.

v) Test on Voltage Transformer as per IEC: 60186
Pressure and Gas Leakage Test,
Verification of Terminals Markings,
Power Frequency Withstand Tests on Primary Winding and Partial
Discharge Measurement (150% of rated max. phase voltage),
Power Frequency Withstand Tests Between Sections and on Secondary
Windings,
Induced Over-voltage Withstand Test,
Test for Accuracy,

vi) Test on Surge Arrestor as per IEC: 60099-4
Pressure Test on Enclosure,
Lightning Impulse Residual Voltage Test,
Measurement of Power Frequency Voltage,
Partial Discharge Measurement.

vii) Test on Local Control Cubicles.
Visual and Dimensional Check,
Checking of BOM and Layout,
Verification of Correct Wiring,
Dielectric Tests,
IR Measurement,
Functional Tests by Simulation.

The details of tests are given in Model Quality Assurance Plan of Gas Insulated Switchgear.

10.3. Field Tests

All field tests including tests during installation, pre-commissioning, commissioning,
field acceptance tests shall be conducted by the Contractor, in presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance test shall be submitted well in advance, at least six (6) month before start of relevant testing, for approval by the

Section:2 Page 25 of 26
Employer.

All field tests shall be carried out under the supervision of Manufacturer.

10.3.1. Tests during installation, pre commissioning and commissioning

At least the following tests shall be performed:

- Visual inspection, checks and verifications,
- Mechanical operation tests of circuit breakers, disconnector and earthing switches and high-speed earthing switches,
- Gas leakage test,
- Insulation resistance measurement,
- DC resistance measurement of the main circuit,
- Gas density monitor check,
- Inter lock test,
- Measurement of moisture content in gas before filling,
- Test of auxiliary devices,
- CT and PT testing,
- High voltage tests on the main circuit on complete assembly,
- Power frequency test of auxiliary and control circuit (2 kV r.m.s for 1 minute),
- Partial discharge measurement test,
- Testing of on line monitoring systems and verification and calibration of various sensors,
- Recording of leakage current in the surge counters,
- Recording and analysing of base line data of gas density, gas pressure, moisture, CF4 and air in gas (offline) in CB sections,
- Other tests not mentioned specifically but required by IEC/IEEE.

10.3.2. Performance testing

If nothing unusual has been observed after energization of GIS, the test service period of 72 hours shall follow. During this test service period, the GIS must operate continuously without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the test service period.

The Contractor shall be responsible for the equipment during test service and also for the way it is operated. However, Employer's personnel will operate the equipment under the Contractor's guidance during test service period.

10.3.3. Field acceptance tests

Gas tightness, gas density, pressure and moisture in gas shall be verified after 72 hours of test service period and results shall be compared with before energization value. The GIS shall be accepted if values are normal and no abnormalities have been observed and partial discharge is less than the guaranteed value.
SECTION - 3
GENERAL TECHNICAL REQUIREMENTS

3.0 GENERAL

This section stipulates the General Technical Requirements under the Contract and will form an integral part of the Technical Specification.

The provisions under this section are intended to supplement general requirements for the materials, equipments and services covered under other sections and are not exclusive. However in case of conflict between the requirements specified in this section and requirements specified under other sections, the requirements specified under respective sections shall hold good.

3.1 SITE INFORMATION

<table>
<thead>
<tr>
<th>Particular</th>
<th>NHPC LIMITED</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Customer/ Owner</td>
<td>Bharat Heavy Electricals Limited</td>
</tr>
<tr>
<td>b) Purchaser</td>
<td>Parbati Hydroelectric Project Stage-III(H.P.) India</td>
</tr>
<tr>
<td>c) Project Title</td>
<td>Located in Kullu District of Himachal Pradesh. Project Headquarter is proposed at Sainj which is about 258 kM from Chandigarh on Chandigarh-Manali National Highway NH-21.</td>
</tr>
<tr>
<td>d) Location</td>
<td>The nearest broad gauge railhead is at Kiratpur, which is 190 kM away. The nearest Airport is located at Bhuntar. The approximate distance of Sainj (Project Headquarter) from different important towns is as follows: From Bhuntar(Airport) 36 kM, From Delhi 508 kM, From Chandigarh 258 kM, From Kiratpur 190 kM, From Shimla 208 kM. Parbati H.E.Project, Stage-III is connected by 172 kMs long National Highway(NH-21) from nearest broad gauge railhead Kiratpur sahib upto Aut and thereafter by the existing 3/5 M wide state PWD road 21 kMs in length upto dam proposed at village Suind and other components of the project.</td>
</tr>
<tr>
<td>e) Transport Facilities</td>
<td>The maximum permitted size of bulkiest package for transportation upto project site is as under: Length - 6.0 M, Width - 4.5 M, Height (including trailer bed) - 5.5 M, Height above ground</td>
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SITE CONDITIONS

<table>
<thead>
<tr>
<th></th>
<th>Postal Address</th>
<th>To follow</th>
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<tbody>
<tr>
<td>a)</td>
<td>Mean Max. Ambient air temp.</td>
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</tr>
<tr>
<td>b)</td>
<td>Mean Min. ambient air temp.</td>
<td>-4°C</td>
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<tr>
<td>c)</td>
<td>Design Ambient Temperature</td>
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<tr>
<td>d)</td>
<td>Maximum Relative Humidity</td>
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<tr>
<td>e)</td>
<td>Minimum Relative Humidity</td>
<td>4.40%</td>
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<tr>
<td>f)</td>
<td>Maximum height above sea level</td>
<td>1000 M for GIS and 1087 for Potyard</td>
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<tr>
<td>g)</td>
<td>Pollution Severity</td>
<td>Heavily Polluted (Creepage 25 mm/kV)</td>
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<tr>
<td>h)</td>
<td>Basic horizontal Seismic Coefficient</td>
<td>Zone V</td>
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<td></td>
<td>Peak ground acceleration</td>
<td>0.36g for Maximum Credible Earthquake (MCE) and 0.18g for Design Basis Earthquake (DBE)</td>
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<tr>
<td>i)</td>
<td>Average number of thunderstrom days per annum</td>
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<td>j)</td>
<td>Average Soil resistivity</td>
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<td>k)</td>
<td>Average rainfall</td>
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<td>l)</td>
<td>Maximum wind speed</td>
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<tr>
<td>m)</td>
<td>Prevailing Wind Direction</td>
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</tbody>
</table>

3.2 GENERAL TECHNICAL REQUIREMENT

3.2.1 GENERAL

This part covers technical conditions which form integral part of the Contract. The following provisions shall supplement all the detailed technical specifications and the requirements brought out in the various sections of this specification.

3.2.2 CODES AND STANDARDS

All materials and equipment shall generally comply in all respect with the latest edition of relevant international electro-technical commission (IEC) or any other internationally accepted standard which ensure equal or better quality or relevant Indian standard (IS) mentioned against each equipment and this specification.

The equipment are also to comply with latest and revised Indian electricity act and electricity rules and any other electrical statutory and provisional rules and regulations. In the event of supply of equipment conforming to any international or internationally recognised standard which will ensure equal or better than those standards specified for each equipment in this specification, salient features of comparison shall be brought out and furnish along with bid in English language. However, in case of standard other than IS & IEC or CBIP, if requested by the Engineer the supplier shall supply at his own expense three copies of the adopted standard in English language and one in original language. Brief detail of relevant standards has been given in section 2 for reference.
3.2.3 **TYPE TESTS**

All equipment/systems to be supplied shall conform to type tests as per relevant standards and proven type.

The Bidder / Contractor shall furnish the reports of all the type tests carried out in within last five years as listed in relevant clauses in respective electrical specification and relevant standards for all components / equipment / systems. These reports should be for the tests conducted on identical/similar components/equipment/systems to those offered/proposed to be supplied under this contract.

In case Contractor is not able to submit report of type test(s) conducted in last five years, or in case type test report(s) are not found to be meeting the specification/relevant standard requirements, then all such tests shall be conducted under this contract by the Bidder free of cost to Employer, and reports shall be submitted for approval. No charges shall be paid under this contract.

Irrespective of the Contractor furnishing valid test report as indicated above, Employer will get some type test conducted under this contract specified as Mandatory Tests in other sections of this specification. The charges for each of these type tests shall be given in the offer.

All acceptance and routine tests as per relevant standards and specification shall be deemed to be included in the bid price.

3.2.4 **DOCUMENTATION TO BE FURNISHED BY THE BIDDER**

The number of copies/ prints/ reproducibles, manuals, computer CD-ROM’s/ manuals to be furnished for various types of document is given in ANNEXURE-A.

The documentation shall include but not limited to the following as applicable, in addition to the documents if specified in Sections 1 and 2.

3.2.4.1 **DETAILED ENGINEERING**

1. Layout, General Arrangements, Elevations and Cross Section drawings of all equipment and facilities of the plant.
2. Flow diagram. Process & Instrumentation Diagrams
3. Technical data Sheets.
4. Detail design calculations for components, system, piping etc. wherever applicable including sizing calculations.
5. Characteristic Curves/ Performance Correction Curves.
6. Power Supply Single Line Diagram, Block logic, Control Schematics, Electrical Schematics etc.
7. Protection System Diagrams and Relay Settings.
8. Cable Schedules and interconnection diagrams
9. Cable Routing Plan
10. Instrumentation schedule, measuring point list, functional write ups, installation drawings for field mounted instruments, wiring and tubing diagrams of the panels and enclosures etc. Drawings for open and closed loop controls (both hardware and software). Motor list and valve schedule including type of actuator etc.

11. Alarm and annunciation/Sequence of Event (SOE) list and trip set points.

12. Sequence and protection interlock schemes.

13. Type test reports (of tests conducted within 5 years).

14. Control system configuration diagrams and card circuit diagrams and maintenance details.

15. Detailed software manuals and software listing.

16. Detailed flow chart for digital control system.

17. Mimic diagram Layout.

18. Civil drawings consisting of foundation and structural work, civil calculation sheets including structural analysis and design.

19. Model study reports wherever applicable.

20. Documentation in respect of Quality Assurance System as listed out elsewhere in this specification.

3.2.4.2 INSTRUCTION MANUALS

The instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. The instruction manual shall comprise of the following-

ERECTION MANUALS

The minimum contents of Erection Manual shall be as follows -

1. Erection Strategy
2. Sequence of Erection
3. Erection Instructions
5. List of tool, tackles, heavy equipment like cranes, dozers etc.
6. Bill of Material
7. Procedure for erection
8. Procedure for initial checking after erection.
9. Procedure for testing and acceptance norms.
10. Procedure / Check List for pre-commissioning activities.
11. Procedure / Check List for commissioning of the system.
12. Safety precautions to be followed in electrical supply distribution during erection.
OPERATION AND MAINTENANCE MANUALS

The operating and maintenance instructions together with drawings (other than shop drawings) of the equipment, as completed shall be in sufficient detail to enable the Owner to operate, maintain, dismantle, reassemble and adjust all parts of the equipment. They shall give step by step procedure for all operations likely to be carried out during the life of the plant/equipment including operation, maintenance, dismantling and repair. Each manual shall also include a complete set of drawings together with performance / rating curves of the equipment and test certificates wherever applicable.

If after the commissioning and initial operation of the plant, the manuals require any modification/ additions/ changes the same shall be incorporated and the updated instruction manuals shall be submitted to the Owners for records.

A separate section of the manual shall be for each size / type of the equipment and shall contain a detailed description of construction and operation, together with all relevant pamphlets and drawings.

The manuals shall include the following -

1. List of spare parts along with their drawings and catalogues and procedure for ordering spares.
2. Lubrication Schedules including charts showing lubrication checking, testing and replacement procedure to be carried out daily, weekly, monthly and at longer interval to ensure trouble free operation.
3. Wherever applicable, fault location charts shall be included to facilitate finding the cause of the mal-operation or break down.

Detailed specifications for the consumables including lubricant oils, greases, chemicals etc. shall be required for the complete plant.

3.2.4.3 DRAWINGS

1. All drawings shall be made in Autocad 2006 or latest Version. All drawings shall be plotted in ink. All dimensions and data shall be in SI metric units. All items of the equipment should be clearly identified by proper part numbers in the contract drawings. Such parts which are to be dispatched to site from works in dispatchable units and are re-assembled at site, should be marked by proper identification marks at works and indicated in the drawings and quantified. All the items of the shipping list should be identified in the drawing. The language for all inscriptions shall be English.

2. All drawings submitted by the contractor including those submitted at the time of bid shall be in sufficient detail indicating the type, size, arrangement, weight of each component for packing and shipment, external connection, fixing arrangement required, the dimensions required for installation and interconnections with other equipment and materials clearances and spaces required between various portions of equipment.
3. Each drawing shall bear a title block at the right hand bottom corner with clear mention of the name of the Owner, the System designation, specifications title, specifications number the name of the Projects drawing number and the revisions. If standard catalogue pages are submitted the applicable items shall be indicated there. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be metric units. **The title block for the drawings and documents and the numbering system shall be furnished to the successful bidder, which has to be strictly followed.**

4. The furnishing of detailed engineering data and drawings by the Contractor shall be in accordance with the time schedule for the Project. The review of these documents /data/ drawings by the Owner will cover only general conformance of the data/ drawings/documents to the specifications and contract, interfaces with the equipment provided by others and external connections of the dimensions which might affect plant layout. The review by the Owner should not be construed to be thorough review of all dimensions, quantities and details of the equipment, material, any devices or items indicated or the accuracy of the information submitted. The review and/or approval by the Owner shall not relieve the Contractor of any of his responsibilities and liabilities under the contract.

5. After the approval of the drawings, further work by the Contractor shall be in strict accordance with these approved drawings and no deviation shall be permitted without the written approval of the Owner.

6. All manufacturing, fabrication and execution of the work in connection with the equipment/system, prior to the approval of the drawings shall be at Contractor’s risk. The Contractor is not expected to make any change in the design of the equipment/system, once they are approved by the Owner. However, if some changes are necessitated in the design of the equipment/ system at a later date, the contractor may do so, but such change shall be promptly be brought to the notice of Owner indicating the reasons for the change and get the revised drawing approved again.

7. Drawing shall include all installation and detailed piping drawings. All piping of 100 mm and larger diameter shall be routed in detail and smaller pipe shall be shown schematically or by isometric drawing.

8. As Built Drawings - After final acceptance of individual equipment/ system by the Owner the contractor will update all original drawings and documents for the equipment /system to “As Built” conditions.

9. Drawings must be checked by the contractor prior to submission to the Owner. In case drawings are found to be submitted without proper checking by the contractor, the same shall not be reviewed and returned to the contractor for re-submission.

10. The Bidder shall submit the specified number of prints of drawings /data/ document **along with soft copy** for Owner’s review and approval. The Owner shall review the drawings and return one (1) copy to the contractor authorizing either to proceed with manufacture or fabrication or marked to show changes desired. When changes are required, drawings shall be resubmitted promptly, with revisions clearly marked for the final review. Any delays arising out of the failure of the contractor to submit /rectify in time shall not be accepted as a reason for delay in the contract schedule.
11. The Bidder shall submit to the employer for approval within the time given in the contract or in the Program such drawing, samples, models or information as may be called for therein, and in the number therein required. During the progress of the works, such drawings of the general arrangements and details of the works as specified in the Contract. The Employer shall signify his approval or disapproval within 30 days. Approve drawings samples and models shall be signed or otherwise identified by the employer. The Contractor shall supply additional copies of drawings in the form and number stated in the contract.

12. The following Schedule and procedure of drawing approval to be followed:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Steps</th>
<th>Action/Approved status</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>First Submission by Bidder</td>
<td>COMMENTED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( as per approved program)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1- “Approved”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2- “Approved- Except As Noted”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3- “not Approved”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4- “For Information Only”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21 Days</td>
</tr>
<tr>
<td>2.</td>
<td>Second submission by Bidder</td>
<td>For ‘1’ –Approved drawings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>within 10 days</td>
<td>Resubmitted with incorporation of comments/modifications with revision no.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For ‘3’ –Returned with corrections/changes with Revision no.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 Days</td>
</tr>
<tr>
<td>3.</td>
<td>third submission by Bidder</td>
<td>For ‘1’ Approved</td>
<td></td>
</tr>
<tr>
<td></td>
<td>within 07 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 Days</td>
</tr>
</tbody>
</table>

Note-

Resubmission of ‘2’ category and ‘3’ category shall be within 7 days 10 days respectively to be recorded from the date of return of such drawings.

Approval of any drawing by the Employer shall not relieve the Bidder of his responsibility for the accuracy thereof or modification required during actual execution or for any deviation in scheme from Technical specification with accepted deviation if there by any.

3.2.5 QUALITY ASSURANCE PROGRAMME

To ensure that the equipment and services under the Scope of Contract, whether manufactured or performed within the Contractor’s works or at his Sub-Contractor’s premises or at the Owners’ site or at the other place of work are in accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points, as necessary. Such programme shall be outlined by the Contractor and finally accepted by the Owner/ Authorized representative after discussions before the award of Contract. The QA programme shall be generally in line with ISO-9001/IS-14001. A quality programme shall be generally cover the following:
1. His Organization structure for the management and implementation of the proposed quality assurance programme.
2. Quality System Manual
3. Design Control System
4. Documentation Control System
5. Qualification data for Bidder’s key personnel
6. The procedure for purchase of materials, parts, components, and selection of Subcontractor’s services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchased etc.
7. System for shop manufacturing and site erection control including process controls and fabrication and assembly controls.
8. Control of non-conforming items and system for corrective actions.
9. Inspection and test procedure both for manufacture and field activities.
10. Control of Calibration and testing of measuring, testing equipment.
12. System for indication and appraisal of inspection status.
13. System for authorizing release of manufactured product to the Owner.
14. System for handling, stores and delivery
15. System for maintenance of records.
16. Furnishing of quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of the equipment/ component as per format enclosed in SCHEDULE-4 & 5 of section -5.

3.2.6 QUALITY ASSURANCE DOCUMENTS

The Contractor shall submit the following Quality Assurance documents within three weeks after dispatch of the equipment.

1. Material mill test reports on components as specified by the specification and approved Quality Plans.
2. The inspection plan with verification, inspection plan check points verification sketches, if used and methods used to verify that the inspection and testing points in the inspection plan were performed satisfactorily.
3. Sketches and drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
4. Non-destructive examination results reports including radiography interpretation reports.
5. Factory tests results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
6. Inspection reports duly signed by QA personnel of the Owner and Contractor for the agreed customer hold points
During the course of inspection, the following will also be recorded.

(A) When some important repair work is involved to make the job acceptable and
(B) The repair work remains part of the accepted product quality

7. All the accepted deviations shall be included with complete technical details.

3.2.7 ENGINEER’S SUPERVISION

To eliminate delays and avoid disputes and litigation all matters and questions shall be referred to the Owner and Contractor shall proceed to comply with the Owner’s decision.

The work shall be performed under the supervision of the Owner. The scope of the duties of the Owner pursuant to the Contract will include but not be limited to the following.

1. Interpretation of all the terms and conditions of these documents and specifications.
2. Review and interpretation of all the Contractor’s drawings, engineering data etc.
3. Witness or his authorized representative to witness tests and trials either at the manufacturer’s work or at site, or at any place where work is performed under the contract.
4. Inspect, accept or reject any equipment, material and work under the contract.
5. Issue certificate of acceptance and/or progressive payment and final payment certificates
6. Review and suggest modifications and improvement in completion schedules from time to time and
7. Supervise the quality assurance programme implementation at all stages of the work.

3.2.8 INSPECTION, TESTING AND INSPECTION CERTIFICATES

1. The word ‘Inspector’ shall mean the Owner and/or his authorized representative and/or an outside inspection agency acting on behalf of the Owner to inspect and examine the materials and workmanship or the works during its manufacture or erection.
2. The Owner, his duly authorized representative and or an outside inspection agency acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the contractor shall obtain for the Owner and for his duly authorized representative permission to inspect as if the works were manufactured or assembled on the contractors own premises or works.
3. The contractor shall give the Owner/inspector fifteen (21) days written notice of any material being ready for testing. Such tests shall be to the contractor’s account except for the expenses of the inspector’s. The Owner/inspector, unless the
witnessing of the tests is virtually waived, will attend such tests within fifteen (15)
days of the date on which the equipment is noticed as being ready for
tests/inspection and he shall forthwith forward to the inspector duly certified copies
of test reports.

4. The Owner or inspector shall within fifteen (15) days from the date of inspection
as defined herein give notice in writing to the contractor, or any objection to any
drawings and all or any equipment and workmanship which is in his opinion not in
accordance with the contract. The contractor shall give due consideration to such
objections and shall either make modifications that may be necessary to meet the
said objections or shall confirm in writing to the Owner/inspector giving reasons
therein, that no modifications are necessary to comply with the contract.

5. When the factory tests have been completed at the contractor’s or subcontractors
works the Owner/inspector shall issue a certificate to this effect fifteen (15) days
after completion of tests but if the tests are not witnessed by the Owner/inspectors
the certificates shall be issued within fifteen (15) days of the receipt of the
contractor’s test certificate by the Owner/inspector. Failure of Owner /inspector to
issue such a certificate shall not prevent the contractor from proceedings with the
works. The completion of these tests, or the issue of the certificates shall not bind
the Owner to accept the equipment should it, on further tests after erection be
found not to comply with the contract.

6. In all cases where the contract provides for tests whether at the premises or works
of the contractor or any sub contractor, the contractor except where otherwise
specified shall provide free of charges such items as labour, materials, electricity,
fuel, water, stores, apparatus and instruments as may be reasonably demanded by
the Owner/inspector or his authorized representatives to carry out effectively such
tests on the equipment in accordance with the contractor and shall give facilities to
the Owner/inspector or to his authorized representative to accomplish testing.

7. The inspection by Owner and issue of inspection certificate there on shall in no
way limit the liabilities and responsibilities of the contractor in respect of the
agreed quality assurance programme forming a part of the contract.

8. To facilitate advance planning of inspection in a addition to giving inspection
notice as per clause 3 of 3.2.8, the contractor shall furnish quarterly inspection
programme indicating schedule dates of inspection at customer hold point and final
inspection stages. Updated quarterly inspection plans will be made for each three
consecutive months and shall be furnished before beginning of each calendar
month.

9. All inspection, measuring and test equipment used by contractor shall be calibrated
periodically depending on its use and criticality of the test/measurement to be
done. The contractor shall maintain all the relevant records of periodic calibration
and instrument identification and shall produce the same for inspection by Owner.
Wherever asked specifically the contractor shall recalibrate the measuring test
equipment in the presence of Owner engineer.

3.2.9 GENERAL REQUIREMENTS QUALITY ASSURANCE

1. All materials, components and equipment covered under this specification shall be
procured, manufactured, erected, commissioned and tested at all stages, as per a
comprehensive Quality Assurance Programme. An indicative programme of
inspection/tests to be carried out by the contractor for some of the major items is given in the respective technical specification. This is however, not intended to form a comprehensive programme as it is the contractor responsibility to draw up and implement such programme duly approved by the Owner. The detailed quality plans for manufacturing and field activities should be drawn by the Bidder, separately in the format attached at Section 5 and will be submitted to Owner for approval. Schedule of finalization of such quality plans will be finalized before award.

2. Manufacturing quality plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by contractor’s quality control organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc. during all stages of material procurement, manufacture, assembly and final testing performance testing.

3. Field quality plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the contractors site quality control organization, during various stages of site activities from receipt of materials/equipment at site. Format for field Quality Plan is given in Section 5.

4. However if Owners/ Purchasers Standard Manufacturing Quality Plan OR the Standard Check List is furnished at Section 5 of this specification or at contract stage separately, the Bidder shall give his concurrence to the same. In case Owners Standard Manufacturing Quality Plan OR the Standard Check List is furnished then Contractor’s Manufacturing Quality Plan is not required.

5. The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in quality plans along-with quality plans. These quality plans and reference documents/standards etc. will be subject to Owner’s approval without which manufacture shall not proceed. These approved documents shall form a part of the contract. In these approved quality plans Owner shall identify Customer Hold Points (CHP), i.e test/checks which shall be carried out in presence of the Owner’s engineer or his authorized representative and beyond which the work will not proceed without consent of Owner/authorized representative in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Owner along with technical justification for approval and disposition.

6. The contractor shall submit to the Owner field welding schedule for field welding activities if applicable. The field welding schedules shall be submitted to the Owner along with all supporting procedures, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site. The format for the welding schedules shall be furnished at contract stage, if applicable.

7. No material shall be dispatched from the manufacturer’s work before the same is accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspection by Owner’s engineer/ authorized
representative, and duly authorized for dispatch issuance of MDCC.

8. All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.

9. WELDING AND BRAZING

All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section-IX/BS-4870 or other international equivalent standard acceptable to the Owner.

All welding/brazing procedures shall be submitted to the Owner or its authorized representative for approval prior to carrying out the welding/brazing.

All brazers, welders and welding operators employed on any part of the contract either in contractors/his subcontractors works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.

Test results of qualification tests and specimen testing shall be furnished to the Owner for approval. However, where required by the Owner, tests shall be conducted in presence of Owner/authorized representative.

For all pressure parts and high pressure piping welding the latest applicable requirements of the IBR(Indian Boiler regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with.

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

No welding shall be carried out on cast iron components for repair.

Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.

All non-destructive examination shall be performed in accordance with written procedures as per International Standard. The NDT operator shall be qualified as per SNT-TC-IA(of the American Society of Non-destructive Examination). NDT shall be recorded in report which includes details of methods and equipment used, result evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.

10. SUB-VENDORS

All the sub-vendors proposed by the contractor for procurement of major bought out item including castings, forging, semi-finished and finished components/equipment, list of which shall be drawn up by the contractor and finalized with the Owner shall be subject to Owners approval. The contractors
proposal shall include vendors facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation and shall be submitted to the Owner for approval prior to any procurement. Such vendor approval shall not relieve the contractor from any obligation duty or responsibility under the contract.

For components/equipment procured by the contractors for the purpose of the contract, after obtaining the written approval of the Owner, the contractors, purchaser, specification, and engineering shall call for quality plans to be submitted by the suppliers along with their proposals. The quality plans called for from the vendors shall set out, during the various stages of manufacture and installation, the quality practice and procedures followed by the vendor’s quality control organization, the relevant reference documents/standards used, acceptance level, inspection of documentation raised etc.

Such quality plans of the successful vendors shall be finalized with the Owner and such approved quality plans shall form a part of the purchase order/contract between the contractor and vendor. Within three weeks of the release of the purchase order/contracts for such bought out items/components, a copy of the same without price details but together with the quality plans and delivery conditions shall be furnished to the Owner by the contractor.

11. Owner reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the contractors or their sub-vendors quality management and control activities. The contractor shall provide all necessary assistance to enable the Owner to carry out such audit and surveillance.

The contractor shall carry out a programme during manufacture in his works and that of his sub-contractors and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identify and acceptability of all materials parts and equipment. He shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.

12. Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the contractor in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings etc.

For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.

13. Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner/authorized representative.

3.2.10 FIELD INSPECTION & TESTS

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 OWNER ACCEPTANCE TESTS -

1. On completion of erection of the equipment and before start-up, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Owner and the contractor for correctness and completeness of installation and acceptability for start-up, leading to initial pre-commissioning tests at site. The list of pre-commissioning tests to be performed shall be as mutually agreed and included in the contractor’s quality assurance programme.

2. The contractor’s commissioning/start-up engineers, specially identified as far as possible shall be responsible for carrying out all the pre-commissioning tests at site. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over the complete equipment shall be placed on initial operation during which period the complete equipment shall be operated integral with sub-systems and supporting equipment as a complete plant.

3. All piping system shall be flushed steam blown as required and cleanliness demonstrated using acceptable industry standards procedures to accomplish this work shall be submitted for approval to the Owner six months prior to the respective implementations. The Owner will approve final verification of cleanliness.

4. The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.

5. The check outs during the pre-commissioning period should be programmed to follow the construction completion schedule. Each equipment/system, as it is completed in construction and turned over to Owners commissioning (start-up) Engineer(s) should be checked out and cleaned. The checking and inspection of individual system should then follow a prescribed schedule to be agreed by Owner.

6. The contractor during trial operation and performance testing conduct vibration testing to determine the base line of performance of all plant rotating equipment. These tests shall be conducted when the equipment is running at the base load, peak load as well as lowest sustained operating condition as far as practicable.

3.2.11 MATERIAL AND WORKMANSHIP

All material used for the construction of equipment shall be new and shall be in accordance with the requirement of this specification. Material utilized for various components shall be those which have established themselves for use in such applications.

All castings shall be true to pattern, free from defects and of uniform quality and condition. The surfaces of castings, which do not undergo machining, shall be free from foundry irregularities. The casting shall be tested for NDT, chemical, mechanical and metallographic tests. This shall be specified in quality plan for the specific equipment. All components machined or fabricated from plate, sheet or bar stock shall meet the material requirements of ASTM. Structural steel rolled shapes, bars, etc. shall comply with the latest ASTM.

All or a representative number of such components shall be subjected to one or more of the tests: visual, dye penetration, magnetic particle (transverse and longitudinal), ultrasonic or radiograph. These tests shall be in accordance with the ASTM. The
acceptance shall be as per ASTM Specifications.

All joints and fastening shall be so designed, constructed and registered that the component part may be accurately positioned and restrained to fulfil their required function. The heads of all bolts shall register flush on the surfaces, which they fasten.

All the information concerning materials or components to be used in manufacture, machinery, equipment, materials and components supplied, installed or used shall be submitted for approval. Without such approval the Contractor shall run risk of subsequent rejection. The cost as well as time delay associated with such rejection shall be borne by the Contractor.

All components exposed to rain shall be designed with sloped upper surface to avoid water pools.

3.2.12 AUXILIARY SUPPLY

The sub-station auxiliary supply is normally met through a system indicated under section-5 having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform to the parameters as indicated in the following.

<table>
<thead>
<tr>
<th>Normal Voltage</th>
<th>Variation in Voltage</th>
<th>Frequency in HZ</th>
<th>Phases</th>
<th>Neutral connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>415V</td>
<td>+/- 10%</td>
<td>50 +/- 5%</td>
<td>3/4-Wire</td>
<td>Solidly</td>
</tr>
<tr>
<td>240V</td>
<td>+/- 10%</td>
<td>50 +/- 5%</td>
<td>1/2-wire</td>
<td>Earthed.</td>
</tr>
<tr>
<td>220V</td>
<td>+/- 10%</td>
<td>DC</td>
<td>2-wire</td>
<td>Isolated</td>
</tr>
<tr>
<td>50 V</td>
<td>+/- 10%</td>
<td>DC</td>
<td>2-wire</td>
<td>Isolated</td>
</tr>
</tbody>
</table>

Combined variation of voltage and frequency shall be limited to +/- 10%.

3.2.13 RATING PLATES, NAME PLATES AND LABELS

1. General

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder:

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Engineer for approval.

Where applicable, designations in the selected local language shall appear above or to the right of the designation in the Contract language. The translations into and writings in the local language shall be submitted for approval.

2. Equipment Labels and Instruction Plates

Labels written in the contract language shall be provided for all instruments, relays, control switches, push buttons, indication lights, breakers etc. In case of instruments, instrument switches and control switches, where the function is indicated on the
device, no label is required. The label shall be fixed close to the device in such a way that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The wording shall conform to the wording used in engineering documents.

Each separate construction unit (cubicle, panel, desk, box, etc.) shall be identified by its Works identification number. Cubicles and similar units shall also bear this identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. Overall designation of each unit shall be given in the Contract language and – if required – also in a selected local language. These labels shall be made of anodised aluminium with black engraved inscription, arranged at the top section of the units. Manufacturer’s trade label shall – if desired – appear in the bottom section of the units.

All works inside cubicles, panels, boxes, etc. shall be properly labelled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagram, Works list, etc.)

Instruction plates in the Contract and selected local language, the sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboards.

3. Warning Labels

Warning labels shall be made of synthetic resin with letters engraved in the contract and selected local language, where required in particular cases.

For indoor circuit breakers, starters, etc. transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

4. Labels for conduits, etc.

The material shall be non-corrosive and the description be done with 4 mm high letters/figures.

5. Labels for Cables

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Engineer, non-corrosive labels detailing identification number of the cable, voltage, and conductor size. The cable identification number shall comply with those of the cable list.

All cables in cable pits and at the entry to buildings shall be labelled utilising the aforementioned type of label.

6. Rating Plates

Works (hoists, machines, transformers, etc.) rating plates and other technical data/informative plates shall either be of the enamelled type or be of stainless steel suitably protected after engraving with a transparent paint resistant to aggressive atmosphere and solar radiation.
7. Single Line Diagram

Each Switchgear room shall be furnished with a copy of the final as built single line diagram detailing all electrical data and denominations, separate for each individual switchgear/distribution board/MCC, placed under glass and frame/wall mounted at an approved location.

8. Key System for Electric Boards

Key interlocked switches shall be provided with Yale or other approved locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of the positions.

The locks or padlocks shall be co-ordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles, etc.) shall be provided for storing the keys of that board. All keys shall have six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key-hanging hook inside cabinet.

The cabinet door keys shall be similar and shall be six(6) in number.

3.2.14 GROUND TERMINAL

Each equipment shall be provided with two grounding pads, each with two holes for M12 bolts and spring washers suitable for connection to 75mm x 12mm galvanized steel flat. The two pads shall be provided, one each at the middle of the two opposite sides of the bottom frame of the equipment.

3.2.15 BOLTS, NUTS AND WASHERS

Bolts, nuts and plain washers of size M12 and above shall be hot-dip galvanized, while sizes below M12 shall be electro-galvanized or stainless steel. Bolts and nuts shall be hexagonal or socket headed. All spring washers shall be electro-galvanized mild steel suitable for at least service condition. The shall supply the net quantities plus 5 percent of all permanent bolts, screws and other similar items and materials required for installation at site.

In general, screw threads shall be standard ISO metric threads. The use of other thread form will be used only after prior approval. The Contractor shall furnish locking devices for threaded fasteners, which will lock them in such a manner so as to prevent them from coming loose in transport and in service.

3.2.16 NOISE LEVEL

The noise level caused by the installed Works shall not exceed the following values if not otherwise stated in the particular technical specification:

- Machine hall, workshop, etc. max. 85 dB (A) at any place 1 M distant from operating equipment.

- Offices, control rooms, first aid max. 55 dB (A) rooms, canteens, etc.
- Residential areas, daytime max. 50 dB (A) night time max. 35 dB(A)

The noise level definition and measurement shall be in accordance with ISO and IEC. The values stated shall be adhered to taking a normal civil construction into account.

“Not withstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable.

3.2.17 CONTROL CABINETS/ BOXES/ PANELS

Cubicles and control panel enclosures shall be of cold rolled sheet steel with minimum thickness for load bearing members as 2.5mm and non load bearing as 2 mm, of rigid, self-supporting construction and supplied with channel bases made to ensure no bulging takes place.

Cubicles shall be fitted with close fitting, gasketted, hinged, lift-off doors capable of being opened through 180 deg. The doors shall be provided with integral lock and master key.

Cubicles and panels shall be vermin proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances shall the floor/roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved or directed by the Engineer.

The cubicles and panels shall be adequately ventilated, if required, by vents or louvers, and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion-resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel.

Where cubicles are split between panels for shipping, terminal blocks shall be provided on each side of the split with all necessary cable extensions across the splits. These cable extensions shall be confined within the panels with suitable internal cable ducts.

Unless stated otherwise, all cubicles and panels shall be provided with a ground bus with 40mm copper bar extending through out the length. Each end of this bus shall be drilled and provided with lugs for connecting ground cables ranging from 70 to 120mm$^2$.

The standard phase arrangement when facing the front of the motor control centres and switchboard shall be RYB from left to right, from top to bottom and front to back. All instruments, devices, buses and other equipments involving 3 phase circuits shall be arranged and connected in accordance with the standard phase arrangement, where possible. Electrical clearances shall conform to applicable standards and shall not require cutting away of adjacent framework.

All instruments, control knobs and indicating lamps shall be flush mounted on the panels. Relays and other devices sensitive to vibration shall not be installed on doors or hinged panels, and no equipment shall be installed on rear access doors.

The instrument and control wiring, including all electrical interlocks and all interconnecting wiring between sections, shall be completely installed and connected to terminal blocks by the manufacturer.
The arrangement of control and protection devices on the panels and the exterior finish of the panels shall be subject to the approval of the Engineer. The interior of all cubicles and panels shall have a mat white finish unless specified otherwise.

Switched interior light and socket outlets shall be provided for all cubicles and control panels.

All cubicles and control panels shall be provided with lamacoid nameplates, identifying the purpose of the panel and all of its components.

Alarm contacts

Where applicable, all alarm contacts shall be of galvanically isolated type and provide inputs to the following devices.

- Local annunciator
- Station annunciator
- Supervisory control and sequence of events / fault recorder system.

All alarm contacts shall be changeover type. Where required, relays shall be provided as contact multiplier.

All types of panels shall generally conform to IS5039, IS8623 and IEC 439 as applicable.

Suitable 240 V, single phase, 50 Hz heaters with thermostats controlled by switch and fuse shall be provided to maintain inside temperature 10 deg. Above the ambient. The heaters shall be suitably designed to prevent any contact between the heater wire and air. The surface temperature of the heaters shall be restricted to a value which will not shorten the life of the heater sheaths or that of insulated wire or other component in the compartments.

The size of the enclosure and the layout of equipment inside shall provide generous clearances. Each cabinet/box/Kiosk/panel shall be provided with 15 A 240 V AC. 2 pole, 3 pin, industrial grade receptacle with switch. For incoming supply MCB of suitable rating shall be provided. Illumination of each compartment shall be with door operated incandescent lamp. All control switches shall be rotary switch type.

Each box shall be provided with two earthing pads to receive GS flat. The connection shall be bolted type with two bolts per pad. The hinged door shall be connected to body using flexible wire.

In order to ensure adequate ventilation, compartments shall have ventilation openings provided with fine wire mesh of brass or galvanized steel to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds.

The labels etc. on these panels shall be as per clause 3.2.13 above.

3.2.18 Electric Motors

1. General
All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply - as far as applicable - to IEC standard motor dimensions.

The general construction shall be stiff and rigid; no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eyebolts as suitable.

AC motors shall have squirrel cage type rotors.

Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

Motors up to 100 kW
- Service voltage: 3-phase a.c. 415/240 V, 50 HZ
- Mode of starting: direct-on-line up to 50 kW, above 50 kW with suitable starters

Motors up to 0.75 kW
- Service voltage: single-phase a.c. 240 V, 50 HZ
- Mode of starting: condenser

Motors intended to work on the d.c. System
- Service voltage: 220 V D.C.
- Mode of starting: resistor

2. Rating

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

<table>
<thead>
<tr>
<th>Power Demand of Driven Machine</th>
<th>Service Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 5 kW</td>
<td>1.2</td>
</tr>
<tr>
<td>More than 5 kW</td>
<td>1.1</td>
</tr>
</tbody>
</table>

A.C. motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient overvoltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pullout torque for continuously loaded motors shall be at least 160% of the rated torque and for intermittently loaded motors 200% of the rated torque.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 90% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-load and
3. Starting

A.C. motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite busbar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary busbars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed the following values:

- 5 times of rated current for L.V. motors rated 100 kW or above
- 2 times of rated current for D.C. motors (by means of starting resistors)

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each M.V. motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each L.V. motor shall be capable of withstanding three successive starts under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Contractor shall state the frequency of starts permitted in compliance with the motor design.

4. Windings and Insulation Class

The insulation of all motors shall be of class F but maintain in operation the temperature limits of class B materials. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapors and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

5. Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable termination points shall be of class IP55.

They shall have a closed internal cooling air circuit recooled by an external cooling air circuit drawn from the opposite side of the driving end.
Where motors are installed outdoors, a weatherproof design shall be chosen. L.V. motors of IEC size 132 and above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during standstill periods. Such A.C. heater shall be suitably fixed inside the motor casing; the leads shall be led to a separate L.V. terminal box.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85°C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

6. Bearings

As far as possible, the motors shall have sealed ball or roller bearings lubricated for live. All other motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun.

Vertical motors shall have approved thrust bearings.

Where sleeve bearings are being used, they shall be of the self or forced lubricating type. If forced lubrication is required, it shall be arranged common to both the motor and the driven machine and provisions shall be made to ensure lubrication during start-up and shutdown operations without the necessity to start an auxiliary lube oil pump. Self-lubricated bearings shall be equipped with an easily accessible oil reservoir with overflow pipe and oil collecting vessel.

All bearings shall be easily controllable during operation or standstill without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

Service hour meters shall be installed in the motor control centres if maintenance work such as regreasing, oil change etc. depend on the operation time of the motors.

7. Shafts and Couplings

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motorside-coupling, which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

8. Brushgear and Commutators

Brushgear for D.C. motors shall be designed to ensure constant brush pressure. Carbon brushes shall be provided which stand at least 6 months of operation without replacement. Each brush shall be independently adjustable but should not require adjustment throughout its life. A design of brushgear which permits the brush holder to touch the commutator as the brushes wear or which passes current through the pressure
fingers will not be accepted.

A sufficient number of brushes, not less than two per pole, shall be fitted to ensure that vibrations do not affect the commutation.

The minimum safe wearing margin of commutators shall not be less than 20 (twenty) per cent of the total thickness of the commutator bars and the minimum safe diameter shall be clearly marked on it.

9. Terminal Boxes and Earthing

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment/panel shall be earthed by at least two separate earthing strips.

The cable termination philosophy to be adopted shall be such that extensive grouping of signals by large scale use of field-mounted group. JB’S at strategic locations (where large concentration of signals are available, e.g switchgear) is done. Termination / Junction boxes shall have either maxi- terminal or cage clamp type terminals

10. Noise-Level and Vibrations

Under all operating conditions, the noise level of motors shall not exceed 85 dB (A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

Vibration displacements or velocity shall be measured in accordance with relevant IS for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.
11. Tests

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Contractor.

Workshop Tests:
- Measurement of winding resistances
- No-load and short-circuit measurements
- Measurement of starting current and torque
- Efficiency measurement (type test)
- Heat test run
- Dielectric test
- Measurement of insulating resistance
- Overspeed test

Site Tests:
- Measurement of insulation resistance
- Measurement of motor vibrations
- Measurement of starting time.

3.2.19 PROTECTION CLASS OF CABINETS/PANELS, ENCLOSURES, MOTORS ETC.

All panels desk cabinets and enclosures furnished shall at least comply with the requirements of protection classes as indicated below unless otherwise specified in Section 1 or 2:

1. Indoor air conditioned (AC) areas IP22
2. Indoor Non AC areas
   b. Ventilated enclosures IP42
   c. Non Ventilated enclosures IP54
3. Outdoor IP55

3.2.20 SURGE PROTECTION FOR SOLID STATE EQUIPMENT

All solid state systems/equipment shall be able to withstand the electrical noise and surge as encountered in actual service conditions and inherent in a power plant and shall meet the requirements of surge protections as defined in ANSI C37.90.1-1989 or its suitable equivalent class of IEC 254-4. Details of the features incorporated and relevant tests carried out. The test certificates etc. shall be submitted by the Contractor.

3.2.21 INSTRUMENT AIR SYSTEM

The instrument air supply system shall be supplied by the Contractor for various pneumatic control and instrumentation devices like pneumatic actuators, power cylinders, E/P converters, piping/tubing etc.

Each pneumatic instrument shall have an individual air shut-off valve. The pressure regulating valve shall be equipped with an internal filter, a 50mm pressure gauge and a built-in filter housing blow down valve.
Tapping points shall include probes, wherever applicable, for analytical measurements and samplings.

For direct temperature measurement of all working media, one stub with internal threading of approved pattern shall be provided along with suitable plug and washer. The contractor will be intimated about thread standard to be adopted.

The following shall be provided on equipment by the Bidder. The standard which is to be adopted, will be intimated to the Contractor.

1. Temperature test pockets with stub and thermo-well.
2. Pressure test pockets.

3.2.22 LUBRICATION

Equipment shall be lubricated by the systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

3.2.23 LUBRICANTS, SERVO FLUIDS AND CHEMICALS

The Bidder’s scope includes first fill of all lubricants, servo fluids, gases and chemicals. Consumption of all these consumables during the trial operation and final filling after the trial operation shall also be included in the scope of the Bidder. Bidder shall also supply a quantity one year topping requirement of each variety of lubricants, servo fluids and the chemicals used unless specially excluded under Exclusion in the specification. As far as possible, lubricants marketed by the Indian Oil Corporation shall be used. The variety of lubricants shall be kept to a minimum possible.

3.2.24 COLOUR CODE FOR ALL EQUIPMENT/ PIPING/ PIPE SERVICES

All equipment / piping/ pipe services are to be painted by the Contractor in accordance with Owner’s standard colour coding scheme, which will be furnished to the Contractor during detailed engineering stage.

3.2.25 PROTECTION

All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either metallic or a nonmetallic protection device. All ends of valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from the damage. The parts which are likely to get rusted, due to exposure to weather, should also be properly treated and protected in a suitable manner. All primers/ paints / shall take into account the hot humid, corrosive and saline atmospheric conditions applicable for a coastal area.

All exposed metallic surfaces subject to corrosion shall be protected by the shop application of suitable coatings. All surfaces which will not be easily accessible after the shop assembly, shall be treated beforehand and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and prepared in the shop. The surfaces that are to finish painted after
installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.

Shop primer for all steel surfaces which will be exposed to operating temperature below 95 degrees Celsius shall be selected by the Contractor after obtaining specific approval of the Owner regarding quality of the primer proposed to be applied. Special high temperature primer shall be used on surfaces exposed to temperature higher than 95 degrees Celsius and such primer shall also be subject to the approval of the Owner.

All other steel surfaces which are not to be painted shall be coated with suitable dust preventive compound subject to the approval of the Owner.

All piping shall be cleaned after shop assembly by shot blasting or other means approved by the Owner. Lube oil piping or carbon steel shall be pickled.

All metal surfaces shall be treated to provide anti-corrosion protection. All ferrous surfaces for external use shall be hot-dip galvanized after fabrication. High Tensile steel nuts and bolts and spring washers shall be electro-galvanized to service condition 4. All steel conductors including those used for earthing / grounding (above ground level) shall also be galvanized according to IS-2629.

FUNGISTATIC VARNISH - Special moisture and fungus resistant varnish shall be applied to parts, which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface or part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

All Switchgear panels and Control / Relay Panels shall be painted by powder coating. Paint shade for electrical equipment shall be 692 for indoor and 631 of IS : 5 for outdoor equipment. However paint shade has to be matched with existing equipments, which shall be furnished at the detailed design engineering stage.

3.2.26 GALVANIZING

The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the steel by dry process. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking and peeling off, etc.

Unless otherwise specified in Section 1 or 2, the minimum weight of the zinc coating shall be as follows –

It shall be 610 gm/sq.m and minimum thickness of coating shall be 85 microns for all items thicker than 6 mm. The average coating thickness shall be 95 microns. For items less than 6 mm, requirements of coating thickness shall be as per clause 4.1 of IS 4759, 1984. For surfaces which will be embedded in concrete, the zinc coating shall be 900 gm/sq.m minimum. Galvanizing of each member shall be carried out in one complete immersion.
After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment.

1. All bolts, nuts, lock nuts, washers, etc. shall be hot dip galvanized. Nuts, however, may be tapped, but not to cause

2. Adhesion test as per IS 2629:1985

3. Mass of zinc coating as per IS 6745:1972

3.2.27 Terminal Blocks

Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks.

Terminal blocks shall be 1100V grade and have continuous rating to carry the maximum expected current on the terminals. The terminal blocks shall be cage clamp type (Wago or equivalent) or non-disconnecting stud type (Elmex type CAT-M4 or equivalent). The insulating material of terminal block shall be nylon 6.6 which shall be free of halogens, fluorocarbons etc.

Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

The terminal blocks shall be of expandable design.

The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

All circuits except CT /PT circuits Minimum of two of 2.5 sq. mm copper flexible

All CT/ PT circuits Minimum of 2 nos. of 6 sq. mm copper flexible

The arrangements shall be made in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

At least 20% spare terminals shall be provided on each panel/ cubicle/ box and these spare terminals shall be uniformly distributed on all terminals rows.

There shall be minimum clearance of 250 mm between the first/ bottom row of terminal block and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

3.3 SEISMIC WITHSTAND TEST

The seismic withstand test on complete equipment shall be carried out along with the supporting structure.
The Contractor shall arrange to transport the structure from the structure Contractor’s works/ project site or alternatively arrange the structure as per approved drawings for the purpose of seismic withstand test only.

The seismic level specified shall be applied at the base of the structure. The accelerometers shall be provided at the terminal pads of the equipment and any other point as agreed by the Owner. The seismic test shall be carried out in all possible combinations of the equipment. The seismic test procedure shall be furnished for approval of the Owner.

3.4 TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling, jigs and fixtures for maintenance and calibration/ readjustment. Checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Bidder alongwith the offer.

The prices of each tool/ tackle shall be deemed to have been included in the total bid price. The tolls and tackles shall be separately packed and sent to site. This set of tools and tackles shall not be used by during erection and trial operation. For this purpose a separate set of tools and tackles shall be brought/ supplied by the Contractor. In case the above mentioned set is used during erection, commissioning or trial operation the same shall be refurbished repaired/ replaced as required to the satisfaction of the Owner before handing over. All tools and tackles shall be of reputed make acceptable to the Owner.

3.5 PACKING AND TRANSPORTATION

All the equipment shall be suitably protected coated covered or boxed and crated to prevent damage of deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

PACKING IN CRATES

For the equipment packed in crates, the packing wood shall be as per relevant Indian/ International standards. The base of the crate shall be made of wooden batons and planks giving necessary reinforcement, so that the bottom of the equipment is at a height of 100mm minimum from the ground level. The size of the plank shall be decided by the sub-contractor to suit the weight of equipment. Minimum thickness of the plank shall be 25mm and minimum width shall be 150mm. Crate shall be made while keeping the gap from 25mm to 200mm depending upon the size of equipment and weight. However, the responsibility of proper packing and safe delivery of the equipment to site lies with the supplier.

3.6 DEVIATIONS FROM SPECIFICATIONS

Deviation, if any, from any of these specifications shall be listed out separately. Bidder shall attach a separate sheet titled as “DEVIATIONS FROM SPECIFICATIONS” and list all deviations details of each deviation Section wise and Clause wise. In absence of any deviation listed out separately, adherence to the specifications shall be assumed.
3.7 Training

The Contractor shall arrange training to familiarize the customer’s personnel about constructional and O&M aspects of equipment wherever need of specialized training is felt during detail engineering. Cost of such training shall be borne by the Contractor. Traveling and living expenses, of the personnel deputed on such training, however, shall be borne by the Employer.

Besides above, the Contractor shall hold training sessions to familiarize the Employer's personnel with all aspects of operation and maintenance of the plant and sub-systems before the beginning of the dry tests on site. The technical documentation used in the training sessions shall include the Contractor's draft operation and maintenance manuals and test procedure descriptions approved by the Employer.

The Contractor shall provide training for each phase of work as per details agreed at the time of award.

1. General requirements of training

The Contractor shall provide suitable instructors, training material and facilities (instruments, apparatus, simulators, documents, drawings, protective clothing, rooms, office supplies, etc.) for the personnel made available by the Employer for training.

One month before the training start, the Employer will send the list of the trainees and any comments on the training program proposed by the Contractor. This program shall be adapted to the design and nature of the Works, and the needs of trainees. Trainees shall be suitably trained in the various aspects of design, manufacture, installation/erection, operation and maintenance, relevant to the training, of works similar to the Works.

The Contractor shall supervise and provide direction to, and be liable for the acts or omissions, other than negligent or willful misconduct of such personnel, of the Employer’s trainees.

The Contractor shall provide the training described hereafter in accordance with any further specific requirements stated in the Employer’s Requirements.

The Contractor shall assist the Employer in obtaining any visas and other formalities for entering or leaving the territory on which the training is being provided.

The Contractor shall bear responsibility for ensuring the safety of the trainees during their stay in the country of the training. On their part, the trainees shall comply with the laws, regulations and customs of the country in which training is being provided.

In the event of illness or accident, the Contractor shall take all steps to provide the trainees with the appropriate medical care.

2. Training of Employer’s personnel

The scope of service under training of Employer’s engineers shall include a training module covering the following:
2.1. Training during engineering/ manufacturing phase

This shall cover all the related areas like design familiarisation, training on product design features and product design software of major equipment and systems, engineering, manufacturing, erection, commissioning, training on operating features of equipment, quality assurance and testing, plant visits and visits to manufacturer’s works, exposure to various kinds of problems which may be encountered in fabrication, manufacturing, erection, welding etc. The training in areas of Operation and Maintenance shall take place preferably during end of manufacture/ tests.

2.2. Training during the erection / installation / site work

Independently from the supervision and inspection functions of the Employer's Representative, the Contractor shall authorize the Employer’s Personnel to follow the erection / installation / site work at his site.

The Employer’s Start-up Personnel shall take no part in the equipment erection and/or installation operations, which shall be exclusively carried out by the Contractor and under his entire responsibility.

This on site training shall cover each phase of erection / installation / site work and shall be of sufficient duration.

The Contractor shall supply the information or measurements concerning the erection requested by the Employer's Representative or/and by the Employer’s personnel.

2.3. Training during the tests on completion phase

The Contractor shall provide on-the-job training in the operation and maintenance of the Works to the Employer’s Operating Personnel. Such training shall start at least 30 days prior to commencement of Tests on Completion and continue until Taking Over. Its scope and quality shall be such as to provide the trainees with comprehensive understanding of all operational and maintenance aspects of the work. Such training shall also include safety and environmental protection aspects applicable to the work.

3.8 INFORMATION TO BE FURNISHED BY THE CONTRACTOR/ SUB CONTRACTOR

Information/ documents to be furnished at the TENDER / CONTRACT STAGE shall be as given below: (marked 'X' in the appropriate column)

<table>
<thead>
<tr>
<th>DETAILS OF DOCUMENTATION TO BE FURNISHED</th>
<th>At Tender Stage</th>
<th>At Contract Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical offer with details of equipment, scope etc</td>
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<tr>
<td>Guaranteed Technical particulars</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Schedule of Tests to be conducted</td>
<td>X</td>
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<tr>
<td>Schedule of deviations, if any, Section wise, clause wise, with respect to technical specifications</td>
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</tr>
<tr>
<td>List of past supplies complete with purchase &amp; project ref., quantity, order ref., etc. where identical equipment have been supplied</td>
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</tr>
<tr>
<td>Manufacturing Quality Plan/ Standard Check List</td>
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<td>X</td>
</tr>
<tr>
<td>Field Quality Plan</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GA drg with dimensions &amp; weight and foundation/ fixing</td>
<td>X</td>
<td>X</td>
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<tr>
<td>details</td>
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<tr>
<td>-----------------------------------------------------------------------</td>
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<tr>
<td>Drg &amp; Data submission schedule (to be furnished at contract stage shall be specified date-wise here).</td>
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<tr>
<td>Type test Reports.</td>
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<tr>
<td>Bar chart showing the time schedule indicating the timer required for design submission of drawing, manufacture of eqpt, test and inspection.</td>
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<tr>
<td>Routine / Acceptance test reports.</td>
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<tr>
<td>Installation , Operation &amp; Maintenance Manual</td>
<td>X X</td>
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<tr>
<td>Field Quality Plan for receipt and storage, installation, testing and commissioning with details of test equipment, tests to be conducted and acceptance values</td>
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## ANNEXURE-A

### NUMBER OF COPIES AND MODES OF DOCUMENTATION TO BE SUBMITTED

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<tr>
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<th>DESCRIPTION</th>
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<td>PRINTS</td>
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<tr>
<td>2.</td>
<td>Drawings &amp; GTP data sheets after revision for approval</td>
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<td>3.</td>
<td>Drawings &amp; GTP data sheets after revision for approval (Final)</td>
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<td>Test Procedures for approval</td>
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<td>Erection Manual</td>
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<tr>
<td>9.2</td>
<td>O &amp; M Manual</td>
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<td>Commissioning and Performance procedure manual</td>
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<td>O &amp; M Manual</td>
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<td>12.2</td>
<td>Field Quality Plan</td>
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<tr>
<td>13.</td>
<td>Inspection and Test Reports</td>
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</table>

**NOTE:**
Quality Documentation shall be arranged in plastic folders in the same order as they appear in the QP, with cover sheet and index with QP itself as the first document at the top.

Final Documentation shall be submitted in bound volumes with Customer & Project etc. written on top.
### 10.1 Guaranteed Technical Particulars

<table>
<thead>
<tr>
<th>Item / Clause No.</th>
<th>Parameter</th>
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<th>Contractor's Data</th>
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<td>Type/designation</td>
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<td>3</td>
<td>Highest voltage for Equipment, ( U_m )</td>
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<tr>
<td>4</td>
<td>Rated Frequency</td>
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<tr>
<td>4.1</td>
<td>Normal condition</td>
<td>Hz</td>
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</tr>
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<td>4.2</td>
<td>Exceptional Condition</td>
<td>Hz</td>
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<td>Power frequency withstand voltage, (One) 1 minute</td>
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<td>5.1</td>
<td>Phase to ground</td>
<td>kV&lt;sub&gt;rms&lt;/sub&gt;</td>
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</tr>
<tr>
<td>5.2</td>
<td>Phase to Phase</td>
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<td>Power frequency withstand voltage at atmospheric SF₆ gas pressure</td>
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<tr>
<td>6.1</td>
<td>continuously</td>
<td>kV&lt;sub&gt;rms&lt;/sub&gt;</td>
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<tr>
<td>6.2</td>
<td>for (one) 1 minute</td>
<td>kV&lt;sub&gt;rms&lt;/sub&gt;</td>
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<td>7</td>
<td>Lightning impulse withstand voltage</td>
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<td>against ground</td>
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<td>7.2</td>
<td>over isolating distance of isolators</td>
<td>kV&lt;sub&gt;peak&lt;/sub&gt;</td>
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<tr>
<td>7.3</td>
<td>over isolating distance of circuit breakers</td>
<td>kV&lt;sub&gt;peak&lt;/sub&gt;</td>
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<td>8</td>
<td>Switching impulse withstand voltage</td>
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<tr>
<td>8.1</td>
<td>against ground</td>
<td>kV&lt;sub&gt;peak&lt;/sub&gt;</td>
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</tr>
<tr>
<td>8.2</td>
<td>over isolating distances of apparatus</td>
<td>kV&lt;sub&gt;peak&lt;/sub&gt;</td>
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10.1 Guaranteed Technical Particulars

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<td>Maximum partial discharge of switch gear assembly at highest voltage for equipment, ( U_m )</td>
<td>pC</td>
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<tr>
<td>10</td>
<td>Maximum leakage rate in percent of the respective volume, per year</td>
<td>%</td>
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<tr>
<td>11</td>
<td>Temperature rise</td>
<td>°C</td>
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</tr>
<tr>
<td>12</td>
<td>Minimum symmetrical short-time withstand current, (One) 1 second</td>
<td>kA\text{rms}</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Minimum dynamic short-circuit withstand current</td>
<td>kA\text{peak}</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Corona extinction voltage</td>
<td>kV\text{rms}</td>
<td></td>
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<tr>
<td>15</td>
<td>Circuit Breaker</td>
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</tr>
<tr>
<td>15.1</td>
<td>Rated continuous current</td>
<td>A</td>
<td></td>
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<tr>
<td>15.2</td>
<td>Rated short time withstand current</td>
<td>kA\text{peak}</td>
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<tr>
<td>15.3</td>
<td>Rated symmetrical short-circuit breaking current</td>
<td>kA\text{rms}</td>
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</tr>
<tr>
<td>15.4</td>
<td>Rated asymmetrical short-circuit breaking current</td>
<td>kA\text{rms}</td>
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<tr>
<td>15.5</td>
<td>Rated short-circuit making current</td>
<td>kA\text{peak}</td>
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<tr>
<td>15.6</td>
<td>Line charging current breaking capability</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>15.7</td>
<td>Small inductive current breaking capability (without producing excessive over voltages)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>15.8</td>
<td>Operating sequence</td>
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### 10.1 Guaranteed Technical Particulars

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<th>Parameter</th>
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<td>Line breakers</td>
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<td>15.8.2</td>
<td>Generator feeder &amp; tie breakers</td>
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<tr>
<td>15.9</td>
<td>Mechanical opening time</td>
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<tr>
<td>15.9.1</td>
<td>Total breaking time</td>
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<td>15.9.2</td>
<td>Total closing time</td>
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<td>15.9.3</td>
<td>First pole to clear factor</td>
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<td>15.10</td>
<td>Isolator</td>
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<td>15.10.2</td>
<td>Minimum make and break capability for capacitive current</td>
<td>A</td>
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<tr>
<td>15.10.3</td>
<td>Total operating time (closing or opening cycle)</td>
<td>s</td>
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<tr>
<td>15.10.4</td>
<td>Temperature rise</td>
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<td>Fast Acting Grounding Switch</td>
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<td>Rated switching capacity</td>
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<td>15.11.2.1</td>
<td>inductive currents</td>
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<td>15.11.2.2</td>
<td>capacitive currents</td>
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<td>Operating time</td>
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### 10.1 Guaranteed Technical Particulars

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<td>15.12.2</td>
<td>Total operating time (closing or opening cycle)</td>
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<td>15.13</td>
<td>Bus Voltage Transformers</td>
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<td>-/VA</td>
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<td>for metering</td>
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<td>16.2</td>
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<td>16.4</td>
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<td>10 sec</td>
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<td>One minute (dry) power frequency withstand voltage of arrestor housing</td>
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<td>16.9</td>
<td>Impulse withstand voltage of arrestor housing with 1.2/50 ms wave</td>
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<td>Discharge voltage</td>
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<td>Applicable standards</td>
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<td>busbars and bus coupler</td>
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#### Recommended additional spare parts

List hereunder the spare parts which are recommended by the Contractor for purchase in addition to the specified spare parts as per specifications in Section 2 "Section - 10 Clause 10.8" of PTS. The purchase of any or all of the recommended spare parts will be at the option of BHEL/NHPC. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.
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* Use additional sheets if required
10.4 Information to be supplied together with the bid

At least the information listed hereunder shall be given by the Bidder. The Bidder may submit additional documents /descriptions to describe special technical features of offered equipments /system:

1. Dimensional drawings of the proposed switchgear including cross sections showing arrangement of major components including control cabinet details.

2. Description of the main features of the switchgear.

3. Description and typical illustration of the proposed bay module control cabinet preferably documented by principle diagram.

4. Proposed erection procedures including supplier’s requirements regarding environmental conditions.

5. Proposal on dielectric field tests including partial discharge measurements on completely assembled switchgear.

6. Pamphlet with description of the proposed gas processing unit.

7. Pamphlets with functional description and technical data of all the components.
## SECTION – 5

### ENCLOSURES

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<td></td>
<td>Sheet 1 of 2</td>
</tr>
<tr>
<td>3.</td>
<td>Protective relaying and Metering Diagram</td>
<td>NH/DEM/PBT-III/CP/02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheet 2 of 3</td>
</tr>
<tr>
<td>4.</td>
<td>Power House Transformer Cavern-Equipment Arrangement Plan at EL. 984.00 &amp; 981.00M</td>
<td>NH/DEM/PBT-III/PH/11</td>
</tr>
<tr>
<td>5.</td>
<td>Power House Transformer Cavern-Equipment Arrangement Plan at EL. 974.00 &amp; Sections</td>
<td>NH/DEM/PBT-III/PH/11</td>
</tr>
<tr>
<td>6.</td>
<td>Customer’s Specification for Control and Monitoring (SCADA) System for the Station</td>
<td>For Reference (33 pages)</td>
</tr>
<tr>
<td>7.</td>
<td>Customer’s Specification for Protection System for the Station</td>
<td>For Reference (26 pages)</td>
</tr>
</tbody>
</table>
PLAN AT EL. 984.00 M

PLAN AT EL. 981.00 M

REFERENCES DRAWING

1. POWER HOUSE TRANSFORMER CAVERNS PLAN AT EL. 974.00 & SECTIONS NHPB 04-1972-14-GA-4200

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRE AND LEVEL IN METRE.
2. THIS DRAWING SHALL BE READ ALONG WITH DSG NO. NHPB 04-1972-14-GA-0105.

TENDER DRAWING NOT FOR CONSTRUCTION

SCALE
1:25 1:50 1:100 1:200 1 METRE
13. CONTROL AND MONITORING (SCADA) SYSTEM

13.1. Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer’s personnel, handing over to NHPC and guarantee for two years of control and monitoring (SCADA) system as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

13.1.1. Local control boards

The Computerized Control and Monitoring System shall contain at least the following Local Control Boards:

i) Four (4) sets of Unit Control Board (UCB) with all necessary accessories,

ii) One (1) set of LCB for Common, Station Services Board and Dam Monitoring with all necessary accessories,

iii) One (1) set of LCB for Electrical Power Supply Service Boards with all necessary accessories for complete 11kV switchgear and feeders, DG sets, Unit tap off Transformers, Station Auxiliary transformers, and 415 V switchgear,

iv) One (1) set of LCB for 420 kV GIS with all necessary accessories

13.1.2. Central control centre

Central Control Centre shall comprise of the following equipment:

i) Two (2) Operator Workstations each with two sets of TFT monitors and all necessary accessories and software,

ii) One (1) Fixed Engineering station with all necessary accessories and software,

iii) Two (2) Portable Engineering station each with dockable arrangements, printer, all necessary accessories and software,

iv) One (1) projection type Large Screen Display with display controller acting as a video mimic,

v) Emergency shut down systems one for each individual unit,

vi) One (1) Emergency shut down system for the entire station,

vii) Routers/gateway with necessary firewall functionality for control and
remote operation of Parbati H.E. Project, Stage-II from this project with all necessary interfaces, accessories and equipment,

viii) One (1) set of router / gateway with necessary firewall functionality for communication between power house and corporate control room,

ix) One (1) set of router/gateway with necessary firewall functionality for Data transmission to Regional Load Despatch Centre through PLCC,

x) Data Acquisition System (DAS) / Data logger system comprising of two (2) nos. of high-capacity Network Attached Storage systems (one main + one hot standby),

xi) One (1) Training simulator, with all necessary accessories, software along with at least 5 user licenses, implemented on separate workstations and connected to the Central Control Room Network,

xii) Operating desks for Engineering Stations, stations, Data Storage system and Operator Workstations,

xiii) Four (4) chairs with bending mechanism, sitting height adjustment and ergonomic adjustment with desk etc.

13.1.3. Process control networks & Power house LAN

i) Fiber optic Power House LAN with all necessary accessories and interfaces,

ii) Fiber optic Central Control Room Network with all necessary accessories and interfaces,

iii) Fiber optic Plant Control Network with all necessary accessories and interfaces,

iv) Six (6) Plant Computers and Two (2) servers with all necessary accessories and software hooked up with 1Gbps Power House LAN.

13.1.4. Link between power house and dam/power house of stage-II

i) Optical fiber link through OPGW on existing HV line complete in all respects, between power house and dam/power house of stage-II,

ii) RTU equipment and all necessary accessories including UPS, interfacing equipment etc, for real-time, full duplex, single mode optical fiber communication between dam and power house.

13.1.5. Software

i) Supply of all necessary software as per the clause “Design and Construction” of this section, their license for use, and source codes for the process software that are specific for this project,

ii) Necessary routers and firewalls to prevent unauthorized access of process control networks from LAN/WAN connections including Power House LAN.
13.1.6. **Time synchronization**

Universal time synchronization system complete with redundant master clocks, at least six (6) nos. of slave clocks, antenna and any other instrumentation / provisions required for time synchronization of all the equipment of the control system as well as protection system equipment, with Global Positioning System (GPS), so that each piece of equipment shall be synchronized individually.

13.1.7. **Interfacing services and supply**

Coordination, supply of associated interfaces including transducers and integration of all plant equipment and subsystems including all auxiliaries and station services with the computerized control and monitoring (SCADA) system for complete control, real-time communication and data acquisition.

13.1.8. **Miscellaneous items**

i) Printers & plotters as per clause “Printers” of this section,

ii) One (1) set of spare parts in accordance to clause 13.8 “Spare Parts” of this section,

iii) One (1) set of tools and instruments in accordance to clause 13.9 “Tools and Instruments” of this section.

Any other items not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

13.2. **Specific Parameters and Layout Conditions**

13.2.1. **Layout and General Arrangement**

The basic configuration and general layout of the control system shall be as per drawing NH/DEM/PBT-III/CP/04.

All UCB and LCB panels shall be based on IP 52 class of protection for enclosure.

The control and monitoring system shall be built up of distributed and independent control modules in hierarchical control levels. All the components and subsystems in the hierarchical control levels of the control system shall be seamlessly integrated to achieve a highly reliable and scalable power plant control system.

The overall control shall be affected from the Central Control Room. Provision shall be made to adopt the control system for future remote monitoring from a Remote Control Centre. The highest control level shall be the Operator Workstations in the Central Control Room (CCR). From the Operator Workstations, the operator shall have the possibility to perform in real-time, controls and adjustments for all the equipment of the scheme.
All the computers, peripherals, software, actuators, sensors, measuring instruments and other hardware shall be of latest state of the art at the time of supply. If the control system mentioned in the awarded contract becomes obsolete at the time of supply, the Contractor shall offer a latest model without any extra cost to NHPC.

The control system should be built in such a way that in case of a fault in any single equipment others are not affected and system continues to function effectively.

The control system shall be designed on open standards based on IEC 60870-5 series and Object Linking and Embedding for process control (OPC) standards.

The control and monitoring system and the components shall be selected taking the following requirements into consideration:

- Reliability of components and subsystems,
- Scalability of the system for future extensions,
- Backward compatibility and Interoperability with other subsystems,
- Availability of spares,
- Ease of maintenance,
- Service availability and adaptability for future technology developments.

13.2.2. Networking and communications

All the optical fiber cabling shall be protected by suitable metal conduits as shield to protect them from moisture and micro bending. All redundant cables shall be physically routed along different paths so as to ensure higher availabilities. The networks shall be designed for 1Gbps, real time and full duplex (bi-directional) communications.

All networks shall be configured to form a dual star topology with switched based Ethernet. The networks shall be designed with dual homed mesh redundancy.

Process control networks shall be separated from Power House LAN by suitable firewalls to restrict access to the control system. All RTU data communications shall be encrypted.

For the purpose of remote monitoring and control of reservoir level and dam site equipment, all interfaces and accessories shall be provided for single mode optical fiber link through OPGW between Dam and Power House. The link shall be suitable for voice and data communications also.
13.2.3. Interoperability

The complete design of the computerized control and monitoring system shall be based on interoperability of equipment from different manufacturers and the Contractor shall be responsible for overall functional integration of the system. The control system shall be implemented on open standards based on Object oriented design.

It shall be the responsibility of the Contractor to verify and solve all interoperability issues of various components / equipment connected to the network. The Contractor shall perform a type conformance test to validate the implementation of the communication protocols.

The Contractor shall be responsible for establishing necessary SCADA communications/data exchange interfaces for interoperability with Parbati H.E. Project Stage-II SCADA system. Both the hydro projects shall be remotely controllable from this project so as to ensure a cascade/tandem operation in an optimized manner. The Contractor shall ensure compatibility with the SCADA system of Parbati H.E. Project Stage-II in this regard.

13.2.4. Redundancy

The control system shall have both physical and functional or operational redundancies. At least the following physical redundancies shall be ensured in the design of the control and monitoring system:

- Redundancy of communication media shall be through redundant optical fiber cables,
- Operator station redundancy shall be ensured by mirror images of process data on both the operator workstations,
- Networking redundancy shall be implemented by using redundancy of servers, routers and switches in dual star with dual homed mesh redundancy. All networks including field network and Power House LAN shall be redundant,
- All Controllers and their power supply distribution cards used in LCBs/UCBs shall be redundant,
- Event and Alarm printers shall be configured to takeover the duties of each other in the event of failure of any one of them,
- The unit shut down system shall include emergency shut down system implemented by hard wired logic,
- The database storage system shall be redundant and implemented through two Network attached storage devices,
- The GPS synchronization master clocks shall be redundant.
13.3. Rating and Functional Characteristics

13.3.1. Topology, redundancy and availability

The networks shall be configured using redundancy of servers, routers and switches, in dual star switched Ethernet topology with dual homed mesh redundancy, to achieve high operational availabilities for top order events. The system availability shall analyse and calculations shall focus on availability of the control system for the top order event: “Availability to retrieve all process data from LCBs and operate all breakers and shut down all units”. The overall system unavailability shall be computed by considering individual device unavailability in a fault tree analysis using MTTR, MTTF and MTBF values of each device as supplied by its manufacturer.

13.3.2. Decentralised Control

The instrumentation and control system shall be based on the decentralized intelligence system, which means that Controllers of the corresponding system operates the logic and control functions.

The control system shall be divided into discrete functional subsystems. Each sub-system shall be controlled from its Local Control Board if the “LOCAL” position is selected. The Local Control Board of each system includes redundant power supply distribution, interfacing terminals with the process, redundant controllers and HMI. Each Local Control Board shall have provisions and interfaces for direct connection of mobile engineering stations.

The Local Control Boards associated with switchyards and generating units (Unit Control Boards) shall, in addition to the above, consist of automatic and manual synchronizers.

13.3.3. Computers and peripherals

Computers used in the control and monitoring system shall preferably be of a standardized type suitable for industrial environments and of a brand approved by the Employer. The signal transmission shall be via redundant fiber optic cables. All monitors shall be of SXGA resolution, flicker free TFT type with at least 20" screen size. All keyboards / functional keyboards / keypads to be supplied except those in offices and on Power House LAN shall be membrane protected. All Computers, printers and other accessories supplied shall be of robust and tropicalized type of construction so as to withstand Hydro power plant environmental conditions.

13.3.4. Power supply for Local Control Boards

Power supply for control of all Local Control Boards shall be 220 V DC. Each LCB shall be fed from two independent power supplies for control function. One power supply shall be main and other standby. In case of failure of main supply, standby supply shall be switched on automatically.
Power supply converters / units / modules provided in the UCBs / LCBs shall be 100% redundant. In case A.C. supply is used for any control function two on-line station UPS, with one as standby, powered by 220 V DC system shall be provided.

13.3.5. Programmable controllers for LCBs and UCBs

The programmable controllers / PLCs to be supplied shall be modular in architecture and microprocessor based design suitable for harsh industrial environments. All power supply cards, I/O module connections and other external interfaces shall be provided with suitable surge protection devices to protect the controllers and internal circuitry from external surges. Unless otherwise specified, the equipment shall be in compliance with IEC 61131 standard.

All PLC units used in the control and monitoring system shall be, of the same manufacturer and of the same model. Interchangeability and interoperability of PLCs used shall be established by the Contractor.

The supply for PLC shall include all equipment and services for operating and maintenance, such as manufacturer’s standard firmware, licensed PLC programming and debugging tools, test equipment, all software with license for use and source codes for the application programs, spare parts and full documentation along with training. Each PLC shall have long-life internal battery backup/ non-volatile memory for storing running data and programs. All software and firmware supplied must be of latest release/ version.

For each output a safe position shall be defined for cases of failure of power supply, I/O module, CPU, etc. This safe position shall be clearly defined by the Contractor and submitted to the Employer. Each controller shall have built-in functions of on-line self diagnostics / watch dog features etc and shall report failures to the operators of the control system. The CPU shall be able to accept external time synchronization from GPS system, adjust its internal clock with the time synchronization system and then time tag data with an absolute clock.

Each I/O point of the controllers shall be supplied in standard rack-mounted I/O modules with plug-in boards. Each I/O point shall be furnished with:

- Protective network, such as surge protections, optical coupling and/or other isolating barriers,
- Filter for noise reduction,
- Test points and fault indication lamps,
- Fuse protection and fuse failure detection.

13.3.6. Emergency shut down

Emergency shutdown equipment shall be implemented through hardwired logic. Emergency shutdown shall be initiated by the monitoring and
protection devices as well as by manual release of the emergency shutdown buttons to be provided in the UCB and Central Control Room. The timing of emergency shutdown and associated closure devices shall be adjusted according to the hydraulic requirements of the system.

13.3.7. Metering

For monitoring the generation and transmission of power, a metering system using digital meters shall be provided for all lines and feeders of GIS, Generators at 13.8kV level, Unit Tap-Off transformers, Station Auxiliary Transformers and DG Sets. All measurements such as voltage, current, power, energy etc., used for monitoring, shall be provided as per drawings. All the energy meters used for measurements shall have minimum accuracy of 0.2% and shall be connected to the data acquisition system for automatic meter readings. Some of the energy meters in GIS area, as marked in the drawing, are not in the scope of this contract. Only their CT cores and wiring up to GIS Local Control Board are included in this contract.

13.3.8. Time resolution of events

Resolution of dating of events for purposes of sequence of event recording shall be of 1 milli second.

13.4. Performance Guarantee

The computerized control and monitoring (SCADA) system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. It is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars and shall also guarantee the reliability and performance.

The Computerized control and monitoring (SCADA) system shall be fault tolerant with redundancies at all levels as specified in the sub clause “Redundancy” of main clause “Specific Parameters and Layout Conditions”

The control system shall have fail safe features so that even in case of failure of all redundant controllers, the outputs shall be latched on to a safe value that ensure minimum plant safety features. The Contractor shall identify and submit to the Employer a detailed list of these fail safe outputs along with their safe values during detailed engineering.

Real time, full duplex data transmission rate, of at least 1 Gbps shall be provided. The availability of 1 Gbps data channel between two remote stations shall be greater than 99.99% and shall be guaranteed.

The Overall control and monitoring (SCADA) system availability for top order events shall be at least be 99.98% and shall be guaranteed.

The control system shall be guaranteed against interoperability with all the power house equipment and shall comply with IEC 60870-5 series.
13.5. Design and Construction

13.5.1. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60255</td>
<td>Electrical relays</td>
</tr>
<tr>
<td>IEC 60297</td>
<td>Dimension of mechanical structure of 19 inch series</td>
</tr>
<tr>
<td>IEC 60326</td>
<td>Printed Boards</td>
</tr>
<tr>
<td>IEC 60446</td>
<td>Basic and safety principles for man-machine interface, marking and identification, identification of conductors by colours or numerals</td>
</tr>
<tr>
<td>IEC 60478</td>
<td>Stabilized power supplies, DC output</td>
</tr>
<tr>
<td>IEC 60625</td>
<td>Interface system for programmable measuring instruments</td>
</tr>
<tr>
<td>IEC 61000</td>
<td>Electromagnetic compatibility for industrial process – measurement and control equipment</td>
</tr>
<tr>
<td>IEC 61131</td>
<td>Programmable controllers</td>
</tr>
<tr>
<td>IEC 61158</td>
<td>Digital data communications for measurement and control – Field bus for use in industrial control systems</td>
</tr>
<tr>
<td>ISO/IEC 8802</td>
<td>Information technology</td>
</tr>
<tr>
<td>ISO 11064</td>
<td>Ergonomic Design of Control centres</td>
</tr>
<tr>
<td>IEEE 1046</td>
<td>Application guide for distributed digital control and monitoring for power stations</td>
</tr>
<tr>
<td>IEC 60870-5</td>
<td>Tele-control equipment and systems</td>
</tr>
<tr>
<td>IEC 60793 Part 1</td>
<td>Optical Fiber- Measurement and test procedures</td>
</tr>
<tr>
<td>IEC 60793 Part 2</td>
<td>Optical Fiber- Product specifications</td>
</tr>
</tbody>
</table>

Optical Fiber Cables used shall comply with the provisions of latest ITU-T Specifications and IEC standards. The communications and networks of the control system shall be implemented on open network standards conforming to IEC 60870-5 series standards. Any design feature or detail not specified herein shall be in accordance with the above-mentioned standards, which shall supplement these specifications.
All the mimic views, software, printouts, documentation symbols, reports, labels etc. shall be in English language only.

To achieve redundancy and operational centralization, a Central Control Room shall be implemented from where all units along with all their unit auxiliaries, all Station Services, all Common Services, all switchyard and electrical power supply distribution shall be operated and supervised.

13.5.2. General

The designed control and monitoring system shall be common state of art at the time of supply. This specification requires that all local and remote control systems in the power house and the ancillary plant areas shall be suitable for manual and automatic start-up, running and normal and emergency shut-down of the generating units and the station auxiliary systems. Redundant Controllers of latest microprocessor based design with high processing speeds and solid-state electronic elements shall accomplish the control.

13.5.3. System configuration

The basic system configuration shall be as per approved scheme based on Employer’s drawings. The normal turbine-generator start-up and shutdown shall be controlled automatically either from the Unit Control Boards on the machine hall floor or from the Operator Workstations in the Central Control room. Manual control shall be possible from the Unit Control Boards.

According to the sequence of starting, all unit auxiliaries shall be automatically started prior to unit start-up; the generating units shall come up to speed and be automatically synchronized to the grid. On normal stop operation, the unit shall automatically be brought to no-load condition, the generator circuit breaker shall be tripped, excitation switched off and the mechanical brake applied.

The control system shall be furnished with necessary devices for local manual, local automatic and remote automatic control of the units. The design shall permit transfer from one mode of control to another without disturbing the operation of the units. All Local Control Boards including Unit Control Boards shall be provided with HMI panels for process visualization and control. Each Human Machine Interface shall:

- Have station with colour tactile screen or equivalent,
- Have screen size of at least 15” industrial TFT panels of high resolution, with IP 65 class protection for front enclosure.
- Have graphics supervision software,
- Withstand to machine hall environment,
- Connect directly to redundant CPU mechanism,
- Display Mimic diagram views with control functions,
Maintain measurements and indications including running hours,
Maintain alarm and status indications,
Perform archival of events,
Display visualization of subsystem status,
Execute commands.

From the Local Control Board, the operator shall be able to access important information about the system, and initiate automatic, step-by-step or manual sequences to control the process. The main redundant controllers with redundant power supply cards shall be mounted on the Local Control Boards together with all the electrical protections, measurements and indications of all analog parameters, and Alarm / Annunciation system. The communication between electrical protection system and their respective LCB/UCB shall be based on IEC 60870-5-103.

The system shall perform the following functions:

- Data acquisition and control of reservoir level and other related dam control parameters through OPGW. The system in addition to the above shall also continuously monitor Tail water levels and downstream discharges,
- Continuous monitoring for trash rack plugging conditions so as to raise necessary alarms,
- Speed control and load control through governor,
- Generation control based on reservoir level restrictions, Availability based tariff based restrictions, downstream release considerations and time based schedules,
- Flow control: The flow control shall control the power output of the plant according to the water quantity available over a period,
- Parallel operation with the Integrated Generating System. The control system shall be capable of acting as a Group Control Centre for the both of the Parbati basin projects,
- Joint control of all the 4 units,
- Control and monitoring from corporate office control room or a remote control centre,
- Isolated operation on a selected grid,
- Black-start, i.e. no external power source available, but only on the emergency diesel generators,
- Automatic voltage regulation,
- Machine loading with active and reactive power,
- Metering and recording of all characteristics of the turbine and generator operation,
Automatic backup of on-line process data using Network Attached Storage Devices,

Perform periodic permanent backups of process data on archival storage media,

Indication of normal operation of the auxiliaries that are essential for secure and reliable operation of the unit,

Audible and visual warning of dangerous/ faulty operating conditions of the unit and / or essential auxiliaries,

Audible and visual alarm and display of dangerous operation of the unit and the essential auxiliaries, or faults that may initiate tripping of the circuit breaker without stopping the unit,

Power supply and control of essential auxiliaries of each unit,

Video Mimic and indication labels on VDU,

Automatic synchronization,

Manual synchronization,

Manually operated covered push buttons for automatic safe shut down of units,

Fault location: this function shall have a high accuracy. The fault location assessment shall be independent of fault resistance, load current or the supply of a data from different sources,

Automatic station supply changeover,

Interlocking of various equipment for safe operation,

Configuration tools: Easy to use interactive configuration tools shall customize the various functionalities. The configuration tools shall provide visual presentation of the object, adaptations needed in process database, and adaptations of the communication configuration data. These tools shall provide:

- system configuration,
- system testing,
- help functions,
- program documentation,
- down and up loading of programs,
- system commissioning,
- real time distributed data base management,
- changing parameters.

13.5.4. Central control centre

The design and layout of control room shall take into consideration all ergonomic requirements associated with the control room layout as per
provisions of ISO 11064 and other international standards. The architectural finishing work, i.e., suspended ceiling, suspended floor, furniture, wall finishing required for the Central Control Room etc., has to be intimated by the Contractor according to his requirement for subsequent execution by civil Contractor.

13.5.4.1. Layout

In Central Control Room the following equipment shall be provided:

- Operator workstations with video display units keyboards and pointing devices,
- Routers/Gateways for Remote monitoring and operation of Parbati H.E. Project Stage-II, with necessary RTU and other interfaces,
- Routers/Gateways for communication between Power House and Corporate Monitoring Centre & RLDC,
- Data logger and a high performance Data storage system implemented by a pair of Network Attached Storage Systems for online automatic data storage, Devices and drives and necessary media for permanent backup of data on optical medium,
- Colour laser report printer,
- Alarm printer and Event printer,
- Colour Laser Hard copy printer,
- High quality colour plotter along with accessories,
- Engineering stations,
- Training Simulator station,
- Provision for installation of Plant Public Address System and necessary interfaces such as LAN switch for extending the Central Control Room Network to connect to Power House LAN and plant subsystems (e.g.: security and surveillance system),
- Portable engineering stations,
- Provision for placing the VSAT IDU in the control room.

The Central Control Room shall use latest high end, SCSI workstations based on latest version of Windows Networking operating system. Operator Workstations shall be configured so that in case of failure of one operator workstation, the other stations shall automatically takeover the control of the failed one without requiring any operator intervention. Such changeover shall be smooth and rapid without affecting the system that is being controlled. Necessary arrangements for maintaining mirror copies of process data on all operator workstations shall be provided.
All functions shall be accessible through the VDU and keyboards and also through a pointing device such as trackball, so that the operator never needs to take his eyes off the screen.

Basic functions of control and supervision of power plants shall be included in a standard software package. The functions shall be upgradeable by reprogramming through a standard programming language implemented in an Integrated Development Environment (IDE). The supply of IDE along with the programming language shall be included in the scope of supply. A library of functions related to hydro power plant control and operation shall be provided.

The Central Control Room shall:

- provide acquisition of data inputs coming from the local controllers,
- process the data inputs in order to update its real time data base,
- process the data outputs to control the power plant,
- implement screen based video mimics made available on operator workstations, and engineering stations, The above shall be provided with all the necessary views that are required for a fully functional and complete system. Detailed listing of views, their design, look and feel etc, shall be approved by the Employer during detailed engineering,
- printing reports (events and sequence of events logs, periodic log) upon operator's request,
- perform computational functions,
- perform data archiving functions,
- provide facilities for VSAT communication with Corporate Office,
- provide facilities for training and simulation of the control system,
- execute joint control for automatic operation of the plant,
- monitoring of reservoir level, gates and flow regulations and process hydraulic data calculations and also monitor for trash rack plugging conditions,
- provide an interface/module complete in every aspect for remote control of the entire plant from Load Dispatch centre. The system should comply with IEC protocol standards to communicate with remote dispatch centre.

13.5.4.2. Large Screen Display (LSD)

Large Screen Display with 168-inch overall diagonal screens and high resolutions of at least 1280x1024 pixels per block with necessary display controller shall be provided. LSD shall be formed by tiling four identical display blocks fed by digital rear projectors and digital image processors.
LSD shall be connected to the Central Control Room Network through a display controller, so as to display any combination of the control system views to be selected from any of the Operator Work Station. Display blocks used for formation of each LSD shall be of Seamless Mullion or less than 1.0 mm mullion type with all necessary accessories and application software to present high quality, high resolution images. The display screen shall have a high viewing angle and shall have adequate level of brightness for display in ambient light conditions of the control room. In the middle portion over the LSDs, a digital clock with date and time indication shall be provided.

13.5.4.3. Operator workstations

The operator consoles shall assist the operator for an easy operation and control of power station and shall allow to print out and to show on the displays, all relevant signals, events, alarms, status, status changes, abnormalities, history data and plant conditions on request or immediately in case of alarm.

In the control room two operator workstations with desks shall be provided. Each operator desk shall be equipped with two VDUs, sealed membrane covered keyboard and pointing device such as mouse / trackball, sealed membrane covered function keyboard, integrated telephone set, microphone, writing pad and workplace integrated. Each of the two monitors, attached to the workstations, shall be interfaced to be capable of displaying any of the selected plant control mimic views.

All the Operator workstations shall be implemented in such a way so that each workstation shall be capable of individually controlling the entire control system even in the case of failure of all other workstations.

The configuration of each workstation shall be:

- Two VDUs each of at least 20”, TFT flat screen and flicker-free,
- Dual Processor CPU with highest CPU clock speeds and Mother Board Front Side Bus speeds available at the time of supply,
- Minimum of 2 GB RDRAM,
- SCSII CD Writer drive or tape drive,
- 3.5 inch Floppy Disk Drive,
- Two (2) or more – SCSI Hard Disk Drives each of at least 80GB capacity,
- CD- ROM drive,
- USB hub and ports,
- Functional key board with all functions and provision of shortcuts for alarms,
- Pointing device such as mouse or trackball.
The workstations shall be high performance systems with SCSI drives and controllers and latest configuration available at the time of supply. They shall be loaded with latest 'Professional version' of Microsoft Office Suite. The operator desks, to be supplied by the Contractor, shall be provided with all accessories, telephone desk-type, power socket outlets, provision for public address system installation etc.

13.5.4.4. Engineering stations (fixed)

One Engineering Workstations with separate desks shall be provided. The Engineering Station shall be equipped with single 20", SXGA resolution, flicker free TFT flat screen monitor and other hardware configuration same as that of Operator Workstations mentioned above. These stations shall have the following features including software for:

- Reprogramming,
- Process simulation,
- Engineering calculation,
- Program testing,
- Documentation,
- Low level expert system tester,
- Training functions.

Software and programming tools provided shall be responsible for the definition and creation of all mimic views to be displayed. From this desk, it shall be possible to follow the control and operation and to execute trouble shooting, reprogramming, parameter and set point changes and all necessary work to support and maintain the system. Each Engineering station shall be provided with latest 'Developer version' of Microsoft Office Suite.

13.5.4.5. Portable engineering stations (movable)

Each portable engineering workstations with all features and accessories to maintain, reprogram, check the status and test the LCB programmable controllers, loaded with all software & system configuration settings similar to fixed engineering station necessary for the purpose, shall be included in the scope of the supply. In addition to this these stations will be equipped with necessary software & ports to programme, test, data downloading & analysis for Protection relays, Governor and Digital voltage regulator described in other chapters of this document. These stations shall be installed on separate desks in the control room and connected to the control room network through docking arrangements with Advanced Port Replicators (APR). Each desk shall have separate monitor, keyboard, mouse and other necessary accessories connected with APR interface.
13.5.4.6. Simulator and training

One separate simulator station with all accessories for operational staff shall be integrated into the system and included in the scope of supply. The software shall consist of standard and easy to use simulation of the hydro power plant and complete on line documentation to allow the operator to train himself at using the control system. Adequate training of the operator personnel for acquaintance of the system is included in the contract. The simulator shall be implemented by separate computer in the Central Control Room.

13.5.5. Unit Control Boards (UCB)

Dedicated Unit Control Boards with HMI shall be installed for each turbine-generator unit. The governor, excitation system and protection panels shall be integrated with Unit Control Board. These boards shall communicate with the central control system through the Plant Control Network. The main and redundant unit controllers shall be mounted on Unit Control Boards together with all the electrical and mechanical protections of the generating unit, its auxiliaries, generator step-up transformers and measurement of all parameters of the unit. All facilities, equipment and interfaces shall be provided for complete local control of the unit from Unit control board in “Local Manual mode”.

Each Unit Control Board shall comprise of the all the required control and monitoring devices and components required for operation of the unit including:

- Redundant controllers with redundant power supply distribution,
- Necessary I/O module racks,
- Redundant field bus and sub-local network as per requirement,
- All necessary I/O interfacing,
- One colour Human-machine interface terminal to perform local supervision and control of the unit and its auxiliaries,
- Control and monitoring of generator fire fighting system,
- All condition monitoring of Unit such as Vibration, bearing temperatures, stator and rotor temperatures, transformer monitoring etc,
- Necessary energy meters for metering,
- Automatic and manual synchronizing devices and one synchroscope,
- Brake dust collection system,
- Cooling water system,
- High pressure automatic lubrication system,
• Governor oil pressure unit,
• Stator heating system,
• Main inlet valve,
• Integration with unit protection devices and their monitoring as described in “Section 14 – Protection System”,
• Covered push button and necessary controller for unit emergency shut down, Emergency shut down shall be implemented with hardwired logic in addition to the emergency shut down controller for redundancy,
• Other systems not mentioned but are essential for working of the unit.

Each Unit Control Board shall perform at least the following functions:
• Monitoring of draft tube gate indications,
• Control and monitoring of inlet valve,
• Local acquisition of the logic and analog information from generator, excitation, turbine, governor, unit auxiliaries, unit protection and generator transformer, sensors and actuators,
• Local dating of events through the programmable controllers with high resolutions of 1milli second,
• Management of the unit starting and stopping sequences in automatic, local and remote modes,
• Management of emergency shutdown of the unit,
• Control of the process actuators with necessary interlocking and protections,
• Alarm supervision,
• Monitoring of protection system,
• Automatic and manual synchronization control,
• Management of the local operator terminal (HMI),
• Communication with measuring devices,
• Communication with all condition monitoring systems of the unit such as temperature-monitoring device, vibration sensors, etc,
• Communication with the other controllers and Local Control Boards and computer system through the Plant Control Network.

In manual mode, the operator shall be responsible for the good progress of the operating sequence from the Unit Control Board and Local Control Cubicles. Only basic interlocking shall be provided in order to prevent damages to the unit. Orders are initiated through Local Control Cubicles. Otherwise, when the “Local Automatic” mode is selected, all the control
and monitoring is made through the HMI of the Unit Control Board. Control from the Local Control Boards shall be possible even when upper levels are out of order. In an unlikely case of failure of all redundant Unit controllers, the unit if in a stable steady state shall continue to be in the same state (on-line / stopped, etc.).

Sequence controllers shall be provided with all indications on the Central Processor Unit that are required for trouble shooting in case of failures such as:

- missing start conditions,
- missing conditions for the next control step in case of sequence fault,
- Actual step and sequence.

All status information from the logic controllers shall be also transmitted to the Central Control Room (CCR).

All necessary controls and devices shall be provided to allow manual control and synchronization of the generators from their UCBs while the basic safety interlocking and the protection remain operative.

### 13.5.5.1. Modes of operation

The following operating modes shall be selected via a key or code operated selector switch installed in the UCB:

- **OFF**  No operation possible
- **MANUAL**  Manual control from UCB
- **AUTO**  Automatic control from UCB
- **CR**  Automatic control from Central Control room
- **TEST**  Self testing diagnostics

### 13.5.5.2. Sequential control

The automatic starting and stopping of the unit shall be initiated by covered start and stop push buttons. All the component elements of the hydraulic system shall be operated according to a logic and sequential manner, which shall bring the unit to the synchronized condition and automatically synchronized or stop it completely when the stop push-button is pressed.

Video mimics on VDUs of the Central Control Room shall indicate all step indications. All indication signals shall be disabled/switched-off, when status "stand still" or "general overhaul" is achieved.

The controllers used for sequential control shall be provided for the following operating modes:

- Automatic control,
• Step by step control,
• Test.

Simulation of the input signals by setting, while input cards shall be blocked

Complete program tests, while output cards shall be blocked

13.5.5.3. Manual control of unit

Unit Control Boards shall be provided with all features, accessories, wiring, indications, and meters that are necessary for manual control of the unit locally through the unit programmable controllers. It shall be possible to operate generator circuit breaker from UCB even when upper control levels are out of order.

13.5.5.4. Alarms

Each Unit Control Board shall be provided with an Alarm and Annunciation System with all equipment to achieve the required functions, such as alarm units, Annunciation panels, horns, transmission facilities.

13.5.5.5. Temperature measurement

A temperature scanner and printer shall be installed for the winding and bearing temperatures including all necessary sensor cabling. The printer shall print out the temperature values except alarms on request only in the control room. The scanner shall have two alarm settings for high temperature adjustable over the entire range. The scanner shall scan the temperatures periodically - cycle time less than 5 seconds - and shall print out an alarm in the control room with identification immediately after occurrence.

The system shall be capable of handling at least 50 temperature sensors and shall measure all temperatures at the equipment of the pertaining unit.

Temperature measurements shall be available on the HMI of the UCB and shall be printed out in the control room on demand.

13.5.5.6. Generator step up transformers

All Generator step up transformers shall be monitored, controlled and supervised with the electrical system delivered with “Generator Transformers” for temperature, cooling water system and fire fighting system.

13.5.5.7. Synchronizing equipment

Synchronizing facilities shall be provided from control room to allow automatic synchronizing of the units. Local Control Boards shall have the features to synchronies units both manually and automatically.
The fully automatic synchronizing devices shall be of the electronic type, complete with all auxiliaries for automatic connection of the generators to the grid.

The circuit-breaker closing time max. admissible frequency and voltage difference, as well as the control time shall be adjustable.

Selector switches Off/Test/Manual/Automatic and all necessary instruments for manual synchronizing shall be provided at the Unit Control Boards.

The automatic synchronizing shall also be possible when the generating units are controlled locally from their respective Unit Control Boards and plant control network is non-functional.

13.5.6. LCB for electrical power supply service

One LCB shall cater to the electrical power supply needs of all the powerhouse equipment and auxiliaries. The board shall perform control, metering and monitoring of the following general functions:

- Electrical power supply distribution including DG sets, Unit tap off Transformers, Station Auxiliary Transformers, all 0.415 kV boards including UAB/SSB and 11kV switchgear,
- 220 V DC / 48 V DC supply,
- Protection interfaces for all the above systems.

All MV and LV switchgear including DG sets and spare panels if any shall be remotely controllable. All start-up sequences, interlocking and switching operations of MV and LV switchgear shall be controlled from this LCB.

13.5.7. LCB for Common & Station Services and Dam control

The LCB shall cater to the common services of the power station and shall perform control and monitoring of the following general functions:

- High Pressure compressed air system for oil pressure units,
- Low pressure compressed air system for brake and service air,
- Cooling water system,
- Drainage and dewatering system,
- Ventilation and air conditioning system,
- Fire fighting system,
- Any other station services,
- Dam control.

For Communication/data transfer from Dam site equipment, RTU at Dam site and OPGW from dam RTU to this LCB with all necessary provisions
shall be provided. RTU shall be physically located at the dam site and shall include power supply, transducers and cables to connect dam site equipment for control and monitoring reservoir level, intake gates, spillway gates, sluice gates, inflow, spillages, Dam power supply etc. The LCB shall also include Tail water level and downstream discharge monitoring. It shall continuously monitor trash rack for plugging conditions. All necessary provisions shall be provided for data acquisition and analysis of parameters from dam and water conductor system in powerhouse computers and also to display the same on request.

13.5.8. LCB for 420 kV GIS control

One (1) number of LCB shall be provided for control and monitoring of 420kV GIS & pothead yard and monitoring of dam site parameters. The LCB shall perform the following general functions:

- Local controls and monitoring of complete 420 kV GIS system,
- Protection interfaces of complete 420 kV GIS system,
- Power Line Carrier Communication.

420 kV GIS & Pothead yard shall be supervised, interlocked and controlled from this Local Control Boards. Necessary control and alarm functions along with data acquisition of parameters shall be provided. The protection cubicles described in Protection Package shall be integrated into the respective LCB as a protection panel. All the bays shall be controlled and operated safely, reliably and efficiently in all modes of control i.e., remote, local and manual. The Control Boards shall cover the following:

- Complete protection and monitoring equipment of the GIS and Pothead yard
- Operation of Breakers with various interlocks,
- Operation of Isolators with various interlocks,
- Interfacing of various protections of lines / feeders and Bus Coupler as applicable,
- Metering of all lines / feeders as applicable.

13.5.9. Router/Gateway for Remote monitoring and operation

It shall be the responsibility of the Contractor to provide necessary routers/gateways, interfacing and other accessories for remote operation and monitoring of Parbati H.E. Project Stage-II. This shall be used for Supervisory control of the entire Parbati basin with this project acting as Remote Control Centre or Group Control Centre of the river basin. The communication protocol shall be based on IEC 60870-5 series standards.
13.5.10. Router/Gateways for remote data transmission to Corporate Monitoring Centre and Load Despatch Centre

Router / gateway with necessary firewall functionality, interfaces and accessories shall be provided suitable for following communication/data transfer:

- Power house to Corporate Monitoring Centre through NHPC’s CUG SCPC PAMA VSAT network,
- Power house to Regional Load Despatch Centre through PLCC.

It shall be the responsibility of the Contractor to provide implementation profile during detailed engineering for examining the interfacing with profile of RLDC and Corporate Monitoring Centre for effective compatibility of data transmission and shall be responsible for final integration of specific plant data.

13.5.11. Local control cubicles

Separate Local Control Cubicles (LCC) provided for unit auxiliaries, Station services and Common services shall be controlled along with complete sequence interlocks from the LCC itself, corresponding Local Control Board and also from the Central Control Room.

All logics with I/O connections for manual as well as auto operation of the auxiliary shall be built into Local Control Cubicles. Each Local control Cubicle shall be able to perform all its functions in auto and manual modes even when corresponding Local Control Board is not functional or even when communication between LCB and LCC is not established. Each Local Control Cubicle shall be supplied with two selector switches; one switch for selecting between remote operation and local operation and another switch for selecting “Local Auto” mode and “Local Manual” mode. The local control systems shall be controlled locally, from their respective Local Control Cubicles when selector switches are used for “Local Manual” mode.

13.5.12. Software

All software along with necessary licenses, required for performing intended duties in an efficient manner, shall be provided in addition to the software explicitly specified for each individual equipment. The source codes of project specific application software shall be the property of the Employer. The software shall be modular in structure, facilitating changes and extensions of the system. Complete literature including program listings in source language for application and customized application software shall be provided. All documentation and computer print-outs shall be in English only. All software shall comply with open system standards, shall make optimal use of CPU, main memory, and disk space, and shall not cause any problem for the operating systems.
13.5.12.1. Operating system

The operating system shall be latest Windows based network operating system available at the time of supply with a standardized, user friendly look and feel. All Servers shall be based on latest Enterprise edition of windows based Server operating system available at the time of supply.

13.5.12.2. Application software

The purpose of the Application Software is to allow a complete control and monitoring of the plant. The Application Software shall be structured in various levels. The lowest level shall assure system performance and contain basic functions / Application programming interfaces (API), which shall not be accessible by the application and maintenance Engineer for modifications. In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard modules built as functional block elements based on Object Oriented Programming Standard programming language. The functional blocks shall be documented, thoroughly tested and formed into a library. The software shall be implemented in the computer systems of the control room. All operating parameters shall be modifiable by the operator and necessary interfaces /mimic views/ forms shall be provided for assigning set points with respect to voltage, load settings etc, assigning unit priorities, and giving direct orders/commands to the system.

All necessary provisions such as firewalls and other security measures shall be strictly implemented so as to insulate the Control system, networks, plant data bases etc. from unwanted intrusions.

13.5.12.3. Operation Optimization Software:

The Contractor shall develop and supply suitable software for providing on-line optimum scheduling of machine operation for generation considering Availability Based Tariff (ABT) provisions of Indian Power Sector, efficiency of generators, input conditions and load forecasting. The software should be capable of analysing and arriving at optimum load combination to be delivered by group of most efficient generators amongst the available ones matching with the inflows and the prevalent head conditions. The software shall consider all optimisations including cascade/tandem operation of Parbati basin projects, necessary to ensure minimum cost of generation with maximum machine availability. The software shall enable the SCADA system to operate according to a Load Schedule modifiable by the plant operators at any time.

13.5.12.4. Power house intranet

The software supplied by the Contractor shall also include a Power House Intranet Site containing complete information in web pages regarding the working of the power plant with all status reports and information, Maintenance procedures, drawings and detailed documentation of all the equipment of the powerhouse.
The Intranet and its web pages shall be designed to provide access to information of the powerhouse and other details from any computer connected to the Central Control Room Network with appropriate passwords and Access Restrictions at different levels. The Intranet site shall be complete in every aspect with necessary web server and other peripherals, containing full details of all powerhouse equipment, their maintenance procedures, drawings etc. The Contractor shall supply any other software necessary to run, maintain, update and modify the Intranet. The Intranet and its web pages shall be so implemented as to present information in a well-organized and easily understandable manner for use by persons without any technical background.

13.5.12.5. On-line help and diagnostic system

Apart from the printed documentation manuals, the Contractor shall also provide all of his documentation online including equipment drawings and other details. The basic features of online help shall include but not restricted to the following:

- Operator Manual detailing all aspects of the Control system,
- Engineering drawings of equipment,
- Maintenance Manual describing any maintenance duties which need to be carried out on the Control system,
- Troubleshooting Guide outlining how to resolve numerous difficulties and problems, which operators may encounter with either the control system or the equipment being monitored by the Control system.

This documentation shall provide extensive cross-references and search facilities to aid during training and familiarization period and to increase efficiency afterwards.

A comprehensive diagnostic system shall be provided to assist the operator in minimizing the downtime. The system shall guide the operator:

- to analyse all available information,
- diagnose the problem,
- resolve the problem.

Any information that is available to the control system shall be presented to the operator in a clear and consistent manner. Necessary diagnostic screens containing status information shall be provided.

13.5.13. Process Control Networks

13.5.13.1. Central control room network

A separate control room network shall be used in the control room to link the Operator’s Workstations, Engineering Stations, Training Simulator, and other peripherals. Central control Room network shall be redundant.
Optical Fiber cables, based on the TCP/ IP Ethernet Standards at 1GBPS data transfer rate. The separate Control Room Network shall ensure to relieve the Plant Control Network from print jobs and to dedicate the later only for transferring process data.

The Control Room Network shall be extendable to connect Power House LAN installed in the power plant. The plant computers and servers shall be connected to this network, through routers and firewalls which shall be provided with the Central Control Room Network to restrict unauthorized access to the control room network and other process networks.

The network shall have redundant Network Attached Data Storage Systems necessary for automatic backup of online process data. The fiber terminations for the central control room Network (LAN) shall be housed together in a closed unit along with the necessary switches.

13.5.13.2. Plant Control Network

The data transmission between the Local Control Boards and the workstations shall be implemented through a redundant fiber optic Plant Control Network. The network shall be based on ETHERNET standard and use of TCP/IP protocol. 1GBPS data transfer rate shall be used to guarantee fast and reliable data transmission. The two redundant optical fiber buses shall be routed through physically different paths.

13.5.13.3. Power House LAN

Redundant Fiber optic Power House LAN of 1 Gbps transfer rate complete with Gigabit Ethernet LAN switches for at least 24 connections spread across the powerhouse area, all necessary interfaces, routers for LAN/WAN connectivity, connectors, Power Supply, UPS and other accessories shall be provided. Suitable number of Wireless LAN hot spots with all necessary accessories including 24-port wireless switches, access ports etc, shall also be provided for coverage in the areas of Training Hall, Conference Room and Machine Hall Floor.

Six(6) Plant Computers and two medium level servers of latest technology and hardware, available at the time of supply, shall be supplied for supervisory and maintenance functions by various departments, laboratories and workshops in the powerhouse. The configuration of these computers shall be subject to the approval of the Employer. The two Servers shall be used for Administration Control of the Power house LAN, Management and Inventory and Web Server for the Intranet site. Latest Windows based Network Operating System shall be pre-loaded on these servers. All Plant Computers shall be preloaded with latest professional version of Microsoft Office suite along with any other application software required for performing their intended functions. All the three servers in Power house LAN shall be preloaded with latest Developer version of Microsoft Office suite along with any other application software required for performing their intended functions.

Each of these computers shall have a high-resolution 20”, flicker-free TFT flat screen colour monitor. These computers shall be furnished with all
connectors, I/O cards, interfaces, UPS, software etc that are necessary to connect them to the Power house LAN. These computers shall be pre-loaded with all software necessary to access and process information of the power plant. Appropriate passwords and access rights shall allow the users of these computers to access relevant data of the power plant such as trends, reports, alarms etc.

13.5.13.4. Bus system

The data transmission shall be through redundant optical fiber cables.

The bus systems shall be self-monitoring type. The main characteristics of the bus system shall be as follows:

- High reliability of communication realized by double bus (redundant) system. The two systems shall continuously operate separately only in case of traffic interruption on one bus, the other shall take over the traffic. By this principle all bus couplers, bus interfaces etc. shall be coupled with one active and one stand-by device forming a complete system,

- The bus-systems shall be physically redundant installed on different routes,

- Real time, full duplex data transmission rate, of at least 1Giga Bytes per second shall be provided,

- Interfaces shall be according to relevant IEC standards.

13.5.13.5. Optical fiber

Design of optical fibers shall be in accordance with recommendations and practices of relevant IEC standards and ITU-T series standards.

Optical source safety shut off shall be provided to prevent exposure to laser light during maintenance. Equipment shall have sufficient test points to facilitate complete monitoring of the equipment performance without service interruption. Fibers shall be designed to limit degradation after thirty years of intermittent exposure to stagnant water, ambient temperature and 100% relative humidity conditions.

The availability of 1 Gbps data channel between two remote stations shall be greater than 99.99% and this availability shall consider a maximum mean-time-to-repair (MTTR) of 2 hours.

The Dam site shall be linked to the Power Station through fiber optic cables. The link shall provide facilities for voice and data channels required for control and monitoring system, Security and Surveillance system, Public Address System etc. Each optical fiber cable shall consist of at least 12 cores and shall be of single mode type.
13.5.13.6. Communication interfacing

Dedicated bandwidth VSAT communication forming part of Employer’s CUG (Closed User Group) network shall be provided by the Employer for data transmission and communication between power house control room and corporate office control room. The VSAT link shall be a SCPC PAMA link.

The Contractor shall provide router/gateway with necessary firewall functionality, interfaces and accessories suitable for communication between power house control room and corporate office control room through Employer’s CUG (Closed User Group) network. The interfaces on the router to which VSAT IDU shall be connected should be serial WAN interface catering to speed of at least 2 MBPS or higher for which technology is commercially available at the time of supply.

The Contractor shall perform network testing in order to demonstrate all the network features desired.

13.5.14. Audio visual alarm system

Each Local Control Board shall have its independent facilities for Alarm and Annunciation. The system shall be complete with Horns, alarm network/cabling etc. In addition to the above, all alarms shall be presented to the operators in the central control room through audio visual indications. Suitable provisions shall be provided at all Local Control Boards including Unit Control Boards such that the audible alarms shall be activated or deactivated and option shall be available for freely selecting the location for annunciation of audio alarms - either at operator workstations of Control Room or at respective Local Control Boards. Alarms may be acknowledged from only one operator station at a time.

- There shall be an alarm manager function catering to all the alarm services in the Central Control Room.
- Proper mechanism for sorting and filtering of alarms shall be provided.
- Each alarm shall be time tagged.
- There shall be classification of alarms at least for four levels of priority each priority being associated with a distinguished colour code.
- Each raised alarm shall be provided with a suggestive course of action associated with its alarm display window to aid the operator in quick assessment of the fault.
- There shall be proper filtering of the alarms thus eliminating non-significant alarms in a systematic manner.
- Alarms are to be classified at least by the following views:
  - alarms by degree of priority,
  - alarms by mimic view,
alarms by functional subset.

During remote operation from the Central Control Room, the audible sound shall be silenced by automatic acknowledgement after 1 min.

13.5.15. Data logger and data storage system

An on-line Data Storage and Retrieval System shall be provided for the power plant. It shall be located in the Central Control Room area and shall be equipped with storage media for real time data storage and for archival purposes. The data logger of the system shall receive, update, print out and show on the VDU's all signals, events, alarms, status, status change, abnormalities and history data of plant and ambient conditions either periodically, on request or immediately in case of alarm.

All real time plant data shall be stored on high performance, high capacity and redundant Network Attached Storage (NAS) systems to store the plant history data up to the power plant's lifetime. The information stored by these storage appliances shall be available on-line with automatic “hot” backup of on-line data and ready to be shared by clients and servers on the Central Control Room Network and Power house LAN. The NAS devices shall have open system architecture to connect them to other vendors' equipment. This centralized data storage system shall use fast read/write optical backup medium such as re-writable CD-RW media using CD writers or high performance tape drives. Storage media shall be provided for 20 years of storage.

One dedicated Relational Database Management System based on latest available version of ORACLE RDBMS database software, with necessary network user licenses covering all the workstations and computers shall be provided.

The database should be compatible and have interfaces with existing NHPC's MMS software, which uses ORACLE RDBMS as backend database and Visual Basic as front end by a 12 digit unique material codification schema. Development of database of all the operational parameters of power house, spares, tools and other items, compatible with above software, shall be included in the scope of supply.

The Data Storage system shall be a 24 X 7 X 365 type storage database consisting of time tagged event logs with versatile data retrieval tools in the form of curves and in the form of chronological lists of tagged events.

13.5.15.1. Trending and charting

The system shall provide detailed variable monitoring functions for trending and charting. Detailed list of features and functions shall be approved by the Employer during detailed engineering. The trend curves of variables should have selectable sampling ranges. Both time and value scales shall be modifiable by the operator.
13.5.16. **Video Display Units (VDU) and key boards**

All monitors/Video display units (VDU) supplied shall be flicker free, SXGA resolution, flat screen TFT colour monitors of 20” or above diagonal screen size and shall support. The pertaining software shall be included in the scope of supply.

The desk shall be equipped with keyboards, assisting the operator in easy operation of the power plant. Special care shall be taken in designing the keyboards taking ergonomics into consideration. The keyboards and keypads shall be of sealed membrane type suitable to withstand high humidity environments. It shall be possible to operate the plant via the coded numbers and via function groups and loops to be called up directly from the function keys of the keyboard.

13.5.17. **Printers**

Following printers shall be supplied

- Colour Alarm printer,
- Event and data logging printer,
- A3 size Colour Hard copy printer,
- A3 size Two Nos. of heavy duty black & white laser printers,
- High quality colour Plotter.

The selection of peripherals shall take into consideration aesthetics with noise level not to exceed than 60 dB. All the printers shall be of heavy-duty, high speed laser type. Print speed for monochrome printers shall be at least 15 pages per minute and that of colour printers shall be at least 4 pages per minute. All peripherals shall be provided with necessary desks, paper baskets and noise absorption provisions.

13.6. **Drawings, Documents and Design Calculations**

13.6.1. **Design memorandum**

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 1.6 “Record and Documentation” of “Section 1- General Technical Requirements.”

13.6.2. **Drawings and documents**

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in “Section 2 - Technical Documents” of “General Technical Specification (GTS)”.
13.6.3. Design calculation

The Contractor shall submit the design calculation in accordance to Clause 2.6 of “General Technical Specification (GTS)” covering at least the following, for review / acceptance.

- Calculations to prove the overall availability of the system in accordance with “performance criteria and guarantee” for top order event as specified.

13.7. Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.7 “Delivery, Installation and commissioning” of “Section 1 - General Technical Requirements”.

13.8. Spare Parts

Recommended spare parts shall be supplied in accordance to clause 1.8 “Spare Parts” of “Section 1 - General Technical Requirements”. Specified spare parts to be supplied under this section are as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time Synchronizing network cables with connectors</td>
<td>1 nos.</td>
</tr>
<tr>
<td>2</td>
<td>Power supply modules/unit and cards- type / model used</td>
<td>4 sets of each used type</td>
</tr>
<tr>
<td>3</td>
<td>Network Interface Cards of type / model used</td>
<td>4 sets of each used type</td>
</tr>
<tr>
<td>4</td>
<td>Other plug in cards type / model used</td>
<td>4 sets of each used type</td>
</tr>
<tr>
<td>5</td>
<td>Operator Workstation complete with all accessories</td>
<td>1 nos.</td>
</tr>
<tr>
<td>6</td>
<td>Data storage drives of each type / model used</td>
<td>1 nos.</td>
</tr>
<tr>
<td>7</td>
<td>Modem of type for every ten (10) or less installed</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>8</td>
<td>Repeaters of type / model used</td>
<td>2 sets of each used type</td>
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<tr>
<td>9</td>
<td>Optical fiber coupling unit</td>
<td>10% of installed quantity</td>
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<tr>
<td>10</td>
<td>Connectors, patch chords etc. of type / model used</td>
<td>10% of installed quantity</td>
</tr>
<tr>
<td>11</td>
<td>Networking components.</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>12</td>
<td>Recorder of type /model used</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>S. No.</td>
<td>Description</td>
<td>Quantity</td>
</tr>
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<td>--------</td>
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</tr>
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<td>13</td>
<td>Synchronizing device with all accessories</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>14</td>
<td>HMI panel of type / model used</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>15</td>
<td>Measuring transmitter of type / model used.</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>16</td>
<td>Sensors /transducers of type and model used.</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>17</td>
<td>Indicating instruments of type / model used.</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>18</td>
<td>Relays of type / model used.</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>19</td>
<td>Router / gateway with necessary firewall functionality</td>
<td>1 no of each used type</td>
</tr>
<tr>
<td>20</td>
<td>Optical fiber consumables requirement for 2 years for all networks</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>21</td>
<td>Programmable controller of type</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>22</td>
<td>Network switch of type</td>
<td>2 sets of each used type</td>
</tr>
</tbody>
</table>

13.9. **Tools & Instruments**

The Contractor shall supply all necessary tools and instruments etc. for installation, repair and maintenance in accordance to clause 1.9 “Tools and Instruments” of “Section 1 - General Technical Requirements”.

13.9.1. **Special tools**

The Contractor shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), to be accepted by the Employer.

The proposed list of special tools must include the following in addition to tools recommended by manufacturer(s):

- Two (2) nos. of complete single mode fiber networking and maintenance tool kits,
- Two (2) sets of crimping tools of each type used for installation of networks and cabling,
- One (1) set of PC / laptop based protocol conformance test equipment complete with all accessories, tools and software for testing each protocol standard used in the control system,
- Two (2) sets of logic analyser tool,
- One (1) set of programmable controller test equipment of each type for every ten (10) or less installed,
One (1) set of network performance analysers, network testing and certification tools,
One (1) set of optical time domain reflectometer,
One (1) set of optical fiber certification tools to measure loss, length and compliance to standards.

13.10. Quality Assurance and Testing

The Contractor shall follow the quality assurance and testing requirements specified separately in “Quality assurance and Testing Specifications (QTS)".
14. PROTECTION SYSTEM

14.1. Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to NHPC and guarantee for two years of Protection system, as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

14.1.1. Generating unit and Generator-transformer set protection

Four (4) sets of protection equipment for the generating unit and Generator transformers covering

- 87G Generator differential protection,
- 87GT Generator-transformer over all differential protection,
- 26G Generator winding temperature alarm and trip,
- 38 Generator and turbine bearings temperature alarm and trip,
- 39 Generator Vibration alarm and trip,
- 49S Stator thermal overload protection,
- 71 Bearings oil level alarm and trip,
- 46 Negative phase sequence protection,
- 50/51G Generator over current instantaneous and time delay protection,
- 32 Reverse power protection,
- 27/50G Unintentional back energisation,
- 40 Loss of field protection,
- 78 Out of step protection,
- 21G Generator back up impedance protection with timer,
- 59/81 Volt per hertz protection,
• 59G Generator over voltage protection instantaneous and time delay,
• 27 Generator Under voltage protection,
• 81 Under/over frequency alarm,
• 95FF Voltage transformer fuse failure monitoring,
• 64G1 100% stator earth fault protection (time delay),
• 64G2 95% stator earth fault protection (time delay),
• 87GS Generator split phase differential protection,
• 64F Rotor (Field) earth fault protection,
• 59F Field over voltage Protection,
• 64R Generator transformer restricted earth fault protection,
• 51NGT Generator transformer neutral over current protection,
• 71T Transformer oil level alarm and trip,
• 63 Transformer Buchholz Protection,
• 49T Generator transformer winding temperature alarm and trip,
• 26T Generator-transformer oil temperature alarm and trip,
• Transformer oil pressure protection,
• Shaft Current Protection.

14.1.2. 420kV GIS protection

Protection equipment for 420kV GIS bays for generating units, bus bar, bus coupler, 420 kV outgoing line feeders bay protection:

i) Four (4) sets of Generating unit bay protection covering
• 50Z Local breaker failure protection,
• 50/51 Transformer Over current protection.

ii) One (1) sets of Bus coupler bay protection covering
• 50Z Local breaker failure protection,
• 50/51 Over current protection.

iii) One (1) set of Bus bar protection covering
• 87B Differential protection (Bus1 and 2),
• 95 BB CT wire supervision relay (Bus1 and 2).
iv) Two (2) sets of Non-switched 420 kV Transmission line feeder bay protection covering

- 50Z Local breaker failure protection,
- 21 Numerical Distance relay protections – main-I and main-II both numerical,
- 78 Power swing blocking protection,
- 67 Directional over current and earth fault protection,
- 79 Autoreclosing Relay,
- 25 Check synchronizing relay,
- 27 Under voltage protection,
- 59 I/D Over voltage protection (instantaneous and time delay),
- 97L1 and L2 Line CVT fuse failure protection,
- Fault locators.

14.1.2.2. 11 kV switchgear protection

Fourteen (14) sets of Protection equipment for incoming / outgoing and bus coupler bay of 11 kV switchgear covering

- 50/51/51N Instantaneous and time delay over current and earth fault protection,
- 27 Under voltage protection for incoming bays only.

14.1.2.3. Unit Tap-off Transformer and SAT protection

i) Eight (8) sets of protection equipment for Unit Tap-off Transformer and SAT covering

- 49 Transformer winding temperature alarm and trip protection,
- 50/51/51N Instantaneous and time delay over current and earth fault protection on HV as well as LV side,
- 64R Restricted earth fault protection.

14.1.2.4. Excitation Transformer protection

Four (4) sets of protection equipment for excitation transformer covering

- 49 Transformer winding temperature alarm and trip relay,
- (50/51) Instantaneous and time delay over current protection.
14.1.2.5. Other protections and provisions

i) Protection of 415 V switchgear,

ii) Protection of 11kV XLPE cable,

iii) AC and DC supplies for power house,

iv) Necessary ICTs, relay panels, marshalling boxes, isolating and shorting links, etc.,

v) Provision of necessary contacts and/or ports for integration with plant SCADA system,

vi) One (1) set of spare parts in accordance to clause 14.8 “Spare Parts” of this section,

vii) One (1) set of tools and instruments in accordance to clause 14.9 “Tools and Instruments” of this section.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

14.2. Specific Parameters and Layout Conditions

14.2.1. Layout and General Arrangement

Protection shall be provided through relays, which shall be Numeric type protection relays. All integrated numeric protection for Generator and Generator transformer shall be provided with 100% redundancy of relays as well as CTs as indicated in the drawing NH/DEM/PBT-III/CP/02. Generator Protections and Generator Transformer Overall differential protection shall be covered by two completely independent CTs.

The 11 kV incoming feeders from 4 MVA Unit tap-off transformers, 1.0 MVA DG sets and local sub station shall be protected for instantaneous and time delay over current and earth fault protection and under voltage protection (50/51/51N and 27 relays). All outgoing feeders of 11 kV switchgear shall be protected for instantaneous and time delay over current and earth fault protection, (50/51/51N). The protection relays shall be installed on 11 kV switchgear.

415-volt incoming feeders from all transformers and interconnecting breakers between UAB and SAB shall be protected for instantaneous and time delay over current, earth fault and under voltage protection (50/51/51N and 27 relays). The relays will be installed on 415V switchgear.

All required protection system for 220V and 48V DC system shall be supplied along with DC system. The Designer of protection system shall, however, co-ordinate for making all necessary provisions.

All required protection system for DG sets shall be supplied along with DG sets. The Designer of protection system shall, however, co-ordinate for making all necessary provisions.
11 kV XLPE cables connecting 4.0 MVA, 13.8/11 kV Unit tap-off Transformers to 11 kV switchgear shall be covered by Restricted earth fault protection of Tap off transformer. 11 kV XLPE cable connecting 11 kV switchgear to SATs shall be covered by over current protection of 11 kV feeders. 11 kV XLPE cable from DG set to 11 kV switchgear shall be covered in differential protection of DG set.

Protection system shall be complete in all respect. The protection scheme shall also be coordinated with fire protection system for generator, generator-transformers and other areas which may affect the generating units.

The detailed scope of supply given in relevant clause is indicative only. However, all protection as per relevant IEC standards shall be provided in accordance of the capacity of this size of the machine.

The transmission line bays shall have distance protection with three stages with inter-tripping and blocking being carried out over a PLCC link. Main-II protection is provided by another distance protection scheme. Both distance relays should have over current and earth fault protection features.

A single line diagram of the main electrical equipment of the power plant and its protection scheme is shown on the Drawings no. NH/DEM/PBT-III/CP/01 and NH/DEM/PBT-III/CP/02. The requirement of number of current transformers may need to be examined and reviewed in view of the installation of latest state of art protection relays proposed to be installed.

All the relays shall be of reputed make with proven performance. The relay must be in operation for at least three years in three power plants in equivalent voltage level substation.

In accordance of above, the type of protection shall have to be got approved from the Employer before supply / despatch. In integrated protection scheme, the Contractor shall ensure 100% redundancy. The contractor shall certify for availability of spares at least for 10 years from the scheduled date of commissioning.

Tripping signal from protection relays shall be hardwired for shut down of machine and tripping of circuit breaker.

The Contractor has to revise/upgrade the system during detailed engineering if the offered system does not meet all the requirement. The system should be state of art/latest model available at the time of supply. If the protection system mentioned in the awarded contract become obsolete at the time of supply, the Contractor shall offer a latest model without any extra cost to NHPC.

14.2.2. Time synchronisation

All relays, disturbance recorders, event recorders etc. shall be time synchronised through universal time synchronisation system as described in “Section 13 -Control and Monitoring (SCADA) System”.

PROTECTION SYSTEM 14-5
November-2005
14.3. Rating and Functional Characteristics

The system shall provide a high degree of selectivity and discrimination between faulty and healthy circuits. A microprocessor based modular system associated with a human machine communication interface shall be preferred.

All devices shall remain inoperative during internal faults and transient phenomena. They shall be insensitive to mechanical shocks, vibration and external magnetic fields.

All relays shall be suitable for local and remote reset. They shall have self-monitoring facilities and LED status indication.

Service voltage failure and any fault in relays and tripping circuitry shall be indicated.

Tripping circuits shall be operable at 70 % nominal voltage.

CTs shall be shorted automatically, when relevant modules are withdrawn.

Main and back up protection system shall be separated and shall have individual power supply from different source.

The relays shall be provided with the following information, suitably located:

- Function of relay,
- Phase identification,
- Main characteristics.

The protection system shall be divided into protection groups and subgroups. Each protection group shall consist of solid state numerical protection, auxiliary relays, tripping unit and all accessories as required and further specified in the following sections.

The protection groups are defined as follows:

i) Mechanical protection for the generating units,

ii) Electrical protection for the generating units (two sub-items),

iii) Transformer protection for the GSU transformer, Unit Tap-off transformer and excitation transformer,

iv) Station Auxiliary transformers,

v) 420 kV GIS,

vi) 400 kV transmission line protection,

vii) 11 kV switch gear protection (To be provided in 11 kV switchgear panel),

viii) 415 volt switch gear protection (To be provided in 415 V switchgear panel),

ix) 220 volt DC and 48 V DC switch gear protection (To be provided in DC
Each protection group shall be divided into two subgroups. The division shall be maintained throughout to the tripping coils and shut down solenoids. Each breaker and shut down device will be equipped with two tripping coils or solenoids.

The protective equipment for the generating units shall be installed in the Powerhouse along with UCB.

14.4. Performance Guarantee

The protection system along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

14.5. Design and Construction

14.5.1. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

<table>
<thead>
<tr>
<th>Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60255</td>
<td>Electrical relays</td>
</tr>
<tr>
<td>IEC 60870-5-103</td>
<td>Telecontrol equipment and systems</td>
</tr>
<tr>
<td>IEC 60044-2</td>
<td>Instrument transformers - Part 2 : Inductive voltage transformers</td>
</tr>
<tr>
<td>IEC 60044-1</td>
<td>Instrument transformers - Part 1 : Current transformers</td>
</tr>
<tr>
<td>IEC 60044-6</td>
<td>Instrument transformers - Part 6 : Requirements for protective current transformers for transient performance</td>
</tr>
</tbody>
</table>

The Contractor shall submit for the Employer’s approval, a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burden between current transformers and relays, details of the relays circuits and performance calculations.

14.5.2. Numeric relay

14.5.2.1. General Numeric Relay

The numerical relay shall have at least following features
• The relay used in protection system shall be of the numerical, and plug in type arranged in protection cubicles. All relays including all ancillary devices, such as interposing transformers, tripping matrix and relays, test facilities, power supply units, etc. with all circuits shall comply with IEC 60255 Recommendation,
• All communications of protection system with the control system shall be based on universally accepted Protocol namely IEC 60870-5-103,
• There shall be two RS232 ports one on front and the other on rear. The front port shall be used to connect the laptop locally for any change in settings/ downloading the data etc. and the rear port shall be used to inter connect the relays,
• The relay shall have preferably front panel back lit display,
• The relay shall have self monitoring features,
• All major numerical relays shall have an inbuilt disturbance recorder and event recorder,
• DR shall have at least 8 Analog and 16 Digital channels with a scan rate of minimum 1000 Hz. The output of DR should be available on COMTRADE format to enable replay on Numerical test kits. Software and hardware shall be provided for analyzing the records,
• In addition to inbuilt disturbance recorder the distance relay shall have features of fault distance locator, MW, MVAR, current and voltage display recorder,
• The event recorder shall be capable of storing a minimum of 256 digital signals including time marker with a resolution of one millisecond.

14.5.3. Mechanical / electrical protection

14.5.3.1. General

The mechanical protection for the generating units shall be connected to the relevant protective devices or sensors as described in the respective sections and upon mechanical failures shall trip the turbine-generator unit and annunciate alarms.

The mechanical protection shall consist of the necessary relays, as applicable, connected to one or a group of protection devices or sensors, and a tripping unit as described in design requirements.

The protection sensors and devices are described in the relevant sections and shall be wired to terminal blocks in different wiring cubicles.
14.5.3.2. Tripping functions

At least the following protection sensors and devices shall be used to shut down the generating unit:

- Very high temperature in Turbine guide bearing, bulb thermometers,
- Over-speed mechanical device,
- Speed supervision system,
- Electrical governor fault,
- Very low governor oil pressure, pressure switch,
- Very low oil level in governor pressure tank, level switch,
- Very low inlet valve oil pressure, pressure switch,
- Very low oil level in inlet valve pressure tank, level switch,
- Very high vibration in turbine-generator, Vibration supervision system,
- Very high temperature in Generator thrust bearing, bulb thermometers,
- Very high temperature in Generator upper guide bearing, bulb thermometers,
- Very high temperature in Generator lower guide bearing, bulb thermometers,
- Very high temperature in Generator winding and core, temperature supervision system,
- Hot air temperature very high,
- Excitation system failure,
- Emergency stop push buttons,
- Starting or stopping time too long,
- Total cooling water flow too low, flow indicator Tripping shall be delayed 0-10 min., adjustable,
- Generator protection trip,
- Gen. transformer protection trip,
- Unit Tap-off Transformer and Excitation transformers protection trip.

In addition to above mentioned tripping functions the Contractor shall prepare the mechanical protection for the reception of tripping orders from minimum five protective sensors.
Any other protection devices considered necessary by the Contractor for the equipment supplied under this contract shall also be connected to the mechanical protection.

14.5.3.3. Alarm functions

All tripping functions described above shall in addition to the tripping, give alarm indication to the alarm annunciation system described in “Section 13 –Control and monitoring (SCADA) System” including:

- High temperature in Turbine guide bearing, bulb thermometers,
- High water level in Turbine top cover drainage,
- Low governor oil pressure, pressure switch,
- Low oil level in governor pressure tank, level switch,
- Low inlet valve oil pressure, pressure switch,
- Low oil level in inlet valve pressure tank, level switch,
- High vibration in turbine-generator, Vibration supervision system,
- High temperature in Generator thrust bearing, bulb thermometers,
- High temperature in Generator upper guide bearing, bulb thermometers,
- High temperature in Generator lower guide bearing, bulb thermometers,
- High temperature in Generator winding and core, temperature supervision system,
- Excitation system in trouble,
- High generator air temperature,
- Low oil level in governor sump tank, level switch,
- High oil level in governor sump tank, level switch,
- Low oil level in inlet valve sump tank, level switch,
- High oil level in inlet valve sump tank, level switch,
- Low oil level in turbine guide bearing,
- High oil level in turbine guide bearing,
- Low oil level in generator upper bearing house,
- High oil level in generator upper bearing house,
- Low oil level in generator lower bearing house,
- High oil level in generator lower bearing house,
• High temperature in excitation transformer,
• High temperature of the inlet cooling water,
• High temperature in winding of Unit Tap-off Transformer,
• High temperature in generator transformer winding and oil,
• High moisture content in GSU transformer,
• GSU transformer Buchholz relay operated,
• Oil level abnormal GSU transformer,
• Generator transformer differential pressure alarm,
• Sudden pressure release,
• High temperature in winding of Unit Tap-off Transformer,
• High temperature in winding of SATs,
• High temperature in Excitation transformer.

14.5.3.4. Over speed

To prevent over speeding of the units when tripped upon mechanical faults, tripping of excitation breaker and generator circuit breaker shall only be affected after the load-rejection. Adequately located position switches or other equally suitable system separately wired to the protection cubicle shall be furnished. The manufacture shall ensure field breaker tripping after GCB is tripped.

14.5.3.5. Starting of unit

The unit shall not be ready unless confirming at least the following status:

• Locking pin of main inlet valve released,
• Locking pin of Guide vane servomotor released,
• Tail race gate open,
• Mechanical brake released,
• Bearings oil level normal,
• Cooling water system healthy,
• Governor oil pressure normal,
• Governor AC/DC supply healthy,
• All control and protection supply healthy,
• No protection is operated.
14.5.4. Generator protection

14.5.4.1. General

Generator protection shall be provided through an integrated numeric type relay. The relay shall have all the inherent characteristics like- Simplicity, Flexibility, Reliability, Selectivity, Stability, Accuracy, Sensitivity, and Redundancy. The relay shall be microprocessor based and shall be controlled by programs. The protection device shall have provision for human machine communications interface. The programs should be externally user-friendly for operation by the operator. It should prompt the user with messages and confirmations in order to guide the user and avoid errors or incorrect situations. Provision for transfer of sets of parameter settings etc. from and to floppy disk/CD shall be there.

The device should have self-diagnosis and supervisions functions to ensure maximum availability of the protection device as well as the power system it is protecting. Any failure of hardware or software shall be signalled out immediately by alarm contacts. The external and internal auxiliary supplies should be continuously supervised. Special algorithms should be incorporated to check the processor’s memories regularly, to check the execution of the programs etc.

The operator program shall be suitable for configuration and setting of the protection, listing parameters, reading events, and listing the various internal diagnostic data. Provision shall be there for the user to create logical combinations of signals and pick-up and reset delays. Provision for detection of system asymmetric e.g. in the secondary circuits of CTs and VTs shall be made.

The device shall have provision for communication with the station control system (SCADA) via an optical fibre link.

Protection system shall be divided into lock out, non lock out, electrical emergency, mechanical emergency, controlled action shut down etc. depending on the nature of fault.

14.5.4.2. Protection function

The following features shall be furnished for the generator protection:

i) Generator Differential Protection

The generator differential protection shall be three phase current adaptive changed and high stability through fault. This shall be highly sensitive for internal faults and operating time shall necessarily be very short period to minimize the possible damage.

Setting range: 10 to 50 % of I_n in steps of 5% of I_n.

This protection shall not operate in the presence of magnetizing in- rush current and be capable of rapid tripping in the event of energizing onto a fault.
It shall detect and trip all phase and earth faults within the protection zone and shall remain stable for all faults outside the area limited by the relevant current transformers.

The pick-up ratio shall be adjustable. The tripping time shall be less than 40 ms at a differential current equal to five times nominal setting current. The bias and basic sensitivity shall be adjustable in steps.

ii) Reverse Power Protection
The typical setting values would be the following:
Reverse power: 0.5 - 5%
First stage time delay: 0-100 sec
Second stage time delay: 0-100 sec

iii) Back up Impedance Protection
Back up impedance protection shall be provided with two circular zones, each with two separate independent definite programmable time delays. This shall be used as a backup protection. The operation of back up impedance protection shall necessarily be blocked in case of failure of voltage supply to the measuring unit.

iv) Stator Thermal Overload Protection
Stator thermal overload function shall be based on $I^2t$ measurement and provided with a memory of the thermal condition of the stator. Its characteristics shall be closely matched to the generator stator winding. Varying cooling medium temperatures shall be taken into account. The heating and cooling time constants shall be settable.

v) Loss of Field and Out of Step Protection
This protection shall be provided to protect the generator from unintentional opening of field circuit breaker, opening or short-circuiting of field circuit and a fault in the automatic voltage regulator or excitation system.

The protection scheme shall detect the condition of loss of excitation and operate before the generator falls out of synchronism within a short time. In order to obtain a rapidly effective under excitation protection, as a second criterion the excitation voltage shall be introduced into the system. If both, the stability curve and the excitation voltage criteria are satisfied, alarm and trip shall be triggered after an adjustable time delay of 1-2 seconds. The loss of synchronism with the excitation being in normal operation shall be detected by an integrator, which detects the periodical entering of the vector into the instability zone.

vi) Negative Phase Sequence Protection
This protection shall distinguish between an asymmetrical load and an asymmetrical fault. It must always trip after the fault tripping relays. It shall protect the rotor iron from excessive heating and trip the generator before the permissible $I^2t$ value will have been reached. Two set levels shall be available. One fixed time for alarm and one inverse delayed for tripping.
vii) Over Current Instantaneous and Time Delay Protection
   Three-phase over current protection shall be provided for stator to avoid exceeding its current limits. Both instantaneous and inverse characteristic can be employed as applicable and necessary.

viii) Generator Split phase Differential Protection
   This protection shall detect the fault between turns of the generator winding.

ix) Over Voltage Protection
   This protection shall protect the generator against over voltages produced within the generator, for example by a failure of the voltage regulator. The relay shall operate independent of the frequency within the range of at least 0.8 - 1.2 times rated frequency. The relays shall be provided with two independent stages for delayed and instantaneous trip.

x) Under Voltage Protection
   This protection shall be used as a back-up protection against loss of excitation. It shall have a time-delayed stage. It shall operate independent of the frequency within the range of 0.5-1.2 times rated frequency. Typical setting and tripping ranges would be the following:

   Setting range: 0.5 to 1.0 Un
   Tripping time: 0-100 s

xi) Field Over Voltage Protection
   This protection shall be used for over voltage of field. The setting for field over voltage shall be based on generator manufacturer.

xii) Stator 100% Earth Fault Protection
   A complete protection of the stator winding from short-circuits between the stator winding in the slots and the stator core shall be provided. False operation must be prevented assuring reliable discrimination between a fault in the stator circuit and other transient phenomena.

xiii) Stator 95% Earth Fault Protection
   The protection scheme shall necessarily be designed to cope with the way the generator is connected to the network.

xiv) Under / Over Frequency Protection
   The scheme shall have a working range of 45 - 65Hz and an adjustable time delay of 0.5 to about 5 sec.

xv) Generator Voltage Transformer Fuse Failure Monitoring Protection
   This shall be provided for blocking of protection scheme, which may mal operate in the event of PT fuse blowing in primary side or secondary side. It shall be of voltage balance or equivalent type. It shall have sufficient contacts to block tripping of those relays, which are voltage dependent and give alarm.

xvi) Rotor Earth Fault Protection
Rotor earth fault protection shall be provided to detect the earth fault and to trip the machine with a short time delay.

xvii) Rotor Excitation Circuit Over Current Protection

An IDMT three phase over current protection shall be installed on the excitation transformer feeding side to protect the alternating current section against short circuits.

xviii) Shaft Current Protection

For detection of current in the generator main shaft, which could damage the bearings, a shaft current protection device shall be supplied, including a suitable current transformer to be connected to the test points in the generator bearings

14.5.5. Transformer protection

14.5.5.1. Generator transformer protection

The following features shall be furnished for the generator transformer protection

i) Overall Differential Protection

Transformer overall protection shall be provided for the detection of phase and earth faults on the transformer windings. The overall protection shall be of the three winding biased differential type fed from current transformers on the high voltage side of transformer winding and the generator neutral and Excitation transformer and 4MVA Unit Tap-off Transformer side.

The scheme shall have magnetizing in rush current restraint of the harmonic type and shall have individual adjustment of operation and bias settings.

All necessary interposing transformers shall be provided which shall be adequately rated to ensure correct relay performance during maximum through-fault condition.

The minimum operating settings shall not be more than 20 per cent of rated full load of the current transformers.

ii) Restricted Earth Fault Protection

Transformer windings and connections shall be protected by restricted earth fault (REF) protection; relay shall be of static type with an independent measuring unit and the necessary protection against over voltages. Each relay shall have an instantaneous trip attachment. The fault setting shall be between 10 per cent and 60 per cent of the rated current of the protected winding.

The rated stability limit shall not be less than the maximum current available for an external fault. This shall be taken as 16 times the rated current. Separate current transformers (i.e. not sharing transformer biased differential protection) are preferred.
iii) Over Fluxing Protection
This system shall protect the generator transformer iron core from excessive heating in case of voltage rises and/or frequency dips during unit operation.

iv) Buchholz Protection
All oil type transformers shall be fitted with Buchholz devices of the two-element type giving operation under gassing and under surge conditions.

v) Oil and Winding Temperature
Transformers will be provided with oil and winding temperature protection. These will be of the two stage type with adjustable settings giving alarm and trip facilities.

vi) Time Delay Phase Over Current Protection
This protection covers phase over current in transformer HV side and adjacent network.

vii) Transformer protection shall also include:
- Differential pressure alarm and trip,
- Sudden pressure release alarm and trip,
- Low/high oil level alarm,
- Low oil and water flow alarm.

viii) Arrangement of Transformer Protection Trip Circuits
Transformer protection tripping circuits shall be arranged as follows to form two complementary groups.

<table>
<thead>
<tr>
<th>Group 1.</th>
<th>Group 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator Transformer biased</td>
<td>Generator Transformer biased</td>
</tr>
<tr>
<td>differential (main)</td>
<td>differential (Duplicate)</td>
</tr>
<tr>
<td>GT neutral over current and trip.</td>
<td>Phase over current and trip</td>
</tr>
<tr>
<td>Winding temperature trip</td>
<td>HV winding REF</td>
</tr>
<tr>
<td>Buchholz main tank</td>
<td>Oil temperature trip</td>
</tr>
<tr>
<td>Over fluxing protection</td>
<td>Sudden pressure release alarm and trip</td>
</tr>
<tr>
<td>Differential pressure alarm and trip</td>
<td></td>
</tr>
</tbody>
</table>

Each trip relay shall be arranged to operate onto both trip coils on the 420 kV circuit breaker.

14.5.6. GIS protections
420kV GIS protection of the high speed, low impedance, circulating current type shall be provided capable of detecting three phases, phase-
phase and phase to earth faults, under all system generation plant conditions.

The operating time of the measuring relays shall be as short as possible consistent with reliable and secure operation.

The bus bar protection shall be fed from separate CT cores reserved for it.

i) Bus Bar Supervision Protection

Automatic and continuous supervision of current transformer circuits shall be provided to give an alarm when the out-of-balance current reaches an undesirable value. Operation of current transformer supervision equipment should block the protection after a time delay and shall initiate an alarm.

ii) Bus Bar Differential Protection

Three-phase bus bar differential protection including the number of systems and auxiliaries required for the complete bus bar protection system for the H.V. switchgear configuration shown on the drawings.

The bus bar protection shall have the following features:

- The bus bar protection system shall have two criteria. One is to check overall bus differential current without using isolator contacts. The other criteria are to check discriminating zone bus differential current with isolator contacts,
- Bus bar protection shall be comprised of main zone-1 and main zone-2 protection relays for bus 1 and bus 2 respectively,
- Each circuit-breaker trip relay shall be arranged to trip both trip coils on the circuit breaker, i.e., each circuit breaker shall receive two trip commands for a fault. In the case of feeder circuits, operation of bus bar protection trip relays/ LBB shall initiate direct transfer tripping of the remote end circuit breaker via PLCC.

Suitable voltage limiting devices should be provided as necessary.

High speed differential bus bar protection shall cover following features:

- The rated stability limit shall not be less than the three phase symmetrical breaking capacity of the associated switchgear,
- The fault setting for any type of fault shall not exceed 30% of the minimum fault current available,
- Current transformer knee, point voltages shall not be less than twice the relay circuit setting voltage,
- The maximum peak voltage across current transformer secondary wiring shall not exceed 3kV under maximum internal fault conditions,
- Associated current transformers shall be class PS, low reactance type. Split core type current transformers will not be accepted.

iii) Breaker Failure Protection
Breaker failure protection shall be fitted to all 420 kV circuit breakers. The breaker failure protection on a circuit breaker shall be initiated by all the other protection devices, which normally initiate tripping of that breaker. In the event of the circuit breaker failing to open within a preselected time, the breaker failure protection shall initiate tripping of all adjacent CB’s connected to the same bus bar, and direct transfer tripping of the line breakers, via tele-protection channels over PLCC, as appropriate.

Full selectivity shall be achieved for every bus bar zone, hence the replica of every feeder isolator, bus isolator, coupling circuit breaker shall be incorporated by using combinations of NO and NC contacts on each isolator or breaker.

14.5.7. Overhead line protection

14.5.7.1. 400 kV Line

The following features shall be furnished for the overhead line protection: -

i) Distance Relay (Main-I and Main-II)

Distance protection shall be non-switched numerical type, comprised of minimum three-zone distance operation. The distance protection shall operate for all types of phase and earth faults. Separate phase and earth fault distance measuring elements shall be provided. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

Zones 1 and 2 shall operate only for faults in the protected direction. Under no circumstances shall the relay operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases. Details of methods used for polarizing relays to deal with faults close to the relaying point shall be provided. The relay characteristics shall ensure adequate fault resistance cover under minimum plant and single outage conditions. Zone 3 shall be non-directional and shall be capable of being independently offset in both directions.

Starting shall be by impedance measuring relays, over current starting shall not be accepted. The relay characteristic shall cover the protected line plus the longest line emanating from the remote station taking current in-feed into account. The starting relays shall not operate during maximum power transfer. During single phase to earth faults coinciding with maximum power transfer, only the starting relay associated with the faulted phase shall operate.

The reach of each measuring zone and starting relay shall be individually adjustable. The characteristic angle shall be adjustable between approximately 40 and 80 degrees.

Zone 2 and Zone 3 shall have a time delay setting range of minimum 0.2 to 1.0 second and 0.5 to 3.0 seconds respectively.
The sensitivity of the protection shall be adequate for definite operation under minimum plant and single outage conditions and shall not exceed thirty percent (30%) of rated current.

The operating time of each zone shall be substantially independent of fault current magnitude.

A feature shall be incorporated to ensure instantaneous tripping in the event that the circuit breaker is closed onto a fault on a previously de-energized line.

Steps shall be taken to protect the static circuitry from external impressed transient voltages, which could reach the station battery. The routing of cables should be such as to limit interference to a minimum. Any auxiliary supplies necessary to power solid-state circuits shall be derived from the main station battery and not from batteries internal to the protection.

A monitoring system shall be provided to supervise the voltage transformer supply to each distance relay. The secondary voltage of the VT shall be taken to the relay through a MCB with auxiliary contacts. In the event of a trip of the MCB, the monitoring shall inhibit relay operation and initiate an alarm.

The distance relay shall be able to operate in conjunction with the delayed auto re-closing relays.

The distance relays shall incorporate indicators to show the zone in which the relay tripped and the phase or phases, faulted. Indication must not be lost in event of a supply failure.

In addition to tripping contacts, the protection shall have, where necessary contacts for initiating auto re-closing signalling and alarms.

Each protection shall be suitable for single pole tripping and for use in the single and three phase auto re-closing scheme.

The protection and associated auto re-closure equipment shall incorporate whatever means are necessary to ensure that all measuring and starting elements in the healthy phases of the faulted line and all measuring elements on the parallel circuit remain reset during the single phase re-closing dead time. Additionally, the inter-phase fault measuring elements on the faulted circuit shall be stable in the presence of a heavy close-up earth fault. The methods used to ensure correct stability of healthy phase elements during single-phase times and during fault conditions shall in no way prejudice the ability of the protection and auto re-closing scheme to respond to faults during the dead time.

All distance relays shall have Power swing detection with a swing time of as low as 200 ms blocking function and Internal/External faults detection function.

ii) Over Voltage Protection

The 400 kV transmission lines shall be protected for over voltage. The over voltage relay setting for over voltage steps from 100% to 120% in steps of 2.5% each for time delayed protection. For instantaneous over
voltage protection, the setting will be 110% to 150%. Relay setting shall be decided after observing grid condition at time project commissioning.

iii) Automatic Re-closing

Three pole and/or single shot repetitive auto re-closing equipment shall be provided for 420kV overhead line circuit breakers, and shall include, where necessary, dead line and check synchronizing relays. Re-closing shall only take place on overhead line circuits and shall be initiated by following tripping by the distance relay Zone 1 equipment or on receipt of a permissive inter tripping signal.

The following modes of operation shall be selectable by means of a switch or switches:

- Single pole, high speed, auto re-closing only
  
  Auto re-closure shall only be initiated in the event of a signal phase to earth fault. All other types of faults shall result in three phase tripping without auto re-closing.

- Three pole delayed re-closing only
  
  Delayed re-closing shall only be initiated in the event of a single phase or two phase fault. Three phase faults shall result in tripping without auto re-closing.

  - Single pole, high speed and/or three phase delayed, auto re-closing as appropriate
  - No auto re-closing

Three phase tripping without auto re-closing shall take place for any type of fault.

If a second earth fault occurs during the single pole auto re-close dead time, three phase tripping with subsequent delayed three pole auto re-closing shall take place if the auto re-closure selector switch is in the single pole re-close mode, three phase tripping with lockout should follow.

The high speed and delayed re-closing dead times have to be coordinated with the equipment being provided at the remote substation by others, and will be finalized only after Contract award. Tentative ranges are, however, as follows:

- High speed single pole re-closing dead time - 0.3 to 1 seconds.
- Delayed three - pole re-closing dead time - 1 to 30 seconds.

The Contractor shall state available ranges.

A counting facility shall be provided to record the number of re-closures.

Dead line check relays shall monitor the conditions of the line and the bus bar and permit three pole re-closing only when the line is de-energized and the bus bar is energized. The line is considered de-energized when the voltage is less than 20 percent of nominal operating voltage, and the bus bar is considered to be energized when the voltage is at least 80 percent of nominal operating voltage.
14.5.8. Protection and Tripping Relays

Relays shall be of approved types with IEC 60255 or BRITISH Standard 142 and 5992, parts 1, 2, and 3 or IS, as appropriate, fully tropicalized and shall have approved characteristics. The protection relays shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases with protection class IP54 and of the draw out type with rear connections. The protection class of the cover for all relays or protection systems, in which the modules are mounted, shall not be inferior to IP53.

All DC breakers and relays for DC main switchgear protection shall be based on AC trip and close coils and protection relays.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from the separate internal batteries in the protection equipment.

With draw able pattern relay shall be so designed so that when in the withdrawn position associated CTs shall be automatically short-circuited and tripping circuits disconnected.

All static relays shall be adequately protected against damages from incoming surge and shall meet relevant IEC, BS, IS and ANSI SWC test standards.

The input circuit must be galvanically isolated from the electronic circuits. Potential free output contacts must be suitable for the direct control of breaker trip coil.

The system shall be coordinated with the protection system of the interconnected stations. All interface installations shall be included to provide fully functional systems.

The trip circuit supervision scheme shall provide continuous supervision of the trip coils and trip circuits with the circuit breaker in either the open or the closed position and scheme shall have sufficient contacts for visual/available alarm and indication.

Provision shall be made in trip circuit supervision circuits to prevent any type of mal-tripping of a circuit breaker.

Relay alarm should be equipped with well resetting indicators.

The numerical protection relays shall have an operating time of less than 20 ms and single function protection relays shall have the operating time less than 15 ms. The total time taken by the protection system including auxiliary and tripping relays to send trip command to circuit breaker from the occurrence of the fault shall not exceed 70 ms.

Each relay or relay assembly shall have a test device, which facilitates checking the correct functioning of the equipment during operation or stand still.
14.5.9. Auxiliary relays

Auxiliary relays for inputs from the protection sensors and devices such as thermal relays, pressure switches etc. shall be provided as specified in the following sections, and as necessary for the installation.

The relays shall be equipped with a manually reset indicator when applicable.

Each relay shall have self-resetting potential free contacts of suitable rating as needed for connection in the tripping circuits and at least two self-resetting potential free contacts for local and remote alarm and supervision, both wired to terminals.

All relays shall be clearly marked with the corresponding relay function.

14.5.10. Control and tripping circuitry

The tripping circuits shall be accomplished via a tripping MATRIX.

The MATRIX shall include all electrical and mechanical signals as per alarm/tripping schedule and sequence diagram.

Trip circuit supervision systems shall be provided. They shall preferably supervise the circuits continuously irrespectively of circuit breaker position whether it is closed or open. Supervisory systems combined with automatic test facilities will also be considered.

Any fault in a tripping circuit shall be enunciated individually.

The trip circuits shall not be interrupted during test procedure. Correct working shall be indicated by LED's.

For relay testing and setting by means of a portable, precision test set all required circuits shall be terminated to test plugs-switches, arranged at easily accessible locations.

An appropriate test set with all accessories shall be included.

14.5.11. Power Supply Requirements

220V DC shall be provided for the power supply to the control and protection of AC switchgear equipment, while AC shall be provided for the power supply to the control and protection of DC switchgear. Both systems shall be used to supply auxiliary voltage and tripping voltages to the protection system.

Each protection subgroup shall have feeders from circuit breakers in both DC systems with selection being made at the protection cubicle.

All components of the protection system shall function properly at DC voltages from 80%-115% of nominal voltage.

If short-circuit protection is needed inside each protection group, mini circuit breakers shall be used, having auxiliary contacts for initiating alarm for open position.
Converters and suppression filters shall be provided for each protection part.

The converters shall have high insulation level, and shall be equipped with internal fault detection, initiating alarm upon failure in the converter.

The protection systems shall be fed by the 220 V battery banks installed in the control block. Relay shall be suitable for operation on 220V DC systems without the use of voltage dropping resistors. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation. Relays shall utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. The supply units shall be equipped with input filters to protect against external voltage peaks. Protection shall be provided in the primary and secondary circuits of the DC transducers. The supply voltage and all secondary voltages produced by the DC /DC transducers shall be monitored.

The protection systems shall have double in feed with main switch, DC/DC transducers, stabilizers and voltage monitors. Redundancy shall be obtained by de-coupling the two DC/DC transducers by diodes so that, on failure of one circuit, the power supply can fully be maintained. In case of supply voltage drop the auxiliary voltage shall be maintained for 50 ms.

14.6. Drawings, Documents and Design Calculations

14.6.1. Design memorandum

The Contractor shall submit to Employer a design memorandum prepared in accordance to clause 1.6 “Record and Documentation” of “Section 1-General Technical Requirements.”

14.6.2. Drawings and documents

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in “Section 2 - Technical Documents” of “General Technical Specification (GTS)”.

14.6.3. Design calculation

The Contractor shall submit the design calculation in accordance to Clause 2.6 of “General Technical Specification (GTS)” covering at least the following, for review/acceptance.

- Complete protection scheme coordination,
- CT and PT application check,
- Setting for different relays,
- DC power requirements.
14.7. Delivery, Installation and Commissioning

The Contractor shall follow the requirements of Delivery, Installation and commissioning elaborated in clause 1.7 “Delivery, Installation and commissioning” of “Section 1 - General Technical Requirements.”

14.8. Spare Parts

Recommended spare parts shall be supplied in accordance to clause 1.8 “Spare Parts” of “Section 1 - General Technical Requirements”. Specified spare parts to be supplied under this section are as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protection relays of type used</td>
<td>1 set of each used type</td>
</tr>
<tr>
<td>2</td>
<td>Thermal overload relay of type used</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>3</td>
<td>Single phase metrosil (if used)</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>4</td>
<td>Three phase metrosil (if used)</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>Test block</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>6</td>
<td>Tripping relay of type used</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>7</td>
<td>Trip circuit supervision of type used</td>
<td>2 sets of each used type</td>
</tr>
<tr>
<td>8</td>
<td>Auxiliary relays of type used</td>
<td>5 sets of each used type</td>
</tr>
<tr>
<td>9</td>
<td>Auxiliary relays socket of type used</td>
<td>5 sets of each used type</td>
</tr>
</tbody>
</table>

14.9. Tools and Instruments

The Contractor shall supply all necessary tools and instruments etc. for installation, repair and maintenance in accordance to clause 1.9 “Tools and Instruments” of “Section 1 - General Technical Requirements”.

14.9.1. Special tools

The Contractor shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), to be accepted by the Employer.

14.9.2. Testing instruments

The Contractor shall propose the list of testing instruments including their make and detailed specification to be accepted by the Employer.

Proposed list shall include following mandatory items:
◆ Relays / card / module extraction tools,
◆ One (1) portable microprocessor based, universal relay testing equipment,
◆ A laptop with at least 512MB RAM, 80GB hard disk, CD-R/W drive, necessary software and latest features to facilitate testing, recording and analysis,
◆ Two (2) sets of test plug for all types of relays,
◆ Two (2) sets of extension cards for testing of P.C.B.

14.9.2.1. Universal relay testing kit

One (1) portable microprocessor based, universal relay testing equipment for testing of all protection relays of the plant, for checking the accuracy of all types of protection relays e.g. distance relays, differential current relays, voltage relays, timers, definite and inverse type over current relays, automatic reclosing devices up to the maximum possible ranges complete with all types of measuring leads along with case. The testing kit shall measure and display voltage, current, impedance, power, power factor, phase angle and time via an easy to read liquid crystal display. The equipment should be supplied with an additional current source for testing of different relays.

A hold function shall be provided which will allow voltage and current readings to be taken for the duration of half a cycle or less. The timer start-stop input shall respond to change a voltage for contact opening and closing.

Indication shall be provided to show status of timer start-stop inputs with normally opens (NO) and normally closed (NC) contacts of relays. The testing kit must incorporate a provision for continuous phase shifting and fine adjustment of voltage and current.

The characteristics of testing kit shall be as follows:

- Input : 230V, single phase/415V, three phase, 50 Hz,
- DC auxiliary output: 220V DC,
- Timer: Range-0.0 – 99999.9 S, Accuracy – 1 ms,
- Ammeter range : 0-230 (Internal), 0-6A (External),
- Voltmeter range: 0-600 V,
- Max. no. of reclosing : 49,
- Max. testing time : 999 S,
- Current range :0 – 10, 25 and 100A,
- Voltage range :0 – 300V DC, 0 – 250V AC, 0 – 120V AC with phase shift,
- With computer interface (RS 232) and timer.
14.10. Quality Assurance and Testing

The contractor shall follow quality assurance and testing requirements specified separately in “Quality Assurance and testing specifications (QTS)".