GENERAL SPECIFICATION
FOR
POWER DISTRIBUTION
SHOP ELECTRICS
INSTRUMENTATION
TELECOMMUNICATION
(GS-03)

MECON LIMITED
RANCHI - 834002
INDIA
ELECTRICAL SYSTEM

01 GENERAL

01.01 Standards

The design, manufacture, assembly and testing as well as performance of the equipment shall conform to the IPSS (Inter Plant Steel Standard) in respect of items for which IPSS have been issued, otherwise, to the relevant IS specifications (latest revision). In case the Tenderer is not in a position to comply fully with certain IPSS/IS specifications, or in respect of certain items for which there are no IPSS/IS specifications, the Tenderer may base his proposals on IEC recommendations or other reputed national or international standards subject to the approval of the Purchaser.

All equipment supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of the Government of India, the state Government and with the Indian Electricity Rules.

In case of any contradiction between the data given in the Technical Specification and this General specification, data given in the Technical specification shall prevail.

01.02 Climatic Conditions

In case the climatic conditions prevailing at the plant site are specified in the Technical specification, it shall be followed. In case no details are available in the Technical Specification, the following shall be considered.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Area</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Blast furnace</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cast house</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>1.</td>
<td>Furnace proper</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Stock house</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Pump house</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>4.</td>
<td>Stove area</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>5.</td>
<td>GCP area</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>6.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>B.</td>
<td>Sinter Plant</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Sinter machine &amp; Sinter Cooling building, ESP</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td></td>
<td>proper</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Raw material storage building</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>MND building, Exhauster building,</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>C.</td>
<td>Steel Melting Shop</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Converter bay</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sl.No</td>
<td>Area</td>
<td>Data</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>2.</td>
<td>Other areas in the shop</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>**D.</td>
<td>Continuous Casting Shop</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Casting bay</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Withdrawal, straightening and gas cutting areas</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>**E.</td>
<td>Rolling mills</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>General</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Finishing bays</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>**F.</td>
<td>Coke oven &amp; Byproduct plant</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Battery proper</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>**G.</td>
<td>Electrical rooms</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>HT/LT substation &amp; MCC rooms</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Cable basements / tunnels</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>**H.</td>
<td>Control Rooms</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Control rooms – Air conditioned</td>
<td>A/C + 24 Deg. C</td>
</tr>
</tbody>
</table>

Equipment selection and derating shall generally be based on ambient temperature of +50 Deg.C. For specific areas and shops, the ambient temperature conditions indicated above shall be taken into consideration and equipment suitably derated where necessary.

The equipment offered should be suitable for smooth, efficient and trouble free service in the tropical humid climate prevailing at plant site and under the ambient temperature conditions indicated above for the different shops and areas. In hot areas of higher temperature conditions, the equipment shall be adequately protected against damage from radiant heat and hot air.

The equipment shall be designed to give efficient and reliable performance under heavy steel mill conditions and shall be such that the risks of accidental short-circuits due to animals, birds or vermins are obviated.

01.03 **Standard Voltage levels**

In case the standard voltage levels to be adopted in the plant are specified in the Technical specification, it shall be followed. In absence of any details indicated in the Technical Specification, the following standard voltage levels shall be adopted.
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
</table>
| 1     | HTAC        | 33 kV, 3 phase, 50 Hz, resistance earthed  
|       |             | 11 kV, 3 phase, 50 Hz, resistance earthed  
|       |             | 6.6 kV, 3 phase, 50 Hz, resistance earthed |
| 2     | LTAC        | 415V, 3 Phase, 50 Hz, 4 wire, solidly earthed |
| 3     | DC supplies voltage | 220 Volts, |
| 4     | DC voltage for load having individual converters | 900V, 750V, 660V, 460V, 230V |
| 5     | AC control and signaling voltage | 240V, +10% obtained using suitable control transformer. |
| 6     | DC control and signaling voltage | 220V |
| 7     | Control voltage for HT switchgear equipment | 220V DC from battery |
| 8     | Special socket outlets for portable lamps | 24V, single phase, 50 Hz, AC obtained through suitable transformers |
| 9     | Electro-magnetic brakes | 220V, DC, obtained through individual rectifiers |
| 10    | Solenoid valves | Generally 24V, DC, unearthed |
| 11    | Machine tools lighting | 110V, single phase, 50 Hz, lighting AC obtained through centre tapped transformers. |
| 12    | Sockets for Welding purposes | 415V, 100A, 3 pin plus earth with plug interlocked switch |
| 13    | Sockets for hand tools | 240V, 15A, 2 pin plus earth with plug interlocked switch |
| 14    | Illumination system | 240V AC, 50HZ. |
| 15    | PLC power supply | 415/240V AC, 50 Hz, obtained through UPS |
| 16    | Monitoring and signaling in electronic installations, mimic panels | 24/48V, DC |

01.04

**Symmetrical short circuit ratings:**

The three phase symmetrical short-circuit ratings of the switchgear at the different voltage levels shall be as follows unless specifically indicated in the Technical specification:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33 kV switchgear</td>
<td>26.2 kA for 3 sec.</td>
</tr>
<tr>
<td>2</td>
<td>11 &amp; 6.6 kV switchgear</td>
<td>40 kA for 3 sec.</td>
</tr>
<tr>
<td>3</td>
<td>415 V switchgear</td>
<td>50 kA for 1 sec.</td>
</tr>
</tbody>
</table>
01.05 **Permissible variations**

The system/unit/plant/equipment shall be designed so as to be suitable for the following variations in voltage and frequency unless specifically indicated in the Technical specification:

<table>
<thead>
<tr>
<th>Description</th>
<th>Voltage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permissible variations with rated performance, rated current and control</td>
<td>For LT system - +/- 10%</td>
<td>For HT &amp; LT system +3% &amp; - 6%</td>
</tr>
<tr>
<td>effectiveness maintained</td>
<td>For HT system - + 6%, - 9%</td>
<td></td>
</tr>
<tr>
<td>Permissible variations with changes in rated current/torque but without any</td>
<td>+/- 10%</td>
<td>+/- 3%</td>
</tr>
<tr>
<td>undesirable effect on performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible variations for control and Regulation equipment With rated</td>
<td>+/- 15%</td>
<td>+3%, -6%</td>
</tr>
<tr>
<td>performance And control quality Maintained</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible voltage dip at the HT switchgear bus during starting of HT motor</td>
<td>- 15%</td>
<td></td>
</tr>
</tbody>
</table>

01.06 **Criteria for selection of voltage levels for motors & Power devices:**

AC squirrel cage induction motors of ratings upto 200 KW and slipring motors upto 250 KW shall be fed at LT, 415V, 3 phase 4 wire 50 Hz, with DOL or soft starting as applicable. AC motors of ratings in excess of 200KW shall be connected to the HT power supply system. The HT voltage level shall be as specified in the Technical specification.

Thyristor converter sets with power rating above 200KW shall be connected to the HT power supply and those of rating 200 KW & below to LT - 415 V supply system.

01.07 **Design criteria & reliability conditions**

01.07.01 Suitable numbers of 415V load centre substation shall be provided for feeding different motor control centres and auxiliaries power distribution boards as required for the plant. Motor of rating 110 kW and above shall be fed directly from LT switch board. However, power devices like SFU's/ MCCBs, Contactors, Over-load relays, etc. shall be located in MCC’s.

01.07.02 The capacities of the transformer shall be so selected that in case of outage of any transformer, the remaining transformer(s) shall be loaded upto 80% of their rating. The rating of transformers shall be 630 kVA / 1000 kVA / 1600 kVA or as specified in the Technical specification.
01.07.03 The rating of circuit breakers and CTs shall be sufficient for the actual loads taking into consideration derating factors due to ambient temperature as well as for the mounting of the component in the switchboard.

01.07.04 6.6 kV panel mounted load break switches with earthing switches of adequate rating shall be provided in the transformer primaries.

01.08 **Motor starting and permissible voltage dips**

01.08.01 Solid state soft start with energy saving device shall be adopted preferably wherever energy saving is of major consideration for all H.T. & L.T. A.C. motors. Voltage dip on starting of the largest L.T. motor shall be limited to 15% of the nominal voltage at the motor terminals.

01.09 **Spare units**

01.09.01 Every H.T and L.T. switchboards / MCC / PDBs etc. shall be provided with 20% spare cubicles/modules. These spare cubicles/modules shall be complete with the circuit breakers/contactor/starters/other accessories and shall be fully wired. Minimum number of spare feeders on any board shall be 2 nos. The rating and type of spare feeder shall be decided during detailed engineering stage.
02. POWER DISTRIBUTION EQUIPMENT

02.01 33/6.6 kV SWITCHBOARD

02.01.01 Code and Standards

The switchboards and the mounted equipment shall conform to the latest revisions of the following Indian standards:

<table>
<thead>
<tr>
<th>IS:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12729</td>
<td>General requirements for switchgear and controlgear for voltages exceeding 1000 V.</td>
</tr>
<tr>
<td>13118</td>
<td>General requirement for circuit breakers for voltages above 1000 V.</td>
</tr>
<tr>
<td>3427</td>
<td>Metal-enclosed switchgear and control gear for voltages above 1000 V but not exceeding 1100 V.</td>
</tr>
<tr>
<td>5082</td>
<td>Material for data for aluminium bus bars.</td>
</tr>
<tr>
<td>9920</td>
<td>Switches and switch isolators for voltages above 1000V.</td>
</tr>
<tr>
<td>9921</td>
<td>AC disconnectors (isolators) and earthing switches for voltage above 1000 V.</td>
</tr>
<tr>
<td>9046</td>
<td>AC contractors of voltage above 1000 V upto and including 1100 V.</td>
</tr>
<tr>
<td>12661</td>
<td>HV motor starters.</td>
</tr>
<tr>
<td>13703</td>
<td>Low voltage fuses.</td>
</tr>
<tr>
<td>2705</td>
<td>Current transformers.</td>
</tr>
<tr>
<td>3156</td>
<td>Voltage transformers.</td>
</tr>
<tr>
<td>1248</td>
<td>Electrical indicating instruments.</td>
</tr>
<tr>
<td>722</td>
<td>Integrating meters.</td>
</tr>
<tr>
<td>3231</td>
<td>Electrical relays for power system protection.</td>
</tr>
<tr>
<td>6875</td>
<td>Control switches and push buttons.</td>
</tr>
<tr>
<td>694</td>
<td>PVC-insulated cables for working voltages voltage upto and including 1100 V.</td>
</tr>
<tr>
<td>2544</td>
<td>Porcelain post-insulators for systems with nominal voltage greater than 1000 V.</td>
</tr>
<tr>
<td>11353</td>
<td>Guide for uniform system of marking and identification of conductors &amp; apparatus terminals.</td>
</tr>
<tr>
<td>5578</td>
<td>Guide for marking of insulated conductors.</td>
</tr>
<tr>
<td>3618</td>
<td>Phosphate treatment of iron and steel for protection against corrosion.</td>
</tr>
<tr>
<td>6005</td>
<td>Code of practice of phosphating of iron and steel.</td>
</tr>
<tr>
<td>5</td>
<td>Colours for ready mixed paints and enamels.</td>
</tr>
</tbody>
</table>
Wherever Indian Standards are not available, relevant IEC standards shall be applicable.

**02.01.02 General Requirement**

- The switchgear shall be of metal clad, single bus bar/Double bus bar as applicable, self standing, dust proof construction, indoor cubicle type fitted with SF6/vacuum circuit breakers in fully draw out execution.
- The circuit breakers shall be suitable for following duties
  - To withstand inrush magnetizing currents of transformers & capacitor bank ‘ON’ and ‘OFF’ operation.
  - To withstand switching off over voltages caused due to break of lightly loaded low capacity cage type induction motors. It shall also withstand DOL starting of motor with large starting time, and repeated starting like one hot start and two successive cold starts.
  - Transient surge produced by one CB due to severe chopping during rapid interruptions of inductive current e.g motors, shall be within limits allowable for overhauled motors according to IEC34 part 1 otherwise suitable surge absorber shall be provided.
- The controls, indicating lamps, relays and meters shall be mounted on breaker cubicle itself. (for 6.6kV Switchboard). For 33 kV panel separate control & relay panel shall be provided.
- Operation counter, close/open mechanical indications spring charged/discharged indication shall be provided.
- All circuit breakers shall have motor operated spring charged mechanism for closing and shunt tripping coil (220V DC). Closing coil shall be suitable to operate between 85% to 110% of rated voltage and tripping coil between 70-110% of rated voltage. Spring charging motor shall operate between 85-110% of rated AC Voltage.
- Jumpers in the cubicle also shall be of same current rating as that of the breaker. Only the jumpers connected to CT shall be rated according to CT rating.
- A manually operated device to enable charging of closing springs.
- Manual / Mechanical tripping arrangement for emergency tripping of CBs.
- All circuit breaker truck shall have service, test and draw out positions. Test position shall engage only the auxiliary (control) contacts to close the CB during testing.
- Panel door switch shall be provided for illumination inside panel.
- Anti pumping feature shall be provided.
- All live parts shall be insulated by tapping, supported by suitably designed insulators. Proper insulation of bus bars upper and lower contacts of breakers, vacuum bottles (for VCB) and sealing of opening of bushings shall be provided to eliminate accidental contacts. Switchboard busbars shall be taped by proper grade of insulating tape.
- The cubicle shall be provided with a position changing gear arrangement in such a way that by engaging detachable device from outside the front door, it shall be possible to move the breaker truck and change position without opening the cubicle door. Facilities for pad locking in each position shall be provided.
- Each cubicle shall have mimic diagram with metal strip.
- Each cubicle shall be of compartmentalized construction and shall have separate compartments for bus bars, CTs and outgoing cables, metering & protection devices.
- All circuit breaker trucks of same rating shall be identical in all respects (except metering and protective devices) and shall be interchangeable with similar breaker panel.
- Continuous earth bus shall be provided throughout the board.
- The position of various control switches, push buttons, levers etc requiring manual operation shall be at a height not less than 450mm and shall not exceed 1850mm from the finished
floor level. 

**In the design of the switchgear the following positive interlocking shall be provided.**

1. It shall not be possible to move the truck/cassette from the isolated to the Service Position unless low voltage plug and socket connections have been made.
2. It shall not be possible to disconnect the low voltage plug and socket as long as the circuit breaker truck/cassette is in service position.
3. It shall not be possible to withdraw the truck/cassette without disconnecting the low voltage plug and socket.
4. It shall not be possible to move the truck/cassette from the service to the isolated position or vice-versa with the circuit breaker in the ‘ON’ position.
5. It shall not be possible to switch on the circuit breaker when the truck is in between the isolated and the service positions (except in test position).
6. It shall be possible to switch on the earthing switch only when the truck is in the isolated position, wherever an integral earth switch is provided.
7. It shall not be possible to open the circuit breaker enclosure when the breaker is ON or to have access to any part of the draw out assembly which is live when the circuit breaker is in the service position.
8. Shutters shall be lockable in closed position.
9. Where local/remote selector switches are called for, it shall be ensured that:
   * The breaker can be closed locally only if the breaker truck is in the test position and the local/remote selector switch is in local position.
   * The breaker can be operated from remote panel (in shop) only when the breaker truck is in service position and the local/remote selector switch is in remote position.
   * The breaker can be tripped locally regardless of the position of the breaker truck.

**02.01.03 Operating Mechanism**

The operating mechanism parts shall be designed to give longer life, trouble free operation and require minimum maintenance.

The material and components used shall have chopping current limited to minimum.

**02.01.04 Insulation Levels**

Insulation levels corresponding to the rated voltage shall be as follows:

<table>
<thead>
<tr>
<th>Nominal voltage (kV)</th>
<th>6.6</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest system voltage (kV)</td>
<td>7.2</td>
<td>36</td>
</tr>
<tr>
<td>One minute power frequency withstand voltage (kV)</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>1.2/50 micro sec impulse withstand voltage (kV)</td>
<td>60</td>
<td>170</td>
</tr>
</tbody>
</table>

**Clearance in air**: As per IEC

**02.01.05 Short Circuit Strength**

- Rated short time withstand current shall not be less than the system short circuit level specified for the stipulated duration.
- Rated peak withstand current shall not be less than 2.5 times the system short circuit level.
02.01.06 Auxiliary Buses for Control & Protection
1. Control supply buses for AC and DC
2. Signalling supply
3. PT secondary voltage
4. Spare buses – 2 nos.

02.01.07 Provision of Surge Suppressor
In case of breakers like VCB that give rise to over voltage surges due to current chopping phenomenon, surge suppressors to be provided at the load side terminals of the breakers to limit the switching surges to value limited for as per IEC.

02.01.08 Annunciation Schemes
• Flag indications for all faults for which individual protective relays have been specified.
• Warning signalling (as applicable) on individual panels:
  a) All transformer warning / signalling conditions (group signal from corresponding transformer control panel / substation
  b) Loss of trip circuit supply
  c) Earthfault
  d) Control supply failure
  e) PT fuse failure / MCB tripping
  f) SF6 gas pressure low in case SF6 breaker is used.
• Emergency signalling for tripping of HT breakers on fault
• One common signal for warning and one signal for emergency from each panel to be wired to a common annunciation panel of the switchboard, where specified.
• Annunciators for warning and emergency signaling condition on individual panels of solid state facia window type. Common audio signaling with Accept, Reset, and Test push buttons for the switchboard where common annunciation panel is not specified. Audio signaling to have distinct tones for warning and emergency.

02.01.09 Bus Bar and Connections
• Power buses of EC grade aluminium alloy equivalent to E91E WP as per IS-5082 –1981 or high conductivity electrolytic grade copper as per IS : 613-1984. The bus bars shall be tinned at joints.
• Control and Auxiliary buses of electrolytic grade copper.
• The continuous rating of the main horizontal bus shall not be less than the rating of the incomer specified, where not specified, the rating to be selected for at least 125% of the maximum demand of the switchboard taking into account spare feeders.
• The vertical bus rating
  
<table>
<thead>
<tr>
<th>For incomer</th>
<th>Not less than that of horizontal bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>For outgoing</td>
<td>Not less than that of the outgoing breaker, irrespective of relay setting</td>
</tr>
</tbody>
</table>

• Final operating temperature under continuous operation in enclosure limited to 90°C. by thermometer method.
• Both horizontal and vertical bus bars to be designed and supported to withstand the thermal and dynamic stress corresponding to rated short time and peak withstand current specified.
• Cross-section of main horizontal bus to be uniform throughout the switchboard and continuous in one transport unit.
• Bus bar arrangement as per IS 375.
• Phase identification by color in each panel.
• Bus bars (horizontal as well as vertical) shall be provided with heat shrinkable, non-tracking, low absorption type sleeving conforming to international standards for full voltage for 33 kV and 6.6 kV switchboard.
• Bus bar joints and tap off connections of bolted type with zinc dichromate high tensile steel bolts, nuts and spring washers, fishplates with accessories at the end of a transport unit for site connections.
• Bus bar support insulators of non-hygroscopic material having high impact and dielectric strength with an anti-tracking contour.

02.01.10 Internal Control Wiring

• Control wiring shall be carried out by 1100V grade PVC insulated, single core multi-stranded copper wire of minimum cross section 1.5 sq. mm. For CT circuits however, 2.5 sq. mm cross section shall be used.
• Flexible wire of 2.5 sq.mm shall be used from CT chamber to relay chamber and shall have protection against heat & mechanical damage due to flash over. Use of heatproof sleeves and rigid conduit shall be made to run the control wires from back to front.
• Wiring and terminal arrangement for all panels shall be carried out as per approved scheme.
• Flexible wires protected against mechanical damage for wiring to door mounted devices.
• Wires identified at each end in accordance with schematic diagrams by interlocked type ferrules. These shall be firmly located so that these do not move.

**Color code for control wiring**

| AC – Black | Earth wire – Green |
| DC – Light grey | Trip circuit – Red |

• All connections external to a feeder, all the auxiliary contacts of the HV breaker and at least 1 NO & 1 NC spare contacts of the relays shall be brought to terminal blocks.
• Interconnection between panels of adjacent shipping sections to be brought out to a separate terminal block.
• No bunch shall contain more than 12 wires.
• Wiring shall not be joined or tied between the terminal points.
• Control wires shall be run in earthed metallic flexible conduits when laid in HV bus chamber.
• Not more than two connections shall be provided on any one terminal.
• Heat proof arrangement for the passage of wiring in HT panel.
• All telemetering signals shall be wired to terminal strips.

02.01.11 External Terminations

02.01.11.01 Control Terminations

• 650V grade multi-way open type terminal blocks of non-tracking moulded plastic complete with insulated barriers, stud type terminals, washers, nuts and lock nuts and identification strips.
• All terminals going out of the switch board shall be brought to a separate terminal board marked "External Termination". These will be easily accessible.
• External terminal block shall be provided in the relay chamber with proper clamping facilities for cable dressing.
• Control terminals shall be suitable to receive two numbers 2.5 sq. mm copper conductor.
• 20% spare terminals in each control terminal block. Terminal blocks in separate groups shall be provided for DCS/PLC, remote control panels, transformer marshalling boxes, local push button stations, etc.
• Gland plate for control cables shall be of adequate size to accommodate and to facilitate glanding of all the control cables coming from external equipment.
• Terminal blocks shall be placed separately for internal looping and external looping.

02.01.11.02 Power Terminations
• Suitable for accepting cable/bus trunking as specified.
• Sufficient space and support arrangement inside each panel to accommodate HT cable termination kits and sealing kits suitable for the size and number of XLPE cables.
• Dummy panels to be provided adjacent to the switch panel, where the required number cable terminations cannot be accommodated in the cabling chamber of the main panel. Rear extension not acceptable.
• Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of cables separately without disturbing other cables.
• Where specified the following cable termination accessories, suitable for the type, size and number of cables to be terminated, to be supplied with switchboard.
  ⇒ Cable sockets with all HT terminals (sockets set at such an angle that cable tails can be brought up for termination with minimum bending and setting)
  ⇒ HT cable termination and sealing kits
  ⇒ Power cable termination facilities shall be designed to facilitate easy approach to CTs.
  ⇒ Double compression type brass cable glands and crimping type tinned heavy duty copper lugs for HT, LT power and control cables.

02.01.12 Protection and Measurement

02.01.12.01 Electrical Protection
• Selection of protective scheme will be based mainly on reliability, sensitivity, selectivity. All main protections shall be fast acting type in order to clear the faulty system from the healthy system in earliest possible time to minimise damage to equipment and ensure continuity of power supply.

02.01.12.02 Protective scheme requirement
• All the main protective relays shall be microprocessor based numerical & communicable type.
• Auxiliary relays, timers switches etc. required to make the scheme complete shall be considered as part of the scope of work.
• All CT-PT shall be suitable for the relay-meter requirement - lead burden
• All CT-PT wires shall be brought to test terminal blocks before connecting to circuits.
• The circuits of various protections (coming from other panels) shall be connected to master trip relays through aux. relays (flag indicated).
• VAA type aux. relays shall be provided for each transformer fault. Connection of the relay shall be through links to facilitate maintenance.
• Relay ranges and scale of meters shall be finalized during drg. approval stage.
• Contact arrangement, number of poles/ways in control/selector switches shall be as per the requirement/approved scheme.
• ICTs whenever considered necessary shall be included in the scope
• For control supply distribution, panel to panel separate set of terminal blocks shall be provided at top of the panel.
• All relays shall be hand/self-reset type with flag indication. NO/NC contacts for relays shall be as per the requirement of approved protection, annunciation & interlock schemes. Wherever required supplier shall provide aux. relays for contact multiplication.
• Annunciation facia shall be mounted on Incomer switchgear panels and details shall be finalized during drawing approval stage.
• Centre line of switches, lamps, meters shall be matched to give uniform appearance and mounting height of switches shall be between 1.1 to 1.8 m.

02.01.13 Current Transformer (Panel Mounted)
• Separate sets of current transformers shall be used for differential protection and separate cores shall be used for, over current protection and measurement purposes. CT’s on incomer side shall be mounted before incomer breaker and CT’s for outgoing feeder shall be mounted after the breaker.
• Short time ratings and insulation level of CT’s shall be similar to rating of associated breaker.
• CT ratios specified are provisional. Where outputs and accuracy are not specified, these shall be such as may be required by the circuits in which they are used. Generally the protection CT’s and metering CT’s shall have 10P15 and 1.0 class respectively.
• CT’s shall be bar/ window primary type.
• CT’s shall have shorting link on secondary side to facilitate insertion of meters on secondary side without opening CT circuits.

02.01.14 Potential Transformers
• Bus potential transformer shall be provided in separate cubicle.
• High voltage side of PTs shall have fuses and MCCB’s on low voltage side.
• Low voltage star winding shall have all three phase and neutral connections brought out to terminals and one phase shall be earthed.
• Insulation levels shall be similar to rating of associated board.
• Accuracy class 1.0 shall be used.
• VA burden shall be selected based on meters and relays connected with the PT.
• Bus PT’s shall have separate panel.

02.01.15 Relays
• Relays shall be Microprocessor based numerical and communicable type.
• All relays shall be flush mounted in dust proof cases and shall be mounted on front side of cubicle.
• Major relays are as indicated in the specification or single line diagram.
• Master trip relay shall be hand reset and shall have 3 NO and 3 NC contacts in addition to those required by the protection/control scheme.
• All timers and protection relays shall have flag indicators.
• Relay ranges, exact type, number of aux. relays, timers shall be finalized during drawing
approval stage.
- All instantaneous current protection relays shall be of 3 pole type.
- In HT switchboard two nos. bus PT’s, with U/V relays, neutral displacement relays, timer etc. to be provided.

02.01.16 **Indicating Instruments**
- All indicating instruments shall conform to IS:1248-1983 and IS - 2419-1979.
- Shall be capable of withstanding system fault current taking into account CT saturation.
- Shall be back connected.
- Shall be located in the upper part of the panel.
- Shall have 144 sq. mm square flush case, non-reflecting type, clearly divided and indelibly marked scales, sharply out lined pointers and zero adjusting device.
- The minimum scale reading shall not be more than 10%. Maximum reading shall be 15% full load for transformers panels.
- Each voltmeter shall be calibrated with coil hot. The scale shall be open between 60% to 125% of normal volts and shall be suppressed below 60% of normal volts.
- Class of accuracy shall be 1.5 or better.
- The full load reading of each ammeter shall occur at the most prominent part of the scale.
- The minimum scale reading shall not be more than 10%. Maximum reading shall be 15% full load for transformer panels and 600% full load for motor panels.

02.01.17 **Annunciators**
- Shall be of static type.
- Hooter and bell for trip and alarm indication respectively.
- Shall be suitable to work on DC supply as specified.
- Test, accept and reset facilities (with push button) shall be provided on each panel.
- Suitable audio - visual indication shall be provided on DC failure. Audio alarm with reset facility shall be provided. Visual indication shall be panel-wise.
- Spare annunciation points shall be wired upto terminal blocks. 20% spare facias shall be provided.
- Each point shall have two bunch LEDs in parallel.
- All trip points facia shall have red color and non trip points white color.
- The cover plate of facia shall be flush with panel
- Shall be capable to receive simultaneous signals
- Shall be capable to receive signal during testing mode
- Tenderer shall ensure the non-presence of spurious signals due to influence of external electromagnetic / electrostatic interference on the annunciation wiring and switching disturbances from neighboring circuits within panels
- Scope of supply includes all interconnections, bell hooter, buzzer, alarm facility, push button etc. required to achieve complete function of above scheme.
- Sequence shall be as follows:

<table>
<thead>
<tr>
<th>Time</th>
<th>Visual</th>
<th>Audio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence of fault</td>
<td>Lamp flashing</td>
<td>On</td>
</tr>
<tr>
<td>Acceptance</td>
<td>Lamp steady “on”</td>
<td>Off</td>
</tr>
<tr>
<td>Reset</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Test</td>
<td>Lamp flashing</td>
<td>On</td>
</tr>
</tbody>
</table>

- Annunciation in the switchboard shall have following provisions;
⇒ Each transformer shall have 6 facia.
⇒ Each bus PT shall have 6 facia.
• Bus coupler or tie shall have sufficient facia (for each feeder to indicate tripping + 20% spare).
• All auxiliary relays of transformer feeders shall have 4 NO contacts and all master trip relays shall have two NO contact for remote/DCS/PLC indication for repeat annunciation in addition to contacts required for scheme under scope of works.
• Warning and emergency points shall be as per the list approved during detail engineering stage. In general all tripping points and alarm points shall be annunciated. (Transformer alarm and tripping point shall be provided with auxiliary relays to have duplicate annunciation at remote panel/DCS/PLC, etc).
• One common point shall be provided to indicate operation of annunciation system of the complete board (in case of any trouble in the board in tie feeder, bus coupler, incomer, etc).

02.01.18 Control Supply
• Control supply buses shall run throughout the switchgear.
• Two DC feeders shall be taken in each board controlled by MCCB’s.
• In each panel for controlling of its DC supply MCCB (DC duty) shall be used. DC auto changeover and manual changeover facility shall be provided. Failure of each DC supply shall be monitored in the switchboard as well as at remote.
• 240V AC supply shall be taken from a station aux. board.
• Each section shall have separate feed with automatic changeover scheme.
• Each panel shall have one MCB for controlling its AC supply.
• Sub circuits shall be protected with HRC fuses in each panel for indication lamps, closing and tripping circuits.

02.01.19 Earthing Devices
• Either integral earthing switch or a separate earthing switch shall be provided to facilitate earthing of busbars and any feeder circuit.
• Earthing truck (if included) shall have PT and alarm provision. (Separate trucks shall be provided for feeder and bus earthing through bus PT panel in each switchboard). 1 no. earthing truck for feeder earthing and 1 no. for busbar earthing shall be provided for each board. It shall not be possible to use bus earthing truck for feeder earthing and vice-versa.
• Rating of earthing device shall be in line with associated board.
• Interlock provision shall be there so that incomer can not be closed if bus earthing device is connected.
• In case feeders are having integral earth switch, earthing trucks may not be required.

02.01.20 Indicating Lamps
• Type - Cluster type LED lamps.

Color shall be as follows:

<table>
<thead>
<tr>
<th>Status</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>RED</td>
</tr>
<tr>
<td>OFF</td>
<td>GREEN</td>
</tr>
<tr>
<td>AUTOTRIP</td>
<td>AMBER</td>
</tr>
<tr>
<td>TRIP CKT. HEALTHY</td>
<td>WHITE</td>
</tr>
<tr>
<td>SPRING CHARGED</td>
<td>BLUE</td>
</tr>
</tbody>
</table>

Indication lamps shall be provided for CB Service, test & drawout position.
02.01.21 Control and Selector Switches

- Control switches for circuit breaker ON/OFF control - 3 position spring return to neutral with lost motion device and pistol grip handle.
- Other control and selector switches - stay put type with wing type knobs.
- Ammeter selector switches - 4 position, make before break.
- Voltmeter selector switches - 7 position as required.
- Colour : Black
- Contact Rating:
  - Continuous: 10 amps
  - AC 11: 4 amps, 240V
  - DC 11: 0.5A, 220V, L/R - 40 ms

02.01.22 Push Buttons

- Contact Rating:
  - continuous: 10 amps
  - AC 11: 4 amps, 240V
  - DC 11: 0.5A, 220V, L/R - 40 ms
- Colour:
  - ACCEPT: BLUE
  - RESET: BLACK
  - TEST: YELLOW

02.01.23 Protective Earthing

- Continuous earth bus of minimum size 50x6 mm of copper or equivalent aluminum/galvanized steel section, designed to carry the peak short circuit and short time fault current as specified.
- Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel with an earthing terminal at each end for terminal at each end for terminating external earth conductor.
- Vertical earth bus for earthing individual functional units.
- All non-current carrying metal work (including metallic cases of instruments and other panel mounted components effectively) bonded to the earth bus.
- Hinged doors earthed through flexible earthing braid.
- Looping of earth connection resulting in loss of earth connection to other devices when the loop is broken not permitted.
- Withdrawable units provided with self aligning, spring loaded, silver plated copper scrapping earth contacts of make before/break after type, ensuring earth continuity from service to the test position.

02.01.24 Test and Maintenance Equipment

Each board shall be supplied with following items;

- 1 set of test plugs
- 2 common transport trolleys for interchanging withdrawable units, height of the trolley lifting arm adjustable for raising / lowering the units.
- Any other special purpose tools for maintenance.
02.01.25  Constructional Features

02.01.25.01  Mechanical Design
- Sheet steel clad, compartmentalized, floor mounted, free standing design.
- Minimum sheet steel thickness: doors & covers - 2 mm cold rolled, other load bearing members - 2.5 mm
- Doors shall be provided with lock and key arrangement
- Degree of protection shall be IP4X.
- Assembled on base channel of structural steel ISMC 75 painted black.
- Operating height shall be between 450 to 1800 mm. Switchboard height not to exceed 2500 mm.
- Earthed metallic barriers between compartments and between vertical sections.
- Seal off bushings wherever bus bars pass through metallic partition.
- Zinc bichromated and passivated hardwares.
- Transport unit not larger than 3.2 mts.
- Removable lifting arrangement for each transport unit.
- Lockable front doors with concealed hinges with the door not forming part of the draw-out truck.
- Panels shall be extensible on both sides.
- Removable sheet steel covers shall be provided at rear.
- Explosion vent for each chamber
- Control cables entry shall be from front side.
- CTs shall be located in such a way that they are easily accessible.
- Panel door switch shall be provided for illumination inside the panel.
- All live parts shall be insulated by taping, supported by suitably designed insulators. Proper insulation of bus bars, upper and lower contacts of breakers and sealing of opening of bushings shall be provided to eliminate accidental contacts.
- Screw wire mesh in the power cable chamber of incoming feeder is to be provided.

02.01.25.02  Labels
- Switchboard designation nameplate at the center of the board with letters not less than 25 mm high.
- Panel designation number on each panel, both in front and rear
- Inscription plate for each feeder on the door
- Door front mounted devices to have labels directly below them
- Labels made on non-rusting metal or 3 ply lamicoid with engraved inscription of white letters (minimum 3 mm high) on black background.
- Label designation and size of lettering subject to approval.
- Bus side and cable side shutters labeled for identification.

02.01.25.03  Surface Treatment
All metal parts of the panel to undergo surface treatment that includes de-rusting, cleaning, chemically degreasing, pickling in acid, cold rinsing, phosphating and passivating followed by spraying with two coats of zinc oxide primer and baking in oven.

<table>
<thead>
<tr>
<th>Shade of paint</th>
<th>Panel interior</th>
<th>Off white shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior</td>
<td>Light grey 631, as per IS-5</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Particulars</td>
<td>33 kV</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Type</td>
<td>SF6/VCB</td>
</tr>
<tr>
<td>2.</td>
<td>Service</td>
<td>Indoor</td>
</tr>
<tr>
<td>3.</td>
<td>Enclosure</td>
<td>IP-4X</td>
</tr>
<tr>
<td>4.</td>
<td>Nominal System Voltage</td>
<td>33 kV</td>
</tr>
<tr>
<td>5.</td>
<td>Highest System Voltage</td>
<td>36 kV</td>
</tr>
<tr>
<td>6.</td>
<td>No. of phases and frequency</td>
<td>3ph. 50 Hz</td>
</tr>
<tr>
<td>7.</td>
<td>Busbar material</td>
<td>Electrolytic grade aluminium alloy equivalent to E91EWP as per IS:5082:1981</td>
</tr>
<tr>
<td>8.</td>
<td>Bus Color code</td>
<td>RYB</td>
</tr>
<tr>
<td>9.</td>
<td>System Earthing</td>
<td>Earthing through earthing transformer</td>
</tr>
<tr>
<td>10.</td>
<td>Circuit Breaker Rating</td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Continuous Current Rating at 45 deg C</td>
<td>-</td>
</tr>
<tr>
<td>10.2</td>
<td>Short Circuit Rating</td>
<td>26.2 kA</td>
</tr>
<tr>
<td>10.3</td>
<td>Short Circuit duration</td>
<td>3 sec</td>
</tr>
<tr>
<td>11.</td>
<td>Rated making Current</td>
<td>100 kA</td>
</tr>
<tr>
<td>12.</td>
<td>Busbar Rating</td>
<td>As specified</td>
</tr>
<tr>
<td>13.</td>
<td>Power Frequency Withstand voltage</td>
<td>70 kV for 1 minute</td>
</tr>
<tr>
<td>14.</td>
<td>Impulse withstand voltage (1.2/50 micro sec)</td>
<td>170 kV</td>
</tr>
<tr>
<td>15.</td>
<td>Control Voltage</td>
<td>220 V DC</td>
</tr>
<tr>
<td>16.</td>
<td>Spring charge motor voltage</td>
<td>240 V AC</td>
</tr>
<tr>
<td>17.</td>
<td>CT Ratio</td>
<td>Secondary Current 1A</td>
</tr>
<tr>
<td>18.</td>
<td>PT ratio - STAR/ STAR/ Open delta</td>
<td>(33/√3) / (.11/√3) / (.11/3)</td>
</tr>
<tr>
<td>19.</td>
<td>Aux. Contacts</td>
<td>6 NO + 6 NC</td>
</tr>
<tr>
<td>20.</td>
<td>Termination</td>
<td></td>
</tr>
<tr>
<td>20.1</td>
<td>Incomers</td>
<td>BUSDUCT/XLPE Cables</td>
</tr>
<tr>
<td>20.2</td>
<td>Outgoings</td>
<td>XLPE Cables</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Particulars</td>
<td>33 kV</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>21</td>
<td>Clearance in air</td>
<td>As per IEC</td>
</tr>
<tr>
<td></td>
<td>Phase to phase (mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phase to earth (mm)</td>
<td></td>
</tr>
</tbody>
</table>

**02.01.27 Details of major protections for 6.6 kV panels**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of feeder</th>
<th>Protection</th>
</tr>
</thead>
</table>
| 1       | Bus Coupler feeder.                                | ▪ Over-Current IDMT O/C (51-3 Pole)
▪ Earth Fault (51 N-Single Pole) |
| 2       | Incomer from transformer                           | ▪ Over-Current IDMT O/C (51-3 Pole)
▪ Earth Fault (51 N-Single Pole)
▪ Composite Transformer Differential and Restricted earth fault Protection (87 + 64R)
▪ Standby earth fault protection (51G)
▪ Under voltage protection (27) with timer (2)
▪ Fuse failure protection of line PT (97) (for alarm) |
| 3       | Incomer from switchboard                          | ▪ Over-Current IDMT O/C (51-3 Pole)
▪ Earth Fault (51 N-Single Pole)
▪ Under voltage protection (27) with timer (2)
▪ Fuse failure protection of line PT (97) (for alarm) |
| 4       | Outgoing Power Supply Feeder to switchboards      | ▪ Over-Current IDMT O/C (51-3 Pole)
▪ Earth-Fault (51 N-Single Pole) |
| 5       | Outgoing Transformer feeder (all types of transformers) | ▪ Over Current (INST(50) & IDMT O/C 51-3 Pole)
▪ Earth-Fault IDMT 51 N
▪ Provision to trip on transformer fault including stand by earth fault protection (signal to be received from downstream breaker panel) |
| 6       | Outgoing Motor Feeder                              | ▪ Motor Protection (99)
▪ Provision to trip on under voltage (signal received from bus PT)
▪ Provision to trip on signal from temperature element in motor |
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of feeder</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bus Coupler feeder</td>
<td>▪ Over-Current IDMT O/C (51-3 Pole)</td>
</tr>
<tr>
<td>2</td>
<td>Incomer</td>
<td>▪ Over-Current IDMT O/C (51-3 Pole)</td>
</tr>
<tr>
<td>3</td>
<td>Outgoing Transformer feeder (all types of transformers)</td>
<td>▪ Over Current (INST(50) &amp; IDMT O/C 51-3 Pole)</td>
</tr>
<tr>
<td>4</td>
<td>Outgoing Power Supply Feeder to switchboards</td>
<td>▪ Over-Current IDMT O/C (51-3 Pole)</td>
</tr>
<tr>
<td>5</td>
<td>Bus PT Feeder</td>
<td>▪ Under voltage with timer (27+2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Over voltage protection (59)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Fuse failure protection (97) (for alarm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Neutral unbalance protection (60) (for alarm)</td>
</tr>
</tbody>
</table>

**02.01.28 Details of major protections for 33 kV panels**
### 02.01.29 Details of major metering for 6.6 kV panels

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of feeder</th>
<th>Meters on switchboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bus Coupler feeder</td>
<td>Ammeter with ASS</td>
</tr>
</tbody>
</table>
| 2       | Incomer from transformer | Voltmeter with VSS for line PT  
|         |                | Ammeter with ASS  
|         |                | Multi function meter |
| 3       | Incomer from switchboard | Voltmeter with VSS for line PT  
|         |                | Ammeter with ASS  
|         |                | Multi function meter |
| 4       | Outgoing Power Supply Feeder to switchboards | Ammeter with ASS  
|         |                | Multi function meter |
| 5       | Outgoing Transformer feeder  
( all types of transformers) | Ammeter with ASS  
|         |                | Multi function meter |
| 6       | Outgoing Motor Feeder) | Ammeter with ASS  
|         |                | Multi function meter |
| 7       | Bus PT Feeder | Voltmeter with VSS  
<p>|         |                | Multi function meter |</p>
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of feeder</th>
<th>Meters on switch board</th>
<th>Meters on control panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bus Coupler feeder</td>
<td>Ammeter with ASS</td>
<td>Ammeter with ASS</td>
</tr>
<tr>
<td>2</td>
<td>Incomer</td>
<td>Voltmeter with VSS</td>
<td>Voltmeter with VSS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(for both line PT)</td>
<td>for line PT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ammeter with ASS</td>
<td>Multi function meter</td>
</tr>
<tr>
<td>3</td>
<td>Outgoing Transformer feeder</td>
<td>Ammeter with ASS</td>
<td>Ammeter with ASS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KW meter</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Outgoing Power Supply Feeder to</td>
<td>Ammeter with ASS</td>
<td>Ammeter with ASS</td>
</tr>
<tr>
<td></td>
<td>switchboards</td>
<td>KWh meter</td>
<td>Multi function meter</td>
</tr>
<tr>
<td>5</td>
<td>Bus PT Feeder</td>
<td>Voltmeter with VSS</td>
<td>Voltmeter with VSS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multi function meter</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Capacitor Bank Feeder</td>
<td>Ammeter with ASS</td>
<td>Ammeter with ASS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multi function meter</td>
<td></td>
</tr>
</tbody>
</table>

**02.01.31 Control and Relay Panel**  
Control & relay panel for 33kV switchyard equipment shall house relay, control and metering.

**02.01.31.01 Constructional Features**
- Panels shall be arranged to form a continuous board with the mimic and control equipment.
- Panels shall be vertical, free standing, simplex type with rear hinged door, side terminal blocks, control signaling circuit breakers, resistors, fuses, links, isolating switches etc.
- Flush mounted meters, relays, switches, signal lamps etc on front of the panel.
- Made of cold rolled pressed sheet steel thickness 2.5 mm.
- Provided with 75mm base channel and 15 mm anti vibration pad.
- Will have bottom cable entry
- Provided with space heater and interior illumination lamp with switches.
- Anodised aluminum / Chrome plated inscription plate both at back and front side of size to enable a person to read from 5 meters shall be provided.
- All doors, removable covers and panels shall be casketed all around with neoprene gaskets. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.
- The center line of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The center line of relays, meters and recorders shall be no less than 450mm from the bottom of the panel.
- All sheet steel work shall be with 7 tank process.
- After application of the primer, two coats of powder coating shall be provided. The paint shade shall be 631 as per IS:5.
- Facia drawing shall be submitted by successful tenderer, to customer, for approval
- Components i.e. Pushbuttons, selector switches, indicating lamps, annunciation system, meters etc. shall be as per requirement as finalised during detail engineering.
02.02 TRANSFORMER

02.02.01 Electrical Design
- Generally as per IS 2026 - 1977.
- 3 phase core type
- Rated output voltage ratio, vector group shall be as specified in Technical particulars for design.
- Rated frequency 50 Hz, + 3%, -6%.
- Insulation level shall be designed according to the voltages specified below:

<table>
<thead>
<tr>
<th>Nominal system voltage</th>
<th>6.6 kV</th>
<th>33 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. system voltage</td>
<td>7.2 kV</td>
<td>36 kV</td>
</tr>
<tr>
<td>One minute power frequency withstand voltage</td>
<td>20 kV</td>
<td>70 kV</td>
</tr>
<tr>
<td>Peak impulse test withstand voltage</td>
<td>60 kV</td>
<td>170 kV</td>
</tr>
</tbody>
</table>

- Transformers shall be capable of delivering rated current at an applied voltage up to 105% rated voltage without exceeding the temperature limits.
- Overload capacity as per IS 6600 - 1972 unless otherwise specified.
- Shall be operable at its rated capacity at any voltage within ± 10% of rated voltage of the particular tap.
- Permissible maximum temperature at rated output and principal tap ambient temperature of 45 deg. C
  a) Top oil (by thermometer) : 85 deg C
  b) Windings (by resistance method) : 95 deg. C
  c) Maximum hot spot temp : 105 deg C
- Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuits at its terminals. Unless otherwise specified the duration of short circuit shall be 5 seconds.
- The maximum temperature at the end of the specified duration shall not be more than 250 deg. C with the temperature prior to short circuit corresponding to maximum permissible overload.
- Designed for suppression of harmonics especially 3rd and 5th.
- In case of forced cooled transformers, these shall be able to deliver rated power for 10 minutes even if the forced cooling fails with the winding hot spot temperature limited to 140 deg C. Where the coolers are provided, similar operation shall be permissible for 20 minutes on failure of one cooler.

02.02.02 Magnetic Circuit
- Low loss CRGO silicon steel shall be used.
  - CRGO sheets shall be coated with insulation varnish compatible with the sealing liquid.
  - Ducts to be provided to ensure adequate cooling.
  - Core, framework and clamps arranged and tightened to securely hold laminations in order to prevent any settling of displacement in case of heavy shocks during transport, handling or short circuits.
- Flux density under specified over voltage or frequency conditions shall be within the maximum permissible for the laminations.
- Transformers shall be designed to withstand 110% over fluxing corresponding to rated voltage.
02.02.03 Windings
- Material shall be electrolytic grade work hardened copper of high proof stress with more numbers of radial supports.
- Shall be pre-compressed, press board, pre-stabilization of coil.
- Completed core and winding to be vacuum dried in full vacuum and impregnated immediately.
- Shall be braced to withstand shocks due to rough handling, and forces due to short circuit, switching or other transients.
- Permanent current carrying conductors within winding shall be brazed. Connections to bushings and OLTC will be crimped.
- Coils shall be supported using blocks, spacers and cylinders.
- Insulating materials shall be compatible with transformer liquid under all service conditions.
- Leads to the terminal board and bushings shall be rigidly supported.

02.02.04 Insulation
- Interturn and inter coil insulation shall be designed such that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

02.02.05 On Load Tap Changer
02.02.05.01 Electrical Design
- Generally as per IS 8468-1977
- Automatic motor operated, resistive transition impedance type
- Suitable for bidirectional power flow unless specified otherwise.
- Tap Changer shall change the effective transformation ratio without providing phase displacement.
- The tap changer shall have the same rating as the associated transformer with respect to rated current, rated voltage, number of phases, insulation level, over loading capability and short circuit withstand capacity.
- Number of steps 13 and rated step voltage 1.25% unless specified otherwise.
- Shall be suitable for connection to line end of neutral and of the winding as specified.
- DC Control supply voltage shall be 220V DC

02.02.05.02 General Arrangement
- Divertor switch contacts shall be housed in a separate oil chamber not communicating with the oil in the main tank of the transformer.
- The oil used shall be transformer oil conforming to IS 355-1983.
- The OLTC oil chamber shall have oil filling and drain plug, relief vent and glass window for seeing the level. A buchholz relay (hand reset type) also shall be fitted, the outlet of which shall be connected to a separate conservator.
- A mechanical tap position indicator shall be provided locally.
- A mechanical operation counter shall be provided to indicate the number of operations completed.
- The main contacts, switching contacts and transition contacts shall be of sliver faced copper with maximum temperature rise of contacts at 150 % of rated current of transformer limited to 20°C.
02.02.05.03 Control Features
- The OLTC shall have the following control regimes,
  a) Local Manual operation
  b) Local Electrical Operation
  c) Remote electrical operation
  d) Fully automatic operation
- In manual regime, the OLTC shall be operable by a person standing at the ground level. The electrical operation shall be inhibited automatically once the manual operation is restored to.
- For Electrical operation a suitable 3 phase, 415V AC Motor and associated starter with thermal O/L relays, fuses, etc shall be provided.
- The manual electrical operation, either local or remote shall cause one tap movement only. The control switch is to be returned to the OFF position between successive operations.
- Once a switching sequence has started, it shall always be completed. The tap changer shall not stop in an intermediate position even in the event of control power failure.
- Mechanical stop shall be provided to prevent overrunning beyond the extreme tap position. Electrical interlock through limit switches shall also be provided to cut off power for electrical operation.
- A reverse tap change signal during an operation shall be ignored till the mechanism comes to rest and reset the circuit for a fresh operation.
- Emergency stopping provision shall be provided both at the local and remote control panels.
- An indication 'tap change in progress' shall be available at the remote control panel.
- Power and control circuit of motor shall be interlocked.
- If control is set to 'automatic', it shall not be possible to operate the OLTC by manual electric or hand operating gear.
- Automatic voltage regulator with voltage transformer shall be provided for automatic control of OLTC. The regulator shall have a delay between the sensing of change of voltage and the change of tap. The delay shall be inversely proportional to the degree of voltage variation. The voltage setting shall be continuously adjustable from 90% to 100% of rated voltage. The dead band shall be continuously adjustable from 0.5% to 4% of rated voltage. The operation of OLTC shall be blocked if the voltage drops to less than 80% of rated voltage. A hand reset operation indicator and self reset alarm contact shall be provided which operates:
  a) Instantaneously if auxiliary supply fails.
  b) With a delay of 3 seconds if regulated supply fails or drops below 80% of setting
  c) If regulated voltage remains +3% outside the set dead band for more than 15 minutes.
- Where specified, line drop compensation shall be provided with resistive and reactive drops upto 20% of rated voltage in steps of 1%. Resistance and reactance settings shall be independently adjustable.
- CTs required for current reference shall form part of transformer, mounted on bushings. The secondary terminals of the CTs shall be wired to outdoor type terminal block provided with shorting links.

02.02.05.01 Local OLTC Control Cabinet
- Dust vermin and weather proof outdoor cubicle with lockable door, enclosure class IP-55.
- Shall house the drive motor for OLTC, starter, local control equipment, indicators for tap
position, counters, etc.

02.02.05 List of Accessories for OLTC
- Operation counter
- Local tap position indicator
- Buchholz relay
- Oil surge Relay
- Conservator
- Dehydrating breather
- Drain plug and oil filling plug
- Local OLTC control cubicle.

02.02.06 Off-Circuit Tap Switch (Where Applicable)
- Externally hand operated with easily accessible links.
- Designed for sustained over current of at least 150% of the rated current of the winding.
- Shall not occupy any intermediate position between clearly marked tap position.
- Capable of repeated operation and withstanding short circuit forces.
- Tap position indicator
- Inspection and/or repair shall not require removal of transformer core from tank.
- Integral handle with padlocking arrangement

02.02.07 Tank
- Welded thick gauge plates stiffened and reinforced to withstand without deformation all stresses applied during transport and operation or short circuit conditions.
- Oil tight welds and joints
- Fully assembled transformer with its radiators, conservator and other fittings shall withstand for one hour a pressure corresponding to twice the normal head of liquid or to the normal pressure plug 35 kW/sq. m, whichever is higher, measured of the base of the tank.
- Plates shall be protected internally against corrosion due to insulating liquid.
- Provided with inspection opening and cover (with handling equipment) to provide access to bushing connections.
- Form of cover shall be such as to prevent any stagnant water deposit and to drain gas bubbles towards the buchholz relay
- Tank (with radiators when welded to tank) shall be capable of withstanding of 250 mm of mercury vacuum.

02.02.08 Conservator and Breather
- Conservator mounted on frame, integral with tank in such a manner that under all conditions and the lowest oil level the bushings remain under the head of liquid.
- Conservator volume shall be sufficient to maintain oil seal from ambient to oil temperature of 90 deg. C
- Oil filling hole with cap, and a drain valve to drain the oil completely shall be provided. One end of the conservator shall be bolted into position so that it can be removed for cleaning purposes.
- Silica gel breather with inspection window and oil seal shall be mounted at 1.4 m from ground level and connected to conservator.
- Prismatic type oil level gauge with maximum and minimum levels marked. One 150 mm
diameter dial type magnetic level gauge with alarm and trip contacts shall also be provided.

02.02.09 Buchholz Relay
- Double float relay as per IS 3677 - 1966.
- Shut off valves on either sides of the buchholz relay
- Pot cocks at the top and bottom of relay drain plug, inspection window, calibrated scale, terminal box with oil tight double compression type brass gland.
- Potential free, self reset independent alarm and trip contacts, rated to make, break and carry 2 amps at 110 V DC. No auxiliary relay shall be used to multiply the contacts. Contacts are to be wired to the marshalling box.

02.02.10 Cooling
02.02.10.01 General
The cooling system provided may be either of the following or a mixed system of these, as specified.
ONAN - Oil natural, air natural
ONAF - Oil natural, air forced i.e with cooling fans
Where forced cooling is provided, the forced cooling shall be automatically started/stopped through contacts of winding temperature indicator, the settings, of which shall be separately adjustable at site.

02.02.10.02 Radiators
Radiators may be detachable type directly mounted or separately mounted flanged, gasketed and bolted connections shall be used for connecting the radiators to the tank.

The following accessories shall be provided for each radiator/radiator bank
a) Top and bottom shut off valves and blanking plates.
b) Bottom drain plug and top filling plug, air release plug
c) Lifting lugs
d) Thermometer pockets with thermometers in the inlet and outlet pipes (for separately mounted radiator banks).
e) Top and bottom filter valves for each separately mounted radiator bank.

02.02.10.03 Forced Air System
- The fans shall be mounted in a suitable enclosure to ensure protection against rain.
- Galvanised wire mesh guard shall be provided.

02.02.11 Valves and connections
- Valves of sluice type with hand wheels
- Made of gun metal
- Clear indication of open and closed position
- Provided with blanking plates or screwed plugs
- Padlocking facility to lock in closed/open position.

02.02.12 Terminations
It shall be possible to withdraw the transformer easily after disconnecting the connections without disturbing the cable terminations.
For cable termination
- Air insulated cable box suitable for the type and number of cables specified.
- Air insulated disconnection chamber with inspection opening
- Compression type brass cable glands with tinned copper lugs
- Bolted type gland plates.
- Sealing kits with associated accessories like stress relieving cones, insulating tape, trifurcating boot, HT insulating tape, etc.

For bus duct termination
- When bus duct termination is specified, flanged throat shall be provided to suit the bus duct. Flange ends and inspection openings shall have weatherproof gaskets.

02.02.13 Bushings
- Minimum rated current of line and bushings shall be 1.5 times rated current of the corresponding windings
- Clamps and fittings made of steel or malleable iron shall be hot dip galvanized.
- Bushings rated 400 Amps and above shall have non-magnetic clamps and fittings only.
- Neutral bushings shall be provided as required for earthing of neutral point.
- The creepage distance for bushings, insulators etc. shall be adequate for heavily polluted atmosphere, and shall not be less than 25.4 mm / kV corresponding to the highest system voltage.

02.02.13.01 Bushing current Transformers (Where applicable)
- CTs for REF protection and back up earth fault shall be provided on the neutral end.
- For differential protection, CTs shall be provided on primary side
- Removable at site without opening transformer tank cover/active parts.
- Secondary leads shall be brought to a weatherproof terminal box and from there to the marshalling box.

02.02.14 Oil temperature Indicator
150 mm dial type thermometer with manual reset maximum reading pointer. There shall also be two potential free contacts for alarm and trip signals. The alarm and trip settings shall be independently adjustable. The temperature-sensing element mounted in a pocket of oil shall be connected to the indicator through capillary tubing. Contact rating at DC shall be minimum 0.5 amps.

02.02.15 Winding Temperature Indicator
a) Local winding temperature indicator (WTI) shall have a 150 mm diameter dial type indicator with a manual reset maximum reading pointer. There shall be two potential free contacts for alarm and trip signals. For transformers with forced cooling, another set of contacts shall be provided to start/stop the forced cooling system automatically. The settings for closing/opening of each contact shall be independently adjustable. Contact rating at DC11, 110V DC shall be minimum 0.5 amps. The device shall be complete with lamp, sensing element, image coil, calibration device, auxiliary CTs etc. as required.
b) Remote winding temperature indicator with resistance type temperature detector, shall be provided additionally.

02.02.16 Marshalling box
- All outgoing connections from the transformer i.e buchholz relay, temperature indicators, level indicators, CT secondary, fault contacts for annunciation, including forced cooling system and OLTC etc shall be wired to a marshalling box.
- Degree of protection of enclosure shall be IP 52 for indoor and IP 52 for outdoor type respectively.

02.02.17 Remote Control Panel
The following minimum remote control/signalling provisions are to be made as applicable.

a) Remote control devices for manual electrical control of OLTC
b) Automatic voltage regulator and other accessories for automatic control of OLTC
c) Voltmeter to read secondary voltage of power transformer
d) Remote tap position indicator for OLTC
e) Signal lamps for 'tap changing in progress' for OLTC. ON/OFF status for pumps and fans etc.
f) Push buttons, for control of forced cooling system fans and pumps
g) Remote winding temperature indicator

Audio-visual annunciation for the following abnormal operating conditions shall be provided as applicable.

a) Oil level in transformer low (from magnetic level gauge)
b) Buchholz relay operation for transformer
c) High oil temperature in transformer
d) High winding temperature
e) Oil pressure low
f) Cooling fans failed
g) OLTC failed to operate on auto
h) OLTC motor tripped
i) Buchholz relay of OLTC operated
j) Aux. AC supply failed.

A solid state facia window type annunciation system shall be provided for this purpose, with the following features.

i) On incidence of fault - A hooter comes on and window lamp starts flashing
   ii) On pressing ACCEPT button - Hooter stops, lamp becomes steady
   iii) On pressing RESET button - Lamp goes off if fault is removed.
       Lamp continues to glow if fault persists

The required alarm/trip contacts shall be wired to the marshalling box for connection to the annunciation system.

02.02.18 Earthing

- All metal parts of the transformer with the exception of individual core laminations, core bolts, and clamping plates shall be maintained at fixed potential by earthing.
- Two tinned copper earthing terminals
- One end of bushing CTs shall be earthed.

02.02.19 List of fittings and Accessories

- Identification plate
- Rating and diagram plates.
- First fill of oil as per IS-355, 1983 with 10% excess in drums
- Cooling system complete with accessories as specified
- ON load tap changer with accessories / Off-circuit tap switch as specified
- Conservator with oil level gauge
- Dehydrating breather
- Buchholz relay with alarm and trip contacts
- Oil filter valves at top and bottom of tank
- Drain off valve at lowest location to allow complete draining
- Oil sampling device at top and bottom
- Explosion vent with double diaphragm
- Pockets with thermometers for oil temperature and winding temperature indicators
- Bar type level gauge with alarm contacts
- HV, LV and neutral bushings.
- Bushing CTs as specified
- Dial type winding temperature indicator with maximum reading pointer and alarm and trip contacts
- Lifting lugs and jacking pads
- Earthing terminals
- Inspection covers
- By-directional rollers/flanged wheels as specified
- Marshalling box.
- Flat base and foundation bolts.

02.02.20

Technical Particulars

<table>
<thead>
<tr>
<th>Particulars</th>
<th>16/20 MVA, 33/6.9 kV</th>
<th>1000/1600/2000 KVA, 6.6 / 0.433 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Three phase, core type oil filled</td>
<td>Three phase, core type, oil filled</td>
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<tr>
<td>Duty</td>
<td>Outdoor/indoor</td>
<td>Indoor</td>
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<tr>
<td>Voltage</td>
<td>33/6.9V</td>
<td>6.6 / 0.433 kV</td>
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<td>Frequency</td>
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<td>50 Hz</td>
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<td>No. of phase</td>
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<td>Continuous rating</td>
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<td>-</td>
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<td>Insulation class</td>
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<td>Class A</td>
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<td>Cooling</td>
<td>ONAN/ONAF</td>
<td>ONAN</td>
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<tr>
<td>Winding connection</td>
<td>Delta/Star</td>
<td>Delta / Star</td>
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<tr>
<td>Vector group</td>
<td>Dyn 11</td>
<td>Dyn 11</td>
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<td>Particulars</td>
<td>16/20 MVA, 33/6.9 kV</td>
<td>1000/1600/2000 KVA, 6.6 /0.433 kV</td>
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<tr>
<td>-------------------------------------</td>
<td>----------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Neutral grounding</td>
<td>Resistance earthed</td>
<td>Solidly earthed</td>
</tr>
<tr>
<td>System earthing</td>
<td>33kV – earthed through earthing transformer 6.6kV – resistance earthed</td>
<td>6.6 kV – Resistance earthed 415 V - Solidly earthed</td>
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<tr>
<td>Percentage impedance</td>
<td>10%</td>
<td>6.25%</td>
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<td>Termination</td>
<td>33kV-Cable end box for termination of XLPE cable 6.6 kV- Bus duct connection</td>
<td>6.6 kV cable end box for termination of XLPE cables. 415 V – Bus duct connection</td>
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<tr>
<td>Temperature rise over: 50 deg C ambient temp</td>
<td></td>
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</tr>
<tr>
<td>a) In oil (measured by Thermometer)</td>
<td>35 deg C</td>
<td>35 deg C</td>
</tr>
<tr>
<td>b) In winding (measured by Resistance method)</td>
<td>45 deg C</td>
<td>45 deg C</td>
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<td>c) Hot spot Temp.</td>
<td>55 deg. C</td>
<td>55 deg. C</td>
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<tr>
<td>Bushing mounted CT’s</td>
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<tr>
<td>a) Primary bushing mounted PS class CT for differential protection</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>b) Secondary bushing mounted PS class CT for differential protection</td>
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<td>-</td>
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<tr>
<td>c) Neutral bushing PS class CT for REF protection.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>d) Neutral bushing CT for strand by E/F protection 10P15</td>
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<td>1</td>
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<tr>
<td>Tap changer on primary side</td>
<td>On load high speed resistor transition</td>
<td>Off load tap changer</td>
</tr>
<tr>
<td>a) Range</td>
<td>+7.5%-7.5%</td>
<td>+5%-5%</td>
</tr>
<tr>
<td>b) Total tap positions</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>c) Taps above nominal voltage</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>d) Taps below nominal voltage</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>e) Voltage per step</td>
<td>1.25 %</td>
<td>±2.5%</td>
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<tr>
<td>Particulars</td>
<td>16/20 MVA, 33/6.9 kV</td>
<td>1000/1600/2000 KVA, 6.6 /0.433 kV</td>
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<tr>
<td>------------------------------------------------</td>
<td>-----------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Tap change controls</td>
<td>Local Manual, local electrical, remote electrical, fully automatic</td>
<td>Local Manual</td>
</tr>
<tr>
<td>Impulse test withstand voltage</td>
<td>As per IS 2026, Part III – 1981</td>
<td>As per IS 2026, Part III – 1981</td>
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<tr>
<td>One minute dry and wet power frequency</td>
<td>- do -</td>
<td>- do -</td>
</tr>
<tr>
<td>Induced over voltage</td>
<td>- do -</td>
<td>- do -</td>
</tr>
<tr>
<td>Withstand time without injury for 3 phase short circuit at terminals</td>
<td>5 Seconds.</td>
<td>5 Seconds</td>
</tr>
<tr>
<td>Auxiliary supply voltage</td>
<td>220 V DC</td>
<td>-</td>
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<tr>
<td>Parallel operation</td>
<td>Suitable for parallel operation with transformers of similar ratings</td>
<td>Suitable for parallel operation with transformers of similar ratings</td>
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<tr>
<td>Overload capacity</td>
<td>As per IS 6600 –1972</td>
<td>As per IS 6600 –1972</td>
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<tr>
<td>Radiators</td>
<td>Detachable type</td>
<td>Detachable type</td>
</tr>
<tr>
<td>Short circuit level on HV side</td>
<td>1500 MVA</td>
<td>450 MVA</td>
</tr>
</tbody>
</table>

**02.03 NEUTRAL GROUNDING RESISTORS**

**02.03.01** Natural air cooled, suitable for indoor application, sheet steel enclosure, degree protection IP-55 as per IS-13947, technical parameters as specified and confirming to IEEE-32 for 6.6 kV system earthing. The NGR shall be provided with single pole, off load isolator in a segregated chamber.

**02.03.02** Neutral side bushing suitable for overhead connection and earth side bushing suitable for grounding flat connection. The resistor shall be designed for the required system voltage and current as per the technical particulars.

**02.03.03** The resistor grid elements shall be made from unbreakable formed nickel chromium stainless steel (AISI-304), punched construction. The insulation used for the elements shall be of non-deteriorating type and shall be unaffected dimensionally during heating and cooling.

**02.03.04** Temperature rise shall not exceed 250°C over ambient temp. of 50°C during the passage of fault current for 10 seconds. Current transformer for neutral O/C protection shall be provided before the single pole isolator as per the technical particulars.

**02.03.05** All interconnections between unit frames and between tiers shall be of solid copper. The entire assembly shall be designed to ensure ample strength to withstand the mechanical stresses imposed due to fault current.
02.03.06  The enclosure shall be of CRCA sheet steel, totally enclosed without louvers. The min. thickness of sheet steel shall not be less than 2 mm.

02.03.07  Technical particulars

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Requirement 6.6kV System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type</td>
<td>Kiosk Mounted, Punched Stainless Steel</td>
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<tr>
<td>2.</td>
<td>Resistance material</td>
<td>Stainless Steel (AISI-304)</td>
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<tr>
<td>3.</td>
<td>Nominal system voltage</td>
<td>6.6 kV</td>
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<tr>
<td>4.</td>
<td>Highest system voltage</td>
<td>7.2 kV</td>
</tr>
<tr>
<td>5.</td>
<td>One minute power frequency withstand voltage</td>
<td>20 kV</td>
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<td>6.</td>
<td>Resistance</td>
<td>As specified</td>
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<tr>
<td>7.</td>
<td>Current rating</td>
<td>As specified</td>
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<td>8.</td>
<td>Duration</td>
<td>10 Sec</td>
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<tr>
<td>9.</td>
<td>Constructional features</td>
<td></td>
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<tr>
<td>a)</td>
<td>Sheet steel thickness</td>
<td>Minimum 2.0 mm</td>
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<td>b)</td>
<td>Installation</td>
<td>Indoor</td>
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<tr>
<td>c)</td>
<td>Degree of protection</td>
<td>IP-55</td>
</tr>
<tr>
<td>d)</td>
<td>Neutral side connection</td>
<td>Overhead earth strip</td>
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<tr>
<td>e)</td>
<td>Earth side connection</td>
<td>Earth strip</td>
</tr>
<tr>
<td>10.</td>
<td>Paint</td>
<td>Synthetic Enamel</td>
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<tr>
<td>11.</td>
<td>Paint shade</td>
<td>Shade 632 as per IS – 5</td>
</tr>
</tbody>
</table>

02.03.08  Single pole Isolator

A single pole isolator shall be provided along with each NGR panel on the neutral side for isolation of NGR in case of maintenance.

The isolator shall be single pole, off load, manually operated air break type, kiosk mounted along with NGR in a segregated chamber. Connection between the isolator and NGR shall be through bushing.

The isolator shall be provided with the following features.

a)  Mechanical & Electrical ON/OFF indicator.
b)  Position indicator to indicate open and close position of operating handle.
c)  Pad locking facility in ON and OFF condition
d)  Door interlock so that the door can’t be opened with the isolator ON with interlock defeat facility.
e)  4NO + 4NC auxiliary contacts wired to terminal block.

Technical Particulars

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Requirement 6.6kV System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type</td>
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<td>2.</td>
<td>Mounting</td>
<td>Kiosk Mounted</td>
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<td>3.</td>
<td>No. of poles</td>
<td>One</td>
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<td>4.</td>
<td>Nominal system voltage</td>
<td>6.6</td>
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<tr>
<td>Sl. No.</td>
<td>Particulars</td>
<td>Requirement 6.6kV System</td>
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<tr>
<td>--------</td>
<td>-------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>5.</td>
<td>Highest system voltage</td>
<td>7.2</td>
</tr>
<tr>
<td>6.</td>
<td>Current rating</td>
<td>As specified</td>
</tr>
<tr>
<td>7.</td>
<td>One minute power frequency withstand voltage</td>
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<td>8.</td>
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<td>60 kV</td>
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<td>9.</td>
<td>CT ratio</td>
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</table>

02.04 LOAD BREAK ISOLATOR 33 kV, 6.6 kV

02.04.01 Features
- Triple pole air break, fault make, load break type
- Independent manual quick make and quick break type
- Mechanical trip device
- Mechanical ON/OFF indicator
- Suitable to connect cables on incoming and outgoing
- Shall have 3 NO + 3 NC aux contacts
- Earthing switch shall be provided on transformer side having rating same as that of main switch.
- Totally enclosed, floor mounted
- Shall have padlocking facility
- Panel door shall be mechanically interlocked so that isolator cannot be closed on open position of door and door cannot be opened on close position of isolator.
- Earthing switch shall be interlocked with the isolator blades to prevent simultaneous closing of both

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>33 kV</th>
<th>6.6 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Type</td>
<td>Air break / fault make / load break</td>
<td>Air break / fault make / load break</td>
</tr>
<tr>
<td>3</td>
<td>Nominal system voltage</td>
<td>33kV phase</td>
<td>6.6 kV 3 phase</td>
</tr>
<tr>
<td>4</td>
<td>Highest system voltage</td>
<td>36 kV</td>
<td>7.2 kV</td>
</tr>
<tr>
<td>5</td>
<td>Rated frequency</td>
<td>50 Hz</td>
<td>50 Hz</td>
</tr>
<tr>
<td>6</td>
<td>Rated continuous current</td>
<td>As specified</td>
<td>As specified</td>
</tr>
<tr>
<td>7</td>
<td>Short time rating</td>
<td>40 kA for 3 sec</td>
<td>40 kA for 3 sec</td>
</tr>
<tr>
<td>8</td>
<td>Impulse withstand voltage</td>
<td>70 kV</td>
<td>60 kV</td>
</tr>
<tr>
<td>9</td>
<td>One minute power frequency withstand voltage</td>
<td>170 kV</td>
<td>20 kV</td>
</tr>
<tr>
<td>10</td>
<td>System earthing</td>
<td>Resistance earthed</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Termination</td>
<td>XLPE cable on both ends</td>
<td>XLPE cable on both ends</td>
</tr>
<tr>
<td>12</td>
<td>Aux. Contacts</td>
<td>3 NO + 3 NC</td>
<td>3 NO + 3 NC</td>
</tr>
<tr>
<td>13</td>
<td>Interlocking</td>
<td>As specified</td>
<td>As specified</td>
</tr>
<tr>
<td>14</td>
<td>No of poles</td>
<td>Three(3)</td>
<td>Three(3)</td>
</tr>
</tbody>
</table>

02.05 415V SWITCHGEAR
02.05.01 General
- Metal clad, indoor type floor mounted, single tier for incomers, bus couplers, and outgoing ACB feeders in fully drawout execution.
- Sheet steel shall be CRCA of minimum 2.0 mm thickness.
- Circuit breaker shall be mounted on fully drawout truck with service, test and isolated positions and complete with following safety interlocks and safety shutters with padlock facility:
  ⇒ It shall not be possible to move the truck in or out of cubicle when the breaker is closed.
  ⇒ CB compartment door shall be mechanically interlocked so that it will not be possible to close the CB in plug position when the door is open.
  ⇒ It shall not be possible to push the truck in close position if either of the safety shutter is not free and not in close position.
- The position of various control switches, push buttons, levers etc. requiring manual operation, shall be at a height not less than 450mm and shall not exceed 1850mm from the finished floor level.
- Name plate for each incoming buscoupler, and outgoing feeder at front and back, both on the fixed portion of the panel.
- All panels shall have space heater with switch and cubicle illumination lamp with door switch
- All breakers of similar rating shall be interchangeable.

02.05.02 Insulation Level
- Rated insulation voltage 650 V
- One minute power frequency withstand voltage:
  ⇒ 2.5 kV for power circuits
  ⇒ 2 kV for control circuits
- Clearance in air (minimum):
  ⇒ Phase to phase - 25.4 mm
  ⇒ Phase to earth - 19.0 mm

02.05.03 Short Circuit Strength
- Rated short time withstand current not less than the system short circuit level specified for 1 sec.
- Rated peak withstand current not less than 2.1 times the system short circuit level.

02.05.04 Busbars
- Busbars made of EC grade aluminium alloy equivalent to E91E WP as per IS 5082, 1981, size adequate for specified rated continuous and SC current.
- Three phase, neutral (with atleast 50% rating of main buses) and continuous earth bus. Bus bar shall be provided with proper grade & colour of heat shrinkable sleeve.
- Rating of horizontal buses shall be same as that of incomer circuit breakers and vertical run shall be same as that of outgoing breaker rating
- Temperature rise of bus bars shall not be more than 40 deg. C above an ambient of 50 deg. C

02.05.05 Protection Requirements
- One auxiliary relay for each transformer incipient faults:
a) Buchholz - alarm (63X)
b) Oil temp. high alarm (490X)
c) Winding temperature high alarm (49 X)
d) Buchholz trip (63Y)
e) Oil temp. high - trip (490Y)
f) Winding temp. high trip (49Y)

- For the above faults, contacts to be made available for inter tripping primary side breaker also.
- All other protections as specified.

02.05.06 Construction Features (Mechanical Design)
- Sheet steel clad, floor mounted, free standing design, non-dust proof construction
  ⇒ Extension bus links properly spaced for terminating single cables of size 120 sq. mm and above as well as for terminating multiple cables of all sizes.
  ⇒ Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of individual cables separately without disturbing other cables.
  ⇒ Double, compression type brass cable glands and crimping type, tinned, heavy duty copper lugs suitable for the type, size and number of cables to be terminated, to be supplied with the switchboard for all LT power and control cables.
  ⇒ The interior of the switchboard shall be finished with ‘OFF WHITE’ paint shade.
  ⇒ All the panels shall be of uniform depth.
  ⇒ All panels shall be supplied with base channels.

02.05.07 Relays
- Flush mounted
- Mechanically operated flag indicators with all relays capable of being reset without opening casing
- Shall withstand impulse voltage in accordance with IS/IEC recommendation.
- Test facility by plug from panel front.
- CT secondary shall be shorted on relay withdrawal.
- Diagram plate at the back of case to identify connections.
- The relay shall be microprocessor based numerical and communicable type.

02.05.08 CIRCUIT BREAKER
02.05.08.01 Electrical Features
- Air break triple pole drawout type conforming to IS 13947.
- Rated continuous current as specified.
- Symmetrical breaking capacity and 1 second rating of the breaker not less than the system short circuit level specified.
- Performance category : P2
- Auxiliary contacts : 6 NO + 6 NC minimum, convertible from NO to NC and vice versa at site.

Ratings:

<table>
<thead>
<tr>
<th></th>
<th>10 amps</th>
<th>4 amps at 240 V</th>
<th>0.5 amps at 110 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC 11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC 11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
02.05.08.02 Operating Mechanism

- Manual or power operated mechanism as applicable
- Spring charged stored energy mechanism to ensure high speed closing and tripping independent of the operating forces.
- Anti pumping and trip free feature
- Emergency tripping by mechanically operated trip push button (shrouded to prevent accidental closing) acting directly on the trip bar.
- Closing operation of the breaker to charge the tripping spring, ready for tripping.
- Mechanical indication to show:
  - Closing spring charged
  - Breaker ON/OFF/TRIP
- Breaker to close only when spring fully charged
- Non-reset type operation counter
- For manually operated breakers:
  - Independent manual charging of closing spring and closing by handle.
  - Alternatively, closing by mechanical push button with spring previously charged by handle.
- For electrically operated breakers:
  - Charging of closing spring by motor
  - Closing by closing coil
  - Spring charging motor and closing coil suitable for rated control voltage (240 AC unless otherwise specified).
  - One opening and one closing operation without control supply.
  - Provision also for manual closing with spring charging motor automatically decoupled as soon as charging handle is inserted.

02.05.08.03 Drawout Features

- 3 distinct positions viz. service, test, and isolated with the door closed.
- Mechanical position indication and locking/latching facility for all 3 positions.
- Power connections - self aligning, plug-in type.
- Control connections - sliding or plug socket type, mechanically coded, to prevent wrong insertion, continuous rating 16 amps minimum.
- Automatic safety shutters to prevent accidental contact with live parts when the breaker is withdrawn.

02.05.08.04 Safety Interlocks

- It shall not be possible to close the breaker in any intermediate position other than the 3 fixed positions.
- With the breaker closed, it shall not be possible to rack it in from any of the 3 position to another.
- Mechanical stopper to prevent accidental falling while withdrawing.
- It shall not be possible to rack in the breaker from isolated to 'test' position with the door open together with provision for defeat of this interlocking, however, it shall be possible to close the door only when the breaker is brought back to 'isolated' position.
- It shall be possible to open the door only when
  - breaker is OFF and
  - is in 'Isolated' position.
- Remote closing of breaker is not permitted with door open.
- Insertion of breaker into 'Service' position shall not be possible if the shutters are not free.

**02.05.08.05 Internal Control Wiring**
- Control wiring by 1100V grade PVC insulated, single core copper conductor of minimum cross section 2.5 sq. mm
- Flexible wires, protected against mechanical damage for wiring to door-mounted devices.
- Wires identified at each end in accordance with schematic diagrams by interlocked type ferrules.
- Colour code for control wiring:
  - AC – black
  - DC – light grey
  - Earth wire - Green
  - Trip circuit - Red
- All connections external to a feeder, all the auxiliary contacts of the LT breaker, and all spare contacts of the relays shall be wired on to the terminal blocks.
- Interconnection between panels of adjacent shipping sections to be brought out to a separate terminal block, wires for interconnection properly labeled, looped and bunched inside the panel for connection at site.
- Not more than two connections shall be carried out on one terminal.

**02.05.08.06 External Terminations**

**001 Control Terminations**
- 650V grade multiway terminal blocks of non-tracking moulded plastic complete with insulated barriers, stud type terminals, washers, nuts and lock nuts and identification strips.
- Power and control terminals segregated.
- Control terminals of minimum rating 10 amps suitable to receive 2.5 sq. mm copper conductor.
- 20% spare terminals in each control terminal block.

**002 Power Terminations**
- Suitable for accepting cables/bus trunking as specified in the technical particulars.
- All spare contacts wired upto terminal block of the panels
  - a) Protective relays - with drawable type
  - b) auxiliary, timer relays - fixed type

**02.05.09 Indicating Instruments**
- Taut band type
- Size
  - Incomer and sectionalizer: 144 sq. mm
  - Outgoing: 96 sq. mm
- Flush mounting: in front of the cubicle
- Accuracy class - 1.0
- Ammeters shall be compatible with CTs of 5A secondary and read actual currents.
- For motor feeders ammeters shall have suppressed scale upto 6 times of full load current after 1.2 times of full load current and shall have red mark on full load value.

**02.05.10 Protective Devices**
- All control circuits shall be individually fed by MCBs with built in thermal and magnetic
releases. HRC fuses shall be provided for protection of spring charged motors of electrically operated breakers.

02.05.11 Contactors
Contactors shall break without damage 8 times rated current upto 100 amp rating and 6 times rated current for above 100 amp rating. Continuous current shall not exceed 2 amp and initial pick up shall be limited to 9 amp. Class of insulation shall be E or better. Drop out voltage shall be 45-65% of rated voltage and pick up shall be 85-110% contactor duty shall be AC3 unless otherwise specified in design parameters.

02.05.12 Annunciation Scheme
- Shall be static type.
- Hooter and bell shall be provided for trip & alarm indication respectively.
- Number of points shall be as per list.
- Shall have facilities for test, reset and accept.
- Shall consists of annunciation windows, relay blocks warning bell, emergency hooter, push buttons etc.
- All windows shall have two bunch LED in parallel.
- All accessories including actuator (if respective scheme is in Successful tenderer's scope) shall be provided.
- Sequence of operation shall be as follows :

<table>
<thead>
<tr>
<th>Description</th>
<th>Audio</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>On occurrence of fault</td>
<td>ON</td>
<td>Flashing</td>
</tr>
<tr>
<td>On accepting</td>
<td>OFF</td>
<td>Steady ON</td>
</tr>
<tr>
<td>On resetting (fault cleared)</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>On resetting (fault persists)</td>
<td>OFF</td>
<td>Steady ON</td>
</tr>
</tbody>
</table>

02.05.13 Control Supply
- Suitable arrangement for 240V AC reliable control supply shall be provided in each 415V switchboard.
- Two 240V AC feeders shall be provided in each board for control and annunciation purpose.
- Shunt trip shall be suitable for operation on 415V AC.
- Shall have supervision facility, alarm shall be provided for non availability of any one of the control supply.
- MCBs shall be provided on incoming sides of supplies.
- Control buses of two sections shall be connected through sectionalising switch.
- Indication lamps shall be connected to 240V AC supply.
- Isolation arrangement shall be provided on each panel to facilitate fault location and testing. Separate fuses shall be provided for spring charging motors, for indication lamps and for closing/tripping circuits of each cubicle.

02.05.14 Inter Tripping
- Provision shall be made for tripping of incomer breaker on tripping of HT breaker
- Provision for tripping of HT breaker on fault tripping of LT incomer breaker shall also be provided.

02.05.15 Indicating Lamps
All indication lamps shall be clustered LED lamps. Color shall be as follows:

02 - 33
02.05.16 Control and Selector Switches
- Control switches for circuit breaker ON/OFF control 3 position spring return to neutral with lost motion device and pistol grip handle.
- Other control and selector switches - stay put type with wing type knobs.

02.05.17 Push Buttons
- Contact Rating:
  - Continuous: 10 amps
  - AC 11: 1.5 amps at 240V
  - DC 11: 0.5 amps at 110 V DC, L/R - 40 ms
- Colour:
  - ACCEPT: BLUE
  - RESET: BLACK
  - TEST: YELLOW

02.05.18 Protective Earthing
- Continuous earth bus of minimum size 50 x 6 mm copper or equivalent aluminium/galvanised steel section, designed to carry the peak short circuit and short time fault current as specified.
- Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel with an earthing terminal at each end, for terminating external earth conductor.
- Vertical earth bus for earthing individual functional units.
- All non-current carrying metal work (including metallic cases of instruments and other panel mounted components) effectively bonded to the earth bus.
- Hinged doors earthed through flexible earthing braid.
- Looping of earth connection, resulting in loss of earth connection to other devices, when the loop is broken, not permitted.
- Withdrawable units provided with self-aligning, spring loaded, silver plated copper scrapping earth contacts of make before/break after type ensuring earth continuity from service to the test position.

02.05.19 Breaker Handling Truck
- Two for each switchboard, for withdrawing the breakers from the switchboard.
- Height of platform adjustable to suit the levels at which the breakers are mounted.
- Adequate mechanical strength for handling the largest breaker.
- Guide rails and stops.

02.05.20 Auto-Changeover Scheme
In case of failure of any of the incoming supplies, to be sensed by under voltages, the incoming breaker of the de-energised section shall be tripped after a pre-set time delay. Through the normally closed auxiliary contacts of the tripped incoming breakers, the bus coupler shall close
provided the other section is healthy.

The automatic transfer scheme shall be such that the automatic closing of the bus section can be done only once and in case the bus coupler breaker trips during auto-changeover, no further auto closing shall be permitted. Auto changeover shall not take place if the incomer breaker trips on fault. The restoration of power shall be manual.

The automatic transfer circuit shall be controlled through an automanual change-over switch.

### Technical Particulars

#### I.T Switchboard

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal system voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>System earthing</td>
<td>Neutral solidly earthed</td>
</tr>
<tr>
<td>Short time rating</td>
<td>50 kA for 1 Sec.</td>
</tr>
<tr>
<td>Making capacity</td>
<td>105 kA</td>
</tr>
<tr>
<td>Control supply</td>
<td>240V AC</td>
</tr>
<tr>
<td>Configuration</td>
<td>As per IS</td>
</tr>
<tr>
<td>Colour code</td>
<td>R Y B</td>
</tr>
<tr>
<td>Busbar rating</td>
<td>As per SLD</td>
</tr>
<tr>
<td>Enclosure</td>
<td>IP-4X or better</td>
</tr>
</tbody>
</table>

#### Circuit Breakers

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetrical breaking current</td>
<td>50 kA</td>
</tr>
<tr>
<td>Making capacity</td>
<td>105 kA</td>
</tr>
<tr>
<td>Short time rating (for 1 second)</td>
<td>50 kA</td>
</tr>
<tr>
<td>Rating for incomers and buscoupilers</td>
<td>As specified</td>
</tr>
<tr>
<td>Rating for outgoing</td>
<td>As specified</td>
</tr>
<tr>
<td>Closing mechanism</td>
<td></td>
</tr>
<tr>
<td>i) Incomer &amp; bus sectionalizer</td>
<td>Motor operated spring charged stored energy type</td>
</tr>
<tr>
<td>ii) Outgoing</td>
<td>Independent manual</td>
</tr>
<tr>
<td>Tripping mechanism</td>
<td>Shunt trip</td>
</tr>
<tr>
<td>Control supply</td>
<td>240 AC</td>
</tr>
<tr>
<td>No. of auxiliary contacts</td>
<td>6 NO + 6 NC for future use</td>
</tr>
</tbody>
</table>

#### Termination

<table>
<thead>
<tr>
<th>Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomer</td>
<td>Bus duct (top entry)</td>
</tr>
<tr>
<td>Outgoing</td>
<td>Armoured aluminium cable</td>
</tr>
<tr>
<td>Finish paint</td>
<td>Light grey 631 as per IS-5</td>
</tr>
</tbody>
</table>

#### Feeder Arrangement

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomer</td>
<td>Air circuit breakers</td>
</tr>
<tr>
<td>(Mounted in single tier arrangement)</td>
<td></td>
</tr>
<tr>
<td>Outgoings</td>
<td>Air circuit breakers</td>
</tr>
<tr>
<td>(Mounted in double tier arrangement)</td>
<td></td>
</tr>
<tr>
<td>Feeder requirement</td>
<td>As specified</td>
</tr>
</tbody>
</table>

### Schedule of Components

<table>
<thead>
<tr>
<th>Feeder Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Incomer</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Schedule of components equipment specification</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>415V, 50 kA air circuit breaker with:</td>
</tr>
<tr>
<td></td>
<td>- independent manual/motor operated</td>
</tr>
<tr>
<td></td>
<td>spring charged mechanism with</td>
</tr>
<tr>
<td></td>
<td>- shunt trip/microprocessor released</td>
</tr>
<tr>
<td></td>
<td>- Mechanical ON/OFF indicator as</td>
</tr>
<tr>
<td></td>
<td>specified below:</td>
</tr>
<tr>
<td>1.a</td>
<td>Motor operated ACB with</td>
</tr>
<tr>
<td></td>
<td>microprocessor based direct acting O/C,</td>
</tr>
<tr>
<td></td>
<td>S/C &amp; EF release with timer</td>
</tr>
<tr>
<td>1.b</td>
<td>Manual operated ACB with</td>
</tr>
<tr>
<td></td>
<td>Microprocessor based direct acting O/C,</td>
</tr>
<tr>
<td></td>
<td>S/C &amp; EF release with timer</td>
</tr>
<tr>
<td>2.</td>
<td>Control switch ON/OFF with spring return</td>
</tr>
<tr>
<td></td>
<td>to neutral</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter with selector switch</td>
</tr>
<tr>
<td>4.</td>
<td>Ammeter with selector switch</td>
</tr>
<tr>
<td>5.</td>
<td>Selector Switch</td>
</tr>
<tr>
<td>6.</td>
<td>Digital Multi function meter with</td>
</tr>
<tr>
<td></td>
<td>communication port</td>
</tr>
<tr>
<td>7.</td>
<td>kWh meter</td>
</tr>
<tr>
<td>8.</td>
<td>Single core current transformer class 1.0</td>
</tr>
<tr>
<td></td>
<td>for metering</td>
</tr>
<tr>
<td>9.</td>
<td>Numerical inverse time over current relay,</td>
</tr>
<tr>
<td></td>
<td>setting 10-40% for back up earth fault</td>
</tr>
<tr>
<td></td>
<td>protection.</td>
</tr>
<tr>
<td>10.</td>
<td>ON/OFF/Trip on fault/Trip circuit healthy</td>
</tr>
<tr>
<td></td>
<td>lamps</td>
</tr>
<tr>
<td>11.</td>
<td>Auxiliary relays flag indication for</td>
</tr>
<tr>
<td></td>
<td>buchholz trip and alarm and oil</td>
</tr>
<tr>
<td></td>
<td>temperature trip and alarm signals and</td>
</tr>
<tr>
<td></td>
<td>winding temp. alarm and trip signals</td>
</tr>
<tr>
<td>12.</td>
<td>Auto changeover scheme with under</td>
</tr>
<tr>
<td></td>
<td>voltage relay, PT etc.</td>
</tr>
<tr>
<td>13.</td>
<td>Set of relays, contactors, timers, etc. for</td>
</tr>
<tr>
<td></td>
<td>annunciation scheme</td>
</tr>
<tr>
<td>14.</td>
<td>Set of relays, contactors, timers for auto</td>
</tr>
<tr>
<td></td>
<td>changeover scheme</td>
</tr>
<tr>
<td>15.</td>
<td>Annunciators with required no. of windows</td>
</tr>
<tr>
<td></td>
<td>(set)</td>
</tr>
<tr>
<td>16.</td>
<td>415/240V, 2.5 kVA Control transformer</td>
</tr>
<tr>
<td></td>
<td>2 nos. of control transformer for two</td>
</tr>
<tr>
<td></td>
<td>section</td>
</tr>
<tr>
<td>17.</td>
<td>Impulse switch for tripping 6.6 kV breaker</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Schedule of components equipment specification</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Two position, two contacts stay put switch with pistol grip handle for closing permission of upstream HT breaker</td>
</tr>
<tr>
<td>19.</td>
<td>ON/OFF lamp indication of 6.6kV breaker and 6.6kV Isolator</td>
</tr>
<tr>
<td>20.</td>
<td>Inter tripping push button to trip the upstream breaker</td>
</tr>
</tbody>
</table>

02.06 HT/LT BUSDUCT

02.06.01 Electrical Design

i) Electric power supply (Unless otherwise specified)
- 6.6 kV 3 phase, 50 Hz system, neutral resistance earthed
- 415 V, 3 phase 50 Hz system neutral solidly grounded
- System short circuit level as specified.

ii) Insulation level
Rated insulation voltage : (6.6 kV) – 7.2 kV, (415 V)-660 V
One minute power frequency voltage : (6.6 kV) : 20 kV
(415 V) : 2.5 kV
- Clearance in air (minimum) (6.6 kV) : 125 mm
(415 V) : 25.4 mm
- Phase to phase (mm) : 125 mm
- Phase to earth (mm) : 125 mm

iii) Short circuit strength
- Rated short time withstand current not less than the system short circuit level duration 3 sec. for 6.6 kV, and 1 sec for 415 V.
- Rated peak withstand current not less than 2.1 times the system short circuit level.

iv) Rated current
- Rated continuous current as specified while in enclosure and at specified ambient temperature with maximum temperature of bus bars limited to 90 deg. C
- Neutral bus where specified with rating not less than half the rating of phase bus.

02.06.02 General Arrangement

- HT Busduct : Rectangular, phase segregated busduct. Totally enclosed type.
- LT busduct : Rectangular, Non segregated phase, totally enclosed type.
- Comprising of following sections, as applicable, to make the installation complete and to match with the terminal equipment :
  ⇒ Switchgear lead-in section with flexible hood.
  ⇒ Straight section in standard length
  ⇒ Matching section (length as required)
  ⇒ Transformer lead-in section
  ⇒ Corner sections (horizontal and vertical)
Phase cross-over section

- 240V AC space heater to be provided at suitable intervals and wired to external terminal box with heat resistant cables.
- Silica gel breathers at appropriate locations.
- Horizontal bends to be avoided by positioning the switchboard incomers at appropriate place.

02.06.03 Construction Details

- Degree of protection for enclosure IP 52 or better for indoor installation, and IP55 for outdoor part.
- Enclosure material: Aluminium/steel sheet, as specified of minimum thickness 2.0 mm.
- Enclosure construction rectangular welded construction.
- Maximum temperature of enclosure under rated operating conditions limited to 75 deg. C
- Bolted covers with gaskets for easy inspection and access to insulators and bus bar joints.
- Gasketted (Neoprene) connections between adjacent sections of metallic enclosure.
- Rubber bellows at each end to take care of vibrations.
- Provision for mounting on brackets.
- Supply of painted MS supporting structures with necessary hardware shall be included in the scope of supply.
- Surface treatment.

- Two coats of epoxy paint for outdoor and synthetic enamel paint for indoor application, preceded by de-rusting, cleaning chemically, degreasing, pickling in acid, cold rinsing, phosphating, passivating and spraying with two coats of zinc oxide primer.
- Shade of paint:
  - Interior  :  Black
  - Exterior  :  Light grey shade 631 of IS-5 (unless otherwise specified)

02.06.04 Busbars and Connections

- Material EC grade aluminium alloy equivalent to E91E WP conforming to IS 5082, 1981; or high conductivity electrolytic grade copper as per IS-613, 1984.
- Final operating temperature of both bus bars and joints under continuous operation in enclosure limited to 90 deg. C by thermometer method.
- Bus bar arrangement as per IS-375, 1963.
- Phase identification by colour at ends and at regular intervals.
- Busbar joints of bolted type, with zinc bichromated high tensile steel bolts, nuts and spring washers.
- Busbar surfaces to be tinned at joints and coated with oxide inhibiting grease prior to jointing.
- Flexible connections for termination on equipment.
- Expansion joints on straight runs with joints staggered in adjacent phases.
- Bimetallic joints for jointing between dissimilar metals.
- Busbar support insulators of non-hygroscopic material, having high impact and dielectric strength, with an anti-tracking contour.

02.06.05 Protective Earthing

- Aluminium earth bus of size 50 x 10 mm running throughout the length of the busduct,
positively connected to the body of the busduct.

- Provision at each end of busduct for terminating external earth conductor.

02.06 Technical particulars for Design

<table>
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<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>415 V</th>
<th>6.6 kV</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Application</td>
<td>Indoor</td>
<td>Indoor</td>
</tr>
<tr>
<td>2.</td>
<td>Rated system voltage and frequency</td>
<td>415 V</td>
<td>6.6 kV</td>
</tr>
<tr>
<td>3.</td>
<td>System earthing</td>
<td>Solidly earthed</td>
<td>Resistance earthed</td>
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<tr>
<td>4.</td>
<td>Rated continuous current as specified ambient conditions (in enclosure)</td>
<td>As specified</td>
<td>As specified</td>
</tr>
<tr>
<td>5.</td>
<td>Rated short time withstand current (kA,rms) and its duration</td>
<td>50 kA for 1Sec</td>
<td>40 kA for 3 Sec.</td>
</tr>
<tr>
<td>6.</td>
<td>Rated peak withstand current (peak)</td>
<td>105 kA</td>
<td>100 kA</td>
</tr>
<tr>
<td></td>
<td>- Enclosure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Busbar material</td>
<td>Aluminium</td>
<td>Aluminium</td>
</tr>
<tr>
<td>9.</td>
<td>Neutral bus</td>
<td>To be provided</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Earth bus material</td>
<td>Aluminium</td>
<td>Aluminium</td>
</tr>
<tr>
<td>11.</td>
<td>Earth bus size</td>
<td>50 x 10</td>
<td>50 x 10</td>
</tr>
<tr>
<td>12.</td>
<td>Supporting insulators</td>
<td>SMC/FRP</td>
<td>SMC/FRP</td>
</tr>
<tr>
<td>13.</td>
<td>Busduct enclosure material</td>
<td>Aluminium</td>
<td>Aluminium</td>
</tr>
<tr>
<td>14.</td>
<td>Busduct enclosure material thickness</td>
<td>2.5 mm</td>
<td>5.0 mm</td>
</tr>
</tbody>
</table>

02.07 BATTERY, BATTERY CHARGER AND DC DISTRIBUTION BOARD

02.07.01 STANDARD

a. IS-1651 Stationary cells and batteries, lead acid type (with tubular positive plates)
b. IS-1652 Stationary cells and batteries, lead acid type (with tubular positive plates)
c. IS-10918 Vented type nickel cadmium batteries
d. IS-8320 General requirements and method of test for lead acid storage batteries
e. IS-7204 Stabilised power supplies DC output (Part 1 to 4)
f. IS-2147 Degree of protection provided by enclosures for low-voltage switchgear and controlgear
g. IS-13703 L.V. fuses (Part 1 to 4)
h. IS-1248 Direct acting indicating analogue electrical measuring (Part 1,2,9)
i. IS-13947 L.V.switchgear and control gear (Part 1,3,4,5)
j. IS-12021 Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 V AC
02.07.02 SITE CONDITIONS

The battery chargers shall be suitable for installation and satisfactory operation in a pressurised
substation with restricted natural air ventilation in tropical, humid and corrosive atmosphere.
The battery chargers shall be designed to operate under site conditions as specified. If not
specifically mentioned therein, design ambient temperature of 40 deg C and altitude not
exceeding 1000 m above MSL shall be considered with a minimum temperature of 10 deg C for
battery sizing.

02.07.03 GENERAL REQUIREMENTS

Battery unit

The battery shall be of the nickel cadmium or lead acid type (Plantetype/VRLA) as specified.
Nickel – Cadmium battery shall be of pocket plate type
Battery containers shall be high quality translucent polypropylene for Nickel cadmium battery
and hard rubber for lead acid battery.

Ampere hour capacity of the battery shall be selected based on minimum site ambient
temperature and discharge duty cycle as specified. An overall ageing factor of 0.8 shall be
considered for arriving at ampere hour capacity of the battery.

Number of cells and end cell Voltage shall be decided by the vendor on the following basis.

a. Output voltage shall be limited to max. +10% of nominal system voltage when batteries
   are float charged while feeding the load.
b. System output voltage at the end of design duty cycle shall not be less than 90% of
   nominal system voltage.

The battery shall be suitable for being boost charged to fully charged condition from fully
charged condition within 10 hours.

Battery assembly shall be supplied dry and uncharged. Liquid electrolyte shall be delivered with
the battery in suitable sealed containers unless otherwise agreed.

Sets of Indoor Stationary batteries complete with all accessories including but not limited to
the following shall be supplied with each battery set.

a. Battery stand treated first class teakwood assembled without use of any metal fastenings
   and coated with 3 coats of anti-acid paint for lead battery. Mild steel stand pre-
treated and epoxy painted / PVC coated for Nickel cadmium battery.
b. Intercell, inter now and interbank connectors and end-take-offs. These shall be of lead
   plated copper for lead acid battery and tin plated copper for NiCd battery.
c. Cell induitators
d. Stand insulators
e. Required quantity of electrolyte for initial filling of the battery sets with 10% extra in
   non-returnable containers.
f. Cell number plates and fixing pins as required

Nominal cell voltage for lead acid battery shall be 2.0V for lead acid batteries and 1.2 V for Nickel cadmium battery.

02.07.03 Battery Chargers

- Two identical float cum boost chargers, each comprising of:
  - MCCB, line contactor, and overload relay on the ac side
  - 3 phase full wave semicontrolled rectifier bridge complete with free wheeling diode. The thyristors and diodes shall have high speed fuses for protection against short circuits. Necessary snubbers for hole storage effect shall also be provided.
  - Filter circuit at the output
  - MCCB on DC side
  - Control and protection circuits.
- In float mode, the charger operates with a constant voltage controller and the output voltage of the charger shall be maintained within $\pm 1\%$ of the set voltage for
  - $\pm 10\%$ input AC voltage variation
  - 0 - 100% load variation
  - both occurring simultaneously

The output voltage required can be set externally through potentiometers in the range 90-120% steplessly.
- In boost mode, the charger shall operate with a constant current controller suitable for two-rate charging. The charging current shall be externally adjustable from 20 to 100% steplessly.
- Provision of charging with manual control of output voltage shall also be provided.
- During boost charging, the charger shall be cut-off as soon as over voltage occurs.
- Ripple content in the chargers output voltage shall not exceed 0.5% in float mode and 3% in boost mode.
- The supply to the charger will be at 415V $\pm 6\%$, 50 Hz $\pm 3\%$ unless otherwise specified.
- The charger shall have voltage rating corresponding to the battery and minimum current rating as indicated in Technical Particulars for Design. However, the charger rating shall be chosen to charge the battery from 1.85 volts per cell to fully charged condition in 8 hours.

02.07.04 Relays

- The following relays shall be provided:
  - AC input supply to charger failure
  - Battery earth fault
  - Float bus over and under voltage
  - Boost bus over voltage
  - Boost over current for each charger circuit
- All relays shall be in drawout cases and with mechanical hand reset operation indicator.

02.07.05 Indicating lamps

- The following indications shall be provided.
  - AC supply ON (for 3 phases separately) for each charger
⇒ DC supply ON, for each charger
⇒ Boost/float mode ON, for each charger
⇒ Supply ON, for each outgoing distribution feeder

02.07.06 Metering
- The following measurement shall be provided
  ⇒ AC input voltage and current, of each charger (through voltmeter/ammeter selector switches)
- DC output voltage and current, of each charger
  ⇒ Battery charging/drain current
  ⇒ Battery trickle charging current (through amplifier)
  ⇒ DC bus voltage (through selector switch).

02.07.07 Alarm Annunciation
- Annunciation shall be provided for the following:
  ⇒ Failure of AC supply to charger
  ⇒ Battery earth fault
  ⇒ Float bus over/under voltage
  ⇒ Boost bus over voltage
  ⇒ Boost over current for each charger
  ⇒ Failure of thyristor/diodes for each charger
  ⇒ Failure of blocking diode
  ⇒ Output MCCB open for each charger
  ⇒ Battery MCCB open
  ⇒ Outgoing feeders MCCB open
  ⇒ Battery room exhaust fan OFF
- The annunciation system shall incorporate solid state facia window type annunciators. The sequence shall be:
  ⇒ On incidence of a fault, a hooter will come ON and the corresponding window's lamp shall start flashing.
  ⇒ On pressing 'accept' button, hooter shall stop and lamp shall become steady.
  ⇒ On pressing 'reset' button, the lamp will stay ON if the fault still persists or will go OFF if the fault has been cleared.
- The power supply for the above annunciations shall be taken from the DC float bus.
- A separate annunciation with an AC hooter shall be provided for DC supply failure. This annunciation shall be fed from the AC supply. Reset shall be by a stay put push button.

02.07.08 DC Distribution Board
- The DC distribution board shall have double busbar arrangement, viz. one set of the +ve and -ve connected to charger-1 and another set of +ve and -ve bus connected to charger-2. It shall be possible to connect the bus bars with either charger through selector switches.
- Indicating instruments shall be as per IS 1248, accuracy class 1.5, 96 x 96 mm size.
- AC meters shall be taut band type, DC meters moving coil type.
- DC meters shall be zero centre type where applicable.

02.07.09 Feeder Arrangement
- Each outgoing circuit shall be connected to both the sets of bus bars through selector switch.
It shall be possible to connect each outgoing circuit to either set of bus bars. Each outgoing circuit shall have MCCB. The No. of outgoing circuits shall be as per requirement

02.07.10 Construction Features
- The battery chargers and the DC distribution board (including alarm annunciation) may be integrated into one switchboard or separate boards may be provided.
- Switchboard shall be floor mounting type sheet steel enclosed with degree of protection IP 52 or better.
- Sheet steel used shall be CRCA of minimum 2 mm thickness except for doors and covers for which 1.6 mm thick shall be used.
- Cable entry shall be from bottom, removable gland plates shall be provided.
- All components shall be mounted above 450 mm and below 1850 mm from the floor level.

02.07.11 Wiring and Terminations
- All power wiring shall be done through single core PVC insulated copper wires/buses.
- All control wiring shall be done through single core, PVC insulated copper wire of 2.5 sq. mm
- All connections external to the panel/switch board shall be terminated in suitable terminal blocks. Inter panel wiring shall be only between terminal blocks.
- Each wire shall be identified by ferrules corresponding to the schematic diagram.

02.08 AC DISTRIBUTION BOARD (ACDB)
- 415V, 3 phase, 4 wire, 1000 A, 50 KA (short time rating for 1 second) indoor type.
- Board shall be single front, metal clad, front matched, dust and vermin proof, fully compartmentalised and extensible on both sides, IP5X type enclosure.
- Shall have base channel of size ISMC75
- Shall have isolated busbar chamber for main busbar at the top, running through out the length of the board. Chamber shall have removable cover.
- Cable alley shall have sufficient space for aluminum power cables and bottom cable chamber shall be left free completely isolated from the vertical busbars.
- Busbars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber through out the length of the panel.
- Shall have Moulded Case Circuit Breaker (MCCB) triple pole, air break type with independent manual quick make and break type. MCCB shall be capable of breaking rated current at 0.3 pf at the rated voltage. MCCB shall withstand the fault current envisaged for 415V system.
- All feeders shall have ON/OFF lamps and 96 sq mm size ammeter.
- Shall have 2 incomers & 1 bus coupler.
- Incomer & Bus-coupler shall have manual operated ACBs with Microprocessor based o/c, short circuit, earth fault & shunt trip releases and out going shall be MCCBs.

02.09 CAPACITOR BANK

02.09.01 Code and Standards

The capacitor banks and accessories offered shall conform to the latest edition of the following
standards:-

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<th>Description</th>
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<td>IS:2026 Part-2</td>
<td>Specification for power transformers.</td>
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<tr>
<td>IS:2099</td>
<td>Bushings for Alternating voltages above 1000V.</td>
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<tr>
<td>IS:2544</td>
<td>Porcelain post insulators for systems with nominal voltage greater than 1000V.</td>
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<tr>
<td>IS:2834</td>
<td>Shunt capacitors for power systems.</td>
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<td>IS:3156 Parts 1,2 &amp; 3</td>
<td>Voltage transformers.</td>
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<tr>
<td>IS:5553 Parts 1,3,4 &amp; 5</td>
<td>General requirements, current limiting, damping &amp; tuning reactors.</td>
</tr>
<tr>
<td>IS:9402</td>
<td>H.V. Fuses for the external protection of Shunt.</td>
</tr>
</tbody>
</table>
IS:12672 Internal fuses and internal overpressure disconnectors for shunt capacitors.

IS:13925 Shunt capacitors for AC power systems having a rated voltage above 660V.

02.09.02 SITE CONDITIONS
The capacitor banks and accessories shall be suitable for installation and satisfactory operation for indoor application, in a separate room inside substation building, in safe area, in a tropical, humid and corrosive atmosphere. They shall be designed to operate under site conditions specified in the requisition/ data sheet. If not specifically mentioned therein, a design ambient temperature of 40°C and an altitude not exceeding 1000m above mean sea level shall be considered.

02.09.03 CONSTRUCTION

02.09.03.01 The capacitor banks shall comprise the following basic components. Other equipment, not specifically listed below not necessary for the safe and proper functioning of the capacitor bank shall be included.

i) Capacitor units of appropriate kVAR rating.
ii) Series reactor, if specified.
iii) Residual voltage transformer (R.V.T.)
iv) External expulsion type fuses or internal element fuses, as per the manufacturer’s design.
v) Insulators and bushings.
vi) Cable end boxes for cable termination.
vii) PVC sleeved aluminium busbars for interconnecting the units to form bank and for interconnecting the series reactor and the R.V.T.
viii) Discharge resistors, if required.
ix) Elevating steel structure.
x) Lighting arrestor, if specified.
xi) Incoming isolator, if specified.

02.09.03.02 The entire capacitor bank with post insulators, series reactor, RVT, lightning arrestor and incoming isolator shall be supported on steel elevating structures which shall be designed and supplied by the capacitor supplier.

The steel elevating structure shall be so designed that the bottom most portion of any insulator or bushing on the assembly shall be at a minimum height of 2.75m above ground level.

The steel elevating structure shall be galvanised. The amount of galvanising shall be minimum
02.09.04  DESIGN FEATURES

02.09.04.01  Capacitor Units

The capacitor banks shall comprise appropriate nos. of basic single phase units (minimum 4 nos. basic units in parallel per phase) which shall be connected in start formation. In case the kVAR rating is equal to or below 200kVAR per phase and 4 units per phase cannot be achieved, 1 unit per phase may be provided. The dielectric shall be all polypropylene or mixed dielectric with low watt loss. The impregnant in the capacitors shall be non-toxic, non-PCB (Poly chlorinated biphenyl) based, and bio-degradable.

The capacitor units shall be assembled such that the capacitor banks are capable of withstanding the electro-dynamic and thermal stresses caused by transient over currents during switching.

Protection for capacitor banks using internal element fuses or external expulsion type fuses shall conform to the following requirements.

In internal element fuses design, the internal design of series and parallel arrangement of elements shall be such that.

i. In the case of one failure, there is no harmful over voltage across the remaining elements.
ii. Operation of a single fuse element does not cause cascade fuse blowing.
iii. Permissible over voltages and surges do not cause fuse blowing.

In the external expulsion type fuse design.

i. Fuse characteristic shall be co-ordinated with capacitor unit characteristics.
ii. Fuse shall be rated to allow inrush current of the capacitor unit.

02.09.04.02  Busbars

All busbars interconnecting the basic units as well as the series reactor and R.V.T. shall be of electrolytic aluminium and shall be P.V.C. sleeved. All busbar joints shall be shrouded with removable FRP shrouds.

The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. This shall be verified by type test in which the line voltage will be applied between the sleeved main busbar and an aluminium foil wrapped closely around the insulation over a length of 500mm.

The clearances for 6.6kV capacitor bank systems shall be as follows:

Minimum clearance between phases : 228.6 mm.
Minimum clearance phase to earth : 177.8 mm.
02.09.04.03 Series reactor

Series reactor, if specified, shall be provided to limit the inrush current and to suppress the harmonics. The percentage impedance specified by vendor and if found inadequate, suitable sized series reactor shall be offered. The series reactor shall be in a weather protected completely sealed unit.

Series reactor shall be designed to have linear V/I characteristic, at least, upto 150% of rated current. Temperature rise for oil and winding shall not exceed the limits specified in IS:2026. Series reactor shall be of oil-immersed, air cored, non-magnetically shielded design, with conservator.

02.09.04.04 Residual Voltage Transformer (R.V.T.)

A continuously rated voltage transformer for unbalance protection shall be provided with primary connected in star and the secondary connected in open delta. The secondary voltage shall be 110/3 Volts, unless otherwise specified.

02.09.04.05 Cable boxes

Cable boxes suitable for high voltage XLPE insulated, aluminium conductor, screened and overall PVC sheathed cables of sizes specified shall be provided on the series reactor. Cable box shall be designed to withstand specified primary system fault level for 0.25 seconds. Cable box for control cable shall be provided on the R.V.T.

All cable boxes shall be weatherproof to IP-55.

02.09.04.06 Insulators and bushings

Bushings shall comply with SI-2099. Creepages for highly polluted environment as per requirement of the relevant IS shall be provided. The bushing shall be homogenous; free from lamination, cavities and other imperfections that might affect the mechanical and dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

02.09.04.07 Discharge resistors

Discharge resistors, if required, shall be provided to reduce the capacitor terminal voltage to a value equal to or less than 50V in minutes after capacitor is disconnected from the electrical system.

02.09.04.08 Lighting arrestor and incoming isolator shall be provided, if specified in the datasheet. Isolator shall be suitable for off-load isolation of the capacitor bank.

02.09.05 Protection of Capacitor Bank

The following protection is proposed to be provided on the circuit breaker controlling the
capacitor banks by the purchaser.

i) IDMTL over-current relay.
ii) IDMTL earth fault relay.
iii) Inverse time-voltage neutral phase displacement relay.
iv) Definite time under voltage relay.
v) Inverse time over voltage relay.
v) Timer to prevent reclosure of capacitor bank before discharge.

Vendor shall clearly indicate any other protection considered necessary for safe operation of capacitor bank.

02.09.06 Painting and Marking

The casing of the capacitor for outdoor installation and the frame work shall be painted after suitable treatment with one coat of anti-rust paint and two coats of epoxy base acid/alkali resistant paint. Paint shade shall be 632 of IS:5.

All external bolts and nuts shall be cadmium plated or zinc passivated.

Capacitor banks shall be provided with stainless steel nameplate indicating the rating and all technical particulars as per IS:2834 and IS:13925. Capacitor, series reactor, R.V.T and external fuse (if provided) connection diagram shall also shown on the rating cum diagram plate. Stainless steel nameplates shall be provided to indicate the phase to which each capacitor unit belongs and its rating.

Capacitor vendor shall ensure that series reactor and R.V.T. shall also be provided with similar stainless steel nameplates indicating the rating and identifying the terminals clearly.

02.09.07 Engineering

02.09.07.01 Sizing Criteria

The offered capacitor bank conjunction with series reactor will provide minimum net capacitive KVAR at the rated nominal voltage to maintain the power factor as specified. The vendor shall size and design the capacitor bank, series reactor and residual voltage transformer for the maximum continuous over voltage that can appear across each of these elements, considering system voltage variation given in the data sheets and voltage rise because of series reactor. Insulation level shall be chosen accordingly.

Series reactor shall be so sized that it is capable the permissible capacitor bank over current, as specified in the IS for capacitor banks continuously.
If specified, lightning arrester shall be provided and the rating of the lightning arrester shall be equal to the line voltage of the capacitors for ungrounded/resistance ground systems, it shall be 80% of the line to line voltage of the capacitor. Lightning arrester shall also have impulse breakdown voltage (1.2/50 μs test wave) less than 66% of B.I.L. of capacitor bank.

02.09.07.02 Engineering documentation

The manufacturer shall complete the engineering for capacitor usage as detailed below

i) Fuse sizing, in case of external expulsion fuse.
ii) Reactor sizing calculation.
iii) Capacitor bank sizing calculations to show that the net capacitance achieved at the nominal voltage is as specified in the requisition.
iv) Sizing of lightning arrester, if provided.
v) Calculations for the inrush current of the capacitor bank considering worst switching conditions and back connection, if applicable.
vi) Fault contribution from the capacitor bank to a short circuit in the system
   a. Instantaneous
   b. After 5 cycles

02.10 CABLES
02.10.01 General

Types of cables of following grades and general specifications shall be used taking into consideration the application requirements.

Type 1: 33 kV (UE) XLPE cable
33 kV (E) heavy duty power cable, three core, with compact circular stranded (rm/V) aluminum conductor, with extruded conductor shielding of semi conducting material, XLPE insulated, with insulation shielding over individual cores, consisting of extruded semi conducting compound, followed by lapped semi conducting material and copper tape, cores stranded together with a holding tape provided with a common covering of extruded inner sheath of type ST2 compound, galvanized steel wire armoured and FRLS outer sheathed as per latest IS, as amended up to date. Copper screen shall be suitable to carry 1 kA E/F current for one second.

Type 2: 6.6 kV (UE) XLPE cables
6.6 kV (UE) heavy duty power, cables 3 core, with compact circular stranded (rm/V) aluminum conductor, with extruded conductor shielding of semi conducting material, XLPE insulated, with insulation shielding over individual cores, consisting of extruded semi conducting compound, followed by lapped semi conducting material and copper tape, cores stranded together with a holding tape provided with a common covering of extruded inner sheath of type ST2 compound, galvanized steel wire armoured and FRLS outer sheathed as per latest IS, as amended up to date. Copper screen shall be suitable to carry 1 kA E/F current for one second.
Type 4 : 1.1 kV, PVC aluminum power cables
1.1 kV, heavy duty power cable multicore with standard sector shaped (sm) or with compact circular stranded (rm/V) or circular stranded (rm) aluminum conductors as applicable, HR PVC insulated of type PVC compound suitable for 85 deg.C. operation as per IS:5831-1970, core stranded together provided with a common PVC compound, galvanized steel wire armoured and PVC outer sheathed of type ST2 covering of extruded inner sheath of type ST2 compound conforming to IS:1554 (Part-I) - 1976, as amended upto date.

Type 5 : 1.1 kV PVC copper control cables
1.1 kV circular stranded (rm) annealed copper conductor, PVC insulated of type A, PVC compound suitable for 70 deg. C operation as per IS-5831, 1970. Cores shrouded together provided with common covering of extruded inner sheath of type ST1 PVC compound, galvanized round steel wire armoured and overall PVC sheathed of type ST1 compound and multicore to IS : 1554 (Part-I) – 1976.

The number of cores may be standardized as 2,3,4,5,7,10,14,19,24. Each core of control cable with 7 core and above shall be numbered at every 1 meter intervals.

In multi-core control cables, the following minimum reserve cores shall be kept at the engineering stage.

Upto 7 cores       - One reserve core
10 cores           - Two reserve core
14,19, & 24 core  - Three reserve core

Sequential length marking shall be provided in outer sheath of all power and control cables.

Standard drum length for all types of power and control cables shall be offered. ISI marking at every meter of cable length shall be provided.

For all cables, a minimum extra length of 2 metres will be left before jointing.

02.10.02 Cable Joint/termination accessories

The cable accessories shall include end termination kits, straight through joints and also any special tool and tackles and accessories required for making the joints/terminations.

The straight through joint/termination arrangement shall be complete with all fittings and consumables. The joint shall have electrical and mechanical withstand capability, same as that of the associated cable.

The termination kit shall be of heat shrinkable type / push on type.

The termination kits/straight through joints shall have the following features:
- Electrical stress control to be provided at the cable insulation shield terminus.
- An external leakage insulation to be provided between the cable conductors and ground.
- Adequate protection to be provided at the end of the cables against the entrance of the
02.11 **Earthing and lightning protection**

- All metal parts of electrical equipment not intended to be live, transformer neutral, steel supporting structures for equipment/cables, and fencing of outdoor switchyard shall be earthed in accordance with the latest IE Rules and IS 3043, 1987, IEEE 80.
- All earthing connections shall be of sufficient section to carry the fault current for 3 seconds.
- Soldered joints shall not be used. All joints shall be welded.
- Earthing system shall be designed to achieve earth resistance of value not exceeding 1 ohm.
- Grounding stations shall be exposed and not buried. These shall be protected from traffic movement.
- Earth electrodes shall have facilities for measurement of resistance and watering during dry season.
- The substation building shall be provided with suitable arrangement for lightning protection.
- The LV side neutral of the transformer shall be connected directly to two separate and distinct earthing electrodes, not forming part of sub-station earthing ring.
- For equipment ground connections, the minimum conductor sizes used should be as follows:

  75 x 6 GI flat for:
  - Main earthing ring
  - Main switchboards HT & LT
  - Transformers
  - HT Motors
  - Earthing leads to earth electrodes

  50 x 6 GI flat for:
  - Switchboards, Capacitor banks, MCC, PMCC, MLDB etc

**Earthing electrodes**
The earthing electrodes shall be of GI pipes, 50 mm dia and about 4 mm thickness in one piece, provided with water holes and water filling funnel. The earth pit design shall confirm to IS:3404-1987.

02.12 **ILLUMINATION**
The substation premises shall be provided with illumination facilities to achieve and maintain the specified illumination levels. Peripheral illumination shall also be provided around the buildings.

02.12.01 **Source of Power Supply**
Lighting system shall be supplied at 240V through 415V, 3 phase, 4 wire, 50 Hz AC Supply system. The incoming supply cables and their connection also forms part of the scope of work. Source of supply shall be from ACDB located in sub-station building.

02.12.02 **Control board and Control device**
Lighting panel board shall be of sheet steel, dust and vermin proof, heavy duty type. Incoming feeders shall be provided with MCCBs or switch fuse units. Outgoing sub circuits shall be controlled by MCBs. Minimum rating of the MCBs shall be 16 Amps, 9 kA. Individual control switches where ever provided shall be of rotary type. Rating of the busbars shall be one and half time that of the incoming breaker. All metal enclosure shall be fabricated with at least 2 mm thick steel. All equipment and accessories mounted outdoor shall be metallic and weather proof design or shall be enclosed in a weather proof sheet steel enclosure. The enclosure class shall be IP-54 and IP-55 for control boards to be installed indoor and outdoor respectively. The LDB
shall have two incomers and a sectionalizer, so interlocked that any two can be closed at a time. The incomer shall be provided with ON/OFF indication lamps.

**02.12.03 Cabling/wiring**

Wiring shall be carried out with PVC insulated, PVC sheathed, 650/1100 V grade cable with aluminum conductor in hot deep galvanized rigid sheel conduits or with armoured cable to suit location. Heavy duty armoured cable shall be used for incoming feeder. Minimum size of cable shall be 4 sq.mm. Wherever unarmoured cables is used, it shall be taken in galvanized iron pipes.

**02.12.04 Illumination levels**

The number of luminaries shall be adequate to achieve and maintain the illumination levels as indicated below:

- Switchgear room: 200 lux
- Transformer room: 100 lux
- Battery room: 100 lux
- Office: 250 lux
- Store: 100 lux
- Cable basement: 100 lux

**02.12.05 Type of fittings**

Industrial type low bay fittings with HPMV lamps and 40 W tubular fluorescent lamps shall be used for illumination of substation premises. Luminaries in battery room shall be vapour proof type. For peripheral lighting, street light fitting with HPSV lamps shall be used.

The coefficient of utilisation shall be calculated by the successful tenderer, based on room sizes. Maintenance factor should be taken as 0.6-0.7 for both yard and rooms.

**02.12.06 Emergency Lighting**

Total illumination of the sub-station premises shall be achieved through the lighting DB. For emergency lighting, additional light fitting in the switchyard, MRS and HT sub-station shall be supplied from the DCDB to achieve approximately 20% of the specified illumination level.

Portable/ rechargeable hand lamp sets shall also be provided for use in various electrical premises.

**02.12.07 Ceiling Fans/Exhaust Fans**

1400 mm sweep ceiling fans shall be provided for office rooms, stores rooms, other manned premises and other social buildings. At least 1 no. fan shall be provided for every 10 sq.metre area. The ceiling fan shall be complete with electronic regulator.

Exhaust fans of 300 mm switch for toiles, battery room etc. shall be provided with their control devices (MCBs) and louvers.
02.13 INSTALLATION GUIDELINES

02.13.01 Installation of equipments
- All the electrical installations shall conform to the Indian Electricity Act, Indian Electricity Rules, and regulations in force in the state by Electrical Inspectorate. All the items required as per electrical inspectorate shall be included in the scope of work. These shall be installed by duly licensed and authorised person only.
- The mechanical and other installation shall conform to the applicable Acts and Rules of corresponding Inspectorate and other relevant authorities, if any.
- All the works under this contract, including the installation of the equipment, shall be got inspected and approved by the relevant authorities like Electrical Inspectorate etc.

02.13.02 Tools & Tackles
- The Contractor shall provide all tools/tackles jigs and fixtures, winches, alignment tools, welding sets, testing kits, testing meters/instruments, breaker handling devices, all consumable items and construction equipments as required to install the work complete in all respects, and shall necessarily include (but not be limited to) bolts, nuts, rivets, welding rods, shims, wedges, packing sheets, packing compounds, oil, flushings oil, protective greases and oils, all materials required for proper installation and protection of individual equipment in storage and during erection, testing and commissioning.
- This shall also cover proper alignment, tack welding, tagging, laying, marking of, and connection of cables, fabrication supply and installation of all support structures for installation of various electrical equipments and cables.
- Provision of cable glands, ferrules, cable lugs, tags, sealing kits (for HT cables) shall be arranged.
- Supply and installation of first aid boxes, shock treatment charts, rubber mats, and key board etc.

02.13.03 Erection and Commissioning
- Erection, testing and commissioning of various equipments shall be done strictly as per manufacturer's instructions.
- Contractor shall submit proposed test procedure to the purchaser for approval well in advance and shall not commence testing until approval is conveyed.
- All plant and equipment the painting of which has been damaged during transportation/erection or by corrosion shall be given two coats of paint after removal of scales rust oil, etc.
- All iron frame work erected shall be provided with the under coat of primer and one top coat of finish paint.
- Approved type of danger boards, boards inscribing 'ISOLATED', 'DO NOT CLOSE, MEN AT WORK' shall be provided in sufficient numbers.
- All ventilation and forced draft openings shall have suitable screen protection.
- Special care shall be taken to make the enclosed equipment protected against entry of rats, lizard, and creeping reptiles which may create electrical short circuits.

02.13.04 Stages of completion of works
The stages of completion of various works shall be as follows:
1. Completion of erection
   - Equipment shall be considered to be completely erected when the following activities have been completed.
   - Moving of all equipments to the respective foundations.
- Fixing of anchor bolts or tack welding as required.
- Leveling and alignment of equipment.
- Assembling of all accessories such as relays, CTs, PTs, meters, instruments etc. as described in the job specification.
- Drying of equipment as required and testing of oil for dielectric strength.
- Filtration and filling of oil as required.
- Cable laying, termination with continuity check.
- Applying of finishing coat of paint.
- Mounting of lighting fixtures and connections.
- Completion of earthing system.

**02.13.05 Cable Installation**

**001 Mode of cable installation**

Interplant cable shall be laid in trenches, tunnel or on overhead structures as per site conditions. Digging and refilling of cable trenches, required erection accessories shall be in the scope of work. In the substation and MRS cables shall be laid in concrete channels or basement.

**002 Trenches**

The maximum depth of all trenches shall normally be 1.0 meters, with 750mm cover above the protective slabs, unless otherwise agreed. The back filling of the excavation shall be carried out without disturbing the cover slabs or damaging the cables.

**003 Cable laying in trenches**

The cables shall be laid on 8 cms of riddled sand and approved protective slabs of reinforced concrete. Unless agreed otherwise, all power cables shall be spaced 15cms apart, horizontally.

**004 Cable markers**

Approved cable markers of reinforced concrete shall be provided and fixed to mark each and every deviation of all buried cable routes. A marker shall also be placed every 50 metres along straight through part of each route. A concrete cable marker shall also be provided and fixed to mark the position of every buried joint.

**005 Cable fixing**

Cable shall be fixed to cable racks or cable trays or run on cleats or in conduits, which shall be fixed to concrete brick work or steel structure as required for proper support of the cables, easy accessibility and neatness of appearance.

All necessary frame works and fixings for the support of cables and accessories shall be supplied and fixed by the electrical contractor.

Each cable run shall have to be approved before installation commences. Openings in walls and floors if not already provided shall be made. The openings shall be properly sealed, after drawing the cables.

**006 Supporting steel work for outdoor switchyard equipment**

All supporting steel work shall be free from dirt, rust or scales and shall be galvanised.

**007 Cable supporting Structures**

The structures shall be painted. Power cable shall be supported at 750 mm interval on cable racks and control cables shall be supported on perforated cable trays.

Cables shall be laid in separate racks according to voltage levels. Horizontal clearance not less
than diameter of bigger cables shall be provided between two cables.

008 **Fixing to concrete and brick work**
The cable supporting material shall be fixed to concrete and brick work by the use of rawl bolts and rawl plugs. Fibre plugs shall not be used.

009 **Cables in conduits**
Cable conduits, pipes or luck guards shall be provided to protect the cables, where the cables rise through holes at ground level.

Cables shall be laid in conduits upto 2 meters height above the floor in case of vertical run to avoid mechanical damage.

Not more than one cable shall be drawn into one conduit unless agreed otherwise.

Maximum cross section areas of cable passing through conduit shall not exceed 60% of cross section of conduit.

After the cable has been drawn in the conduit, the same shall be sealed by approved means.

010 **Cable terminations**
The cables shall be terminated in accordance with the relevant diagrams. The cable cores from the sealing box or gland to the terminals of the apparatus shall be neatly arranged, and shall be of sufficient length to prevent the development of tension or local pressure on the insulation. They shall be suitably supported as required.

011 **Identification and Marking**
Each end of each core of every control cable shall be fitted with tight ferrules of approved make and shall be of white inflammable plastic insulation material, having the marking engraved in black to correspond with the relevant diagram. Where the ends of one conductor have different markings each end shall also have white ferrules engraved in red with the remote marking.

Each ferrule shall have its number engraved 3 times around the periphery, 120 deg. apart.

The cores of each power cable other than distribution cable shall be identified in accordance with the relevant diagram by means of labels secured to each core.

Distinguishing labels of non-corrodible material marked in accordance with the cable numbers of the cabling diagram shall be permanently attached to each end of every cable. The phase or polarity of each power cable core at the cable ends shall be identified as follows:

AC system  Phases -  Red, yellow and blue painted discs
Neutral -  Black painted disc

012 **Connection to terminals**
Power cable connections shall be made with cable lugs of approved type and material taking into account the bimetallic actions.

All control circuit connections shall be made with the bare conductor with the use of rose courtenay type washers, crimped lugs, etc. The ends of all stranded conductors shall be twisted tightly together. Solid or stranded conductor shall be connected to terminal studs by taking one complete turn around the stud between the flat washers.

013 **Protection of cables**
All cables shall be installed in such a manner that the risk of subsequent damage is minimised. Steel guards shall be provided where necessary.
03.01.01 Low voltage squirrel cage induction motors:

The Motors shall conform to IPSS: 1-03-001 & IS 325 – 19..

001 Constructional features:

- Frame sizes and ratings and other facilities as per IPSS
- For motor body shall be of grey iron casting as per IS:210-1978
- The motor feet shall be integrally cast with the stator and shall be such a design as to prevent breakage or other failures due to vibrations normally encountered in heavy industries.
- Degree of protection for motor & bearings to be IP-54 and IP55 for terminal box.
- Cylindrical shaft ends, unless otherwise specified
- Shaft extension as per requirement.
- For motor of rating upto 5 kW, roller bearings shall be used for both DE & NDE end. For ratings above 5 kW the DE end shall be provided with roller bearing and NDE end shall be provided with ball bearing.
- Bearings shall be suitable for running of motor in either direction.
- Explosion proof/increased safety design for explosion hazardous areas as per requirement.

002 Terminal box:

- Terminal box amply dimensioned to receive aluminium cables and provided normally on the right side as viewed from drive side or on the top as per the requirement.
- Terminal box frame with opening for cable rotatable by 4x90 deg.
- A suitable earthing stud shall be mounted inside the terminal box.
- Terminal Box shall be suitable to receive the aluminium cables as given in Table-I.
- Extension of Terminal box as required shall be done to receive the Aluminium cables to avoid cramping of the cables in the terminal box.

003 Cooling:
- Motors shall be of TEFC design
- Ventilation shall be effective irrespective of direction of rotation.

004 Quality of Operation:
- Motors shall be dynamically balanced with full key on the shaft-end and fan.
- Vibration intensity shall be limited as per IS 12075-1986.
- Noise level should be as per IS: 12065-1987.

005 Electrical Design
- Suitable for DOL starting
- Motors capable to start and run-up at a minimum of 85% of rated voltage at its terminals with the driven mechanism/equipment connected.
- Starting torque shall be not less than 160% of rated torque.
- Starting current shall be less than or equal to six times the rated current.
- Continuous duty motors shall be capable of three equally spread starts per hour under normal condition or two starts in quick succession from cold or one hot start, under rated load condition.
- Designed for 150% rated speed for 2 minutes.
- In case of VVVF control, suitable derating shall be considered while selecting motor rating and frame size.
- Motors shall have class ‘F’ insulation. Minimum Permissible temperature rise of winding shall be limited to 80 deg. C above ambient temperature of 40 deg.C as measured by resistance method.
- Motors selected shall be of normal starting torque type, high starting torque type, high slip type or stall torque type as required for the specific application.
- Space heaters shall be provided for all outdoor motors rating above 37kW.

- Four pole motors to be used for all general applications, unless specific drive requirement or economics call for other poles.

03.01.02  **Low Voltage Slip Ring Induction Motors**

The Motors shall conform to IPSS: 1-03-003 & IS: 325-19…

001  **Application**

- Slip ring motors shall be employed for inter-mittently running drives requiring frequent switching operations and speed control and for heavy drive applications requiring high starting torque and meeting frequent overload conditions.

002  **Constructional features**

- Same as in case of low voltage squirrel cage induction motors except for the following:

- All motors to have continuously rated slip rings.

- Cast iron slip-rings shall not be used.

003  **Terminal box**

Same as in case of squirrel cage induction motor. Separate and distinctly marked terminal box to be provided for stator and rotor connections.

004  **Cooling**

Motors of low KW. machines shall be of TEFC design. For higher rating above frame size 315, CACA or CACW type of cooling shall be employed.

005  **Quality of operation**

Same as in case of squirrel cage motors.

006  **Electrical design**

- Suitable both mechanically and electrically for required number of switchings/reversals or starts per hour.

- Rotor voltage/currents as per CENEL document.
- Pull out torque of the intermittent duty motors to be not less than 300% of the rated torque at 40% duty factor.

- Motors to be provided with class F insulation with temperature rise corresponding to class B i.e. 80°C (as measured by resistance method) over the ambient of 40°C.

- Motors designed for 50% overload for 2 minutes at operating temperature.

- Slipring motors for essential drives to be provided with Pt 100 resistance thermometers / thermocouples or thermistors for over temperature detection and protection.

- All other features as in case of squirrel cage motors.

**03.01.03 Mill/Crane Duty A.C Motors (Slip Ring & Squirrel Cage Type)**

- Shall conform to IPSS No. 1-03-004

- Shall be suitable for a safe running speed of 2.5 times the rated synchronous speed of the motor or 2000-rpm whichever is less.

- Other Electrical design features shall be same as those for the slipring of motors as elaborated above.

- Material of motor body shall be iron/fabricated steel.

- Tapered shafts for all crane drive motors shall be provided.

- Thermistors shall be provided for all motors.

**03.01.04 Roller Table Motors (Torque motors)**

- Shall conform to IPSS No. 1-03-007-85

- Class H insulation.

- Shall be TENV type only

- Roller table motor (Torque motor) shall have built in PTC thermistors.

- Ability to withstand locked rotor conditions for minimum 2 min. under hot conditions, 3 min. under cold conditions. The motors will meet process requirement also.
03.01.05 High Voltage Motors

Motors shall conform to IPSS No. 1-03-018

001 Constructional Features:

- Stator frame of fabricated steel /high-grade cast iron.
- Stator core of laminated sheets of high grade low loss silicon steel
- Casing feet to be integral with the motor frame.
- Degree of protection for motor and bearings shall be IP-55.
- Forged steel shaft
- Motors of ratings upto 1000 kW fitted with anti-friction bearings with regreasing facility and with grease quantity controllers. For higher ratings,(1000 kW & above) pedestal type sleeve bearing with forced oil lubrication to be used. Arrangements to be incorporated to prevent lubricating oil from reaching the windings. Bearing temperature, lubricating oil temperature and pressure to be measured and monitored.
- Pedestals to be insulated against circulating shaft currents.
- Arrow blocks on non-driving end to indicate direction of rotation.
- Vibration monitor shall be provided at the DE end of motor bearing for motors of ratings 1000 kW and above.
- All motors shall be provided with Bearing (DE & NDE) temperature detectors and 6 nos stator winding temperature detectors, RTDs for monitoring alarm and trip conditions. Temperature shall displayed on VDU's. RTD's shall be of PT100 type.

002 Terminal Box:

- Degree of protection for terminal box enclosure shall be IP56.
- For motors where differential protection is required, two terminal boxes of phase segregated type shall be provided one on each side of the motor. The start of each winding shall be brought out to one box and the end to the other.
- In case no differential protection is required, star point of the winding may be formed inside the neutral terminal box to be provided on one side of the motor. The phase segregated terminal box shall be placed on other side of the motor.
- Each terminal box shall have fault withstand capacity equal to atleast rated short circuit level of the system voltage for 0.25 sec.

- Each terminal box to be reversible to suit cable entry from bottom or top.

- Each terminal box to have two inlets to accommodate any parallel cables as required.

- Terminal boxes shall be suitable for termination of XLPE cables with heat shrinkable cable end seals.

- Separate terminal boxes to be provided for space heaters, RTDs for winding/ bearing temperatures, vibration monitors etc.

- All terminal boxes shall be provided with earthing stud for termination of protective earth conductor.

003 Cooling:

- Low kW range machines may be of TEFC design. For higher rating, type of cooling shall be CACA or CACW.

- In case of CACW type of cooling, the cooling systems to be complete with temperature and pressure monitoring devices.

004 Quality of Operation

- Motors shall be dynamically balanced with full key on the shaft end and fan.

- Vibration intensity shall be limited to 37.5 microns peak to peak.

- Noise level should be as per IS: 12065-1987.

005 Electrical Design

- Same as incase of low voltage induction motors except the following:

- All HT motors shall be high efficiency motors with minimum 96% efficiency at full load conditions.

- All HT motors provided with class F insulation but with total permissible temperature limited to class B (as measured by resistance method). The insulation shall be vaccum pressure & impregnation (VPI) system.

- Space heaters to be provided for all HT motors. Heaters to be automatically OFF when the motor is switched ON.
- Starting torque of the motor to be decided depending upon the requirement of the specific application.

- Suitable to withstand at least three successive starts from system cold condition or two consecutive starts from hot condition at normal system voltage and frequency.

- Suitable for three equally spread starts per hour under normal system voltage and frequency and under normal load & services conditions.

- Motors of rating 1000 kW and above shall be provided with differential protection.

- Motors shall be capable of withstanding locked rotor current for at least 5 second longer than starting time under rated load condition.

- Motors shall be designed for operation with SF6/ VCB breakers.

- Insulation of motors shall be designed conforming to IEC 34-15/ 1990.

- Surge protection shall be provided for the HT motors wherever applicable as follows:

  a) Motor winding and inter turn insulation, connections and leads shall be fully insulated using mica insulation. For such motors surge absorbers (with non-linear resistance) shall be provided within 10 to 15 meters from the motor terminals to limit the over voltages.

  b) In case mica is not provided in motor insulation, both surge capacitors and surge absorbers (with non-linear resistance) shall be provided within 10 to 15 mtrs from the motor terminals to limit the over voltages and rate of rise of voltage.

03.01.06 Synchronous Motors

Same as in case of high voltage motors to the extent applicable for synchronous motors

- Motors shall be of cylindrical design with brushless excitation system and automatic voltage and power factor regulation.

- Power factor 0.9 or better.

- Motors shall be of salient pole type with laminated poles.

- Motor stator winding braced for full voltage starting.

- Motor field to have thyristor controlled static excitation system for automatic system power factor correction.
- Class F insulation for field windings as well as for stator with temperature rise limited to 70 °C (as measured by resistance method) over an ambient of 50 °C.

- Motors shall be capable of withstanding locked rotor current for atleast 5 secs longer than starting time under rated load condition.

03.01.07 DC motors for adjustable voltage auxiliary drives

001 Constructional features

- Industrial type, heavy duty, continuously rated, totally enclosed, generally designed and manufactured as per IEC 34/1, BS :2613, IS :4722

- Stator yoke and poles as well as armature shall preferably of fully laminated construction with low loss silicon steel sheet.

- Frame made of cast steel or thick rolled steel plates.

- Shaft forged from special high tensile steel with tapered ends.

- Brush holder to maintain constant brush pressure regardless of brush wear and to ensure sparkless commutation at top speeds and over-load.

- Machine feet cast integral with the body as integral foot mounting construction.

- Degree of protection for motor, bearing housing and terminal box shall be IP-54.

- All motors shall be provided with compensating windings.

002 Bearings and bearing lubrication

- Motors with shaft heights upto 225 mm, shall be life time greased.

- Motors with shaft heights 250 mm and above, shall be equipped with re-greasing devices and grease quantity controllers.

- Bearings for large size motors /special operating requirements shall be provided with lubricating oil circulation and cooling system. Resistance thermometers, pressure gauges and flow sensors to be built-in for supervision and monitoring of bearing temperature.

003 Terminal Box:

- To be dimensioned adequately for receiving Aluminium cable.
- To be provided on the right hand side as viewed from the drive end.
- Shall be rotatable by 4 x 90 deg.
- Separate terminals to be provided in the box for connections to any auxiliary devices.

004 Cooling:  
- TEFC (IC:0141) or totally enclosed air-to-air heat exchanger (CACA) with motor driven blowers depending upon size and design.

005 Quality of operation:  
Same as specified for low voltage squirrel cage induction motors.

006 Electrical design:  
- Operation from thyristor supply
- Shall be suitable for operation from thyristor converters with fully controlled 3 phase, 6-pulse bridge connection without series smoothing reactors.
- Operation shall be unaffected by voltage or current harmonics.
- Field suitable for power supply from semi-controlled single phase bridge circuits.
- Excitation voltage preferably 220V, DC.
- Field forcing upto three times the rated value shall be possible

007 Overload capacity:  
- Minimum 160% frequently repeated momentary load for 15 seconds.

008 Overspeed:  
- Capable of withstanding an overspeed of 20% above rated maximum field weakening speed.

009 Rate of rise of load current:  
- 200 times the rated current/second.
010  **Stand still currents:**

- Shall be capable of withstanding stand still currents upto the full rated current value for 30 seconds with the cooling fan in operation and 15% of rated current for shutdowns of indefinite duration.

**Insulation:**

- Shall be provided with class F insulation throughout the stator and rotor windings but designed for temperature rise of 70 deg C (as measured by resistance method) corresponding to that of class B insulation.

03.01.08  **AISE mill type DC motors**

AISE mill type motors shall be supplied with the following special features in addition to those specified for general purpose D.C. motors.

001  **Ratings and frame sizes:**

- DC mill motors 800 series
  - Shall conform to AISE standards-1 for mill motors and IPSS No.1-03-002-94.
  - Class of Insulation H.Temp. rise over specified ambient of 50 °C shall be 100 °C
  - All forced ventilated motors having motor mounted blowers shall be provided with self closing louvers. Blowers shall have filters.
  - DC mill motors shall be provided with terminal boxes and covers as required.
  - All motors shall have built-in thermistors.

03.01.09  **Brakes**

- DC electro- magnet type suitable for 220V DC.
  - Suitable for arduous steel mill duty having long mechanical life.
  - Floor mounting, two shoes, self-aligning, quick acting with self-lubricating robust bearings.
  - Lining of tough heat resistant material with countersunk fixing rivets to prevent rubbing against the brake wheel.
  - Facility for brake torque adjustment
- Lining wear indication

- Electrically released and spring applied for fail safe operation (gravity operated counterweight type are not acceptable)

- Brake releasing sensing limit switch for interlocks.

- Necessary rectifier and brake forcing equipment shall be included for DC electromagnet brakes used with AC system.

- Brake coil connection brought to appropriate terminal box for ease in maintenance and terminals covered for protection against accidental touch.

03.01.10 Field Devices

- All field switches to have enclosure class IP-65

- Minimum separate contacts 2NO & 2NC for interlocks and as required for process.

03.02 Control System Concept And Philosophy

03.02.01 The electrical control system shall be laid on distributed hierarchial concept with a great extent of decentralisation of control functions so that individual system shall be autonomous in operation as far as possible.

The system shall be sufficient to perform all the functions required of them & shall be designed to achieve high degree of accuracy of control functions.

Three hierarchical levels has been envisaged as indicated below :-

- Functional group control level (Level-1)
- Individual drive control level (Level-0)

001 Individual drive control level (Level-0)

This shall comprise of motors, field devices, HT/LT Switchgears, MCC's, Desks, speed control equipment, etc. which are to be connected to Level-1 System.

002 Functional group control level (Level-1)

It shall comprise of programmable controllers. The programmable controllers shall provide for control, interlocking and sequencing of different drives. This shall also include MMI, visualisation, alarms logging, reporting, trend curves, controlling of set points, etc. for the plant units.
Necessary interface to Level-2 System shall be provided.

03.02.02 Drive Control Requirement

All process drives shall be generally controlled through VDU’s and keyboards. Control desks/ Control Cabinets shall be provided for specific drives as per process requirement.

All drives shall be provided with LCB for local operation/maintenance. LCBs shall be provided with start & stop PBs, Local / Remote Selector switch, any other devices / lamps for the operation of the equipment. Stop PB shall be lockable type with key to release.

For HT motors ammeter shall be provided on LCB and control desk. Interposing CT of secondary 1A shall be provided with purchaser's switchgear at the middle phase for remote metering.

For all HT motors 1000 kW & above, Ammeter shall be provided on the control desk.

All pumps shall be provided with dry running protections.

For all motors, drive status (ON/OFF, open/close, forward/reverse) tripping due to O/L, earth fault, equipment fault, process faults etc. shall be displayed in VDUs.

Where speed control of process drives are envisaged, the speed indicator shall be provided in control desk and also in CRT as applicable.

For HT motors, temperature of each RTD (for winding/bearing) shall be displayed dynamically on VDU.

The colour of indicator lamps and push buttons shall be as per IEC 73-1984.

All emergency conditions like stop push button, emergency stop command, level switches, end- switches, torque switches etc. will be directly hardwired to the main power contactors of the drives, so that the drives are stopped irrespective of mode of controls and by by-passing PLC operations. All these emergency conditions will be displayed in the VDUs also.
03.03 Individual Drive Control Level

03.03.01 Thyristor converters for DC drive

001 Basic design particulars

- Type of connections
  - Non reversible, single phase, full wave uniform bridge/ three phase, six pulse uniform bridge.
  - Reversible, three phase, six/twelve pulse anti-parallel with circulating current free.
  - For ratings above 40 A three phase, six pulses fully controlled uniform bridge.
  - For ratings above 1500kW, twelve pulse uniform bridge (two six pulse converters arranged in series or parallel and fed from two individual secondaries one connected in star and other in delta)
  - All Thyristor Converters shall have Digital Control Technology with communication to Level-1 Automation System.

- Overload capacity
  - As specified for individual drives and in absence of any such specification to meet at least the requirement of duty class IV of IEC 146, viz:
  - 100 % continuous
  - 125 % for 2 hours
  - 200 % for 10 seconds (other than HSM)
  - Converters shall also be suitable for the actual motor overloads.

- Direct voltage capability
  - Ability to maintain rated D C voltage at rated D C current including short time service current at 94 % of rated A C voltage.

- Permissible deviations from rated values
  - Thyristor converter shall be designed for the following variations:
  - Frequency variations : +3%, -6%
  - Phase voltage unbalance : 2% between any two phases
- For control and regulation equipment

- Voltage variation: +10%, -15%

- Frequency variation: +3%, -6%

**002 Thyristor power transformer**

- For drive ratings up to 200 kW, cast resin/VPI resin impregnated dry type (AN) with class H insulation.

- For drive ratings above 200 kW, ONAN type. Temperature rise 55 deg C on continuous full load operation and rated overload for 2 hours.

- For drive ratings up to 200 kW, the primary voltage shall be from 415 V, 3 phase, 50 Hz, 4 wire, earthed system.

- For drive ratings above 200 kW, the primary voltage shall be from 11 kV, 3 phase, 50 Hz, unearthed system.

- For ratings above 1500 kW with two secondary windings, one connected in star and the other in delta where a number of such motors are involved, separate transformers with alternate star and delta secondaries shall be provided to get 12 pulse effect overall.

- Taps at (+/-) 5% of the rated voltage in steps of 2.5% with externally operated off load tap changer.

- Protective features

  - Winding temperature high (alarm)
  - Winding temperature excess (trip)
  - Oil temperature high (alarm)
  - Oil temperature excess (trip)
  - Buchholz relay (alarm and trip)
  - Oil level low (alarm)
  - Transformer accessories as per I.S.

**003 AC Switchgear**

- On the primary side:

- On the secondary side:

  Air circuit breaker/moulded case circuit breaker for converters above 200 kW between transformer and thyristor converter.

**004 Thyristor converter**

- Type, connection and rating as specified
- Power module shall be drawout type.
- For thyristor cells connected in parallel, due allowance shall be given for unequal current sharing between them.
- Thyristor gate firing shall be microprocessor based.
- Adequate redundancy to be built-in to deliver 100% load even in case of failure of one thyristor in each arm.

- Minimum ratings of thyristor cell:
  - PIV rating: 2.5 times the peak value of line voltage.
  - \( \frac{dv}{dt} \) rating: 200 V/microsecond
  - \( \frac{di}{dt} \) rating: 100 A/microsecond

- Protective features

  - AC line surge suppression network shall have fuse monitoring.
  - AC incomer under voltage.
  - AC thermal overload.
  - Phase sequence protection and monitoring.
  - Main fuse failure.
  - RC snubber network across each thyristor cell.
  - Semiconductor fuses with fuse monitoring device in series with each thyristor cell.
  - Air flow/pressure switch for ventilation system.
  - Converter transformer fault.

**005 DC network**

The DC output side of the thyristor converter shall have the following as minimum:

- Speed indicator.
- Converter earth fault.
- Over voltage.
- DC shunt for measurement and feed back.
- DC ammeter and voltmeter.
- Smoothening reactor, as required.

For each motor:

- Line contactor (2- pole).
- Thermal overload relay.
- Magnetic overload relay.
- Shunt with ammeter.
- Resistance for load sharing, if required.
- Dynamic braking resistor & contactor as required.

**006 Regulation and controls**

- Synchronising supply.

- Through PT on the 6.6 kV side in case the transformer is fed from 6.6 kV supply.

- From primary side in case the transformer is fed from 415V supply.

- Control facilities shall include the following But not limited to :

  - Reference speed setter
  - Ramp generator
  - Speed feedback
  - Speed controller
  - Current controller
  - Current feedback
  - Trigger module
  - Pulse transformers
  - Logic command module
  - Sequence module
  - Zero speed/overspeed monitor, where required
  - Adaptive controller
  - Current limiter
  - Active electronic components used shall be of industrial grade.
  - Synchronising supply shall be arranged internally.

- Regulated power supply for reference setting:

- Voltage variation (+/-) 0.1% with input voltage variation of +10%, -15%.
- Steady state regulation of (+/-) 0.25% guaranteed against 100 to 200% load disturbance and +3% & -6% frequency variation.

007 Protection

- For process of large drives which have inverter duty for substantial periods (protection class I as per IEEE-444) shall be provided.

- For other drives Protection class II or III as per IEEE-444 shall be provided as specified.

- The protection equipment shall include the following:
  - Motor over-load protection
  - Magnetic over current protection on DC side.
  - Over voltage and undervoltage protection on DC side.
  - Transient over voltage protection both mains borne and generated within the unit.
  - Loss of phase
  - Converter fan failure
  - Gate suppression for protection against DC short circuits
  - Earth fault
  - Field failure
  - Control regulated power supply failure
  - Motor ventilation failure
  - Any other motor or converter protection as required for a particular application.
  - Wrong phase sequence
  - Against inversion fault

008 Indication

- Speed indicator for the motors where required

- Ammeter for converter output current
  - Ammeter for field current measurement where field control is provided.

- Voltmeter for converter output voltage & field voltage.

009 Annunciation

- Main power ON/OFF
  - Control supply ON
  - Auxiliary ON
  - DC contactor ON
  - DC breaker/contactor tripped
  - Earth fault
- Transformer fault as applicable
- Incoming breaker trip where applicable
- Phase loss
- DC over voltage

Apart from above common fault, following shall also be annunciated:

1. Motor faults
   - Over load
   - Over current
   - Over speed
   - Over voltage
   - Tacho fault

2. Converter faults
   - Over load
   - Over current
   - AC fault
   - DC fault
   - Fuse failure
   - Fan failure
   - Surge suppresser failure

3. Alarms
   - Motor overload
   - Converter overload
   - Memory enabled
   - Ground fault

4. Drive status
   - Readiness
   - Field on

010 Constructional Features

- Floor mounted, free standing
- Dust and vermin proof
- Sheet steel clad

- Minimum 2.5 mm thick for panels.
- Minimum 2.0 mm thick for doors and side covers
- Suitable to withstand vibrations to be encountered in steel plant applications.

- Cubicles with illumination lamps door switches, space heaters and adequate sockets for soldering.

- All control blocks plug-in-type with necessary test sockets.

- Units shall be self contained and serviceable.

011 Enclosure and Ventilation

- Enclosure conforming to IP-41

- Units shall be provided with cooling fans and louvers at the bottom sides. All louvers shall have fine mesh behind them.

- Ventilation through individual ventilation ducts, from bottom not acceptable.

03.03.02 Variable voltage variable frequency converters

Basic design particulars

All VVVF Converters shall have Digital Control Technology with Vector control. VVVF will communicate to Level-1 Automation System.

001 Type of Connections

- Three phase frequency converters with rectification and inversion i.e. variable voltage and variable frequency output with current source / voltage source (PWM) inverters.

- Line reactors for harmonic and noise suppression

- Suitable for 415V, 3 phase, 50 Hz, 4 wire, neutral earthed system or 6.6 kV/11 kV as required

  Overload capacity

- 150% of the rated current for 1 minutes following 100% load & to meet the drive overload capacity.

- Efficiency more than 95% at full load
- Suitable to withstand vibrations more than 0.59.
- Output frequency: 1-50 Hz (Constant torque)
- 50-100 Hz (Constant power)
- Ramp rate: Linear acceleration and deceleration adjustable independently.

Power components:

The main power components of the VVVF equipment shall have the following incoming AC side:

- Matching input power transformer
- AC line surge suppression network.
- ACB/MCCB
- Line contactors

Load side

- Filter network
- Step-up transformer, as required
- Isolator and over-load relay for each motor.

By-pass Arrangement

- By-pass arrangement shall be provided to operate the motor in case of failure in frequency converter.

Thyristor Converter

- Minimum ratings of thyristor cells
- PIV rating : 2.5 times the peak value of line voltage
- dv/dt rating : 200V/microsecond for voltage control and 1000V/microsecond for inverter control.
- di/dt rating : 100A/microsecond

Protective features

- AC line surge suppression network
- Under voltage in supply network
- Phase sequence protection and monitoring
- RC snubber network across each thyristor cell
- Thyristor fuse failure
- Under voltage in DC link
- Over voltage in DC link
- Over speed monitor
- Overload
- Earth fault
- Instantaneous over current
- Transformer fault
- Cooling fan failure - Stall monitor for motor

**Control facilities shall include following but not limited to:**

- Reference speed setter
- Ramp generator
- Speed feed back, as required
- Current feed back
- Trigger module
- Logic control module
- Sequence module
- Zero speed/over speed monitor as applicable
- Slip compensation control
- V/f control
- Current limiter
- Counter current/regenerative braking unit as applicable
- Regulated power supply for reference setting:
  - Voltage variation of (+/-) 0.1% with an input variation of +10%, -15%.
  - Steady state regulation of (+/-) 0.25% guaranteed against 100 to 200% load disturbance and +3%, -6% input supply frequency variation.
- Facility to accept speed reference from programmable controller
Construction features

- Same as described for thyristor converters for DC drives.

Enclosure and ventilation

- Same as described for thyristor converters for DC drives.

Note: Wherever VVVF equipment is used, torsional analysis shall be done by the contractor and result shall be submitted to the purchaser.

03.03.03  LT motor control centres

MCC shall confirm to IPSS :1-03-006

001  Basic design parameters:

Power supply system - 415V, 3 phase, 50 Hz, AC

System neutral - Earthed

Insulation level - 2.5 kV for one minute

System short circuit level - 50 kA for 1 second

Switching device - Load break switch- on incomers and fuse units (AC23 duty) bus coupler:/ACB with manual closing where SFUs of such ratings not available.

MCC's for process drives provided with two incomers and one bus-coupler.

The bus coupler is normally off.

Main power isolating device for outgoing feeders: Switch-fuse units with minimum switch rating of 32A (AC23 duty).

Contactors: - AC3/AC4 as per requirement. Minimum rating 30A at AC-3 duty.

Control circuit:

AC control - 240V, single phase, 50 Hz for control supply. Two nos.415/ 240V control trans-formers, secondary unearthed, shall be provided for each MCC with one working and the other stand-by and with proper interlocks / change-over facility.

Neutral bus - Required

Earth bus - Required
Busbar material - Electrolytic copper/aluminium

Power/Control terminals - Control terminal shall be suitable for connection of 2 Nos. 2.5 sq.mm. Cable and these will be stud type. The minimum rating shall be 10 Amps.

- Power termination shall be stud type. This will also include stud for earth terminal in each module

002 Constructional Features

General:
- Non drawout type
- Floor mounting, free standing with base channel for fixing on the inserts on the floor.
- Single front, totally enclosed, dust and vermin proof
- Degree of protection IP-52 or better, IP-54 for locations in the bays outside rooms.
- Sheet steel with thickness not less than 2.0 mm
- Possibility of extension on either end of MCC
- Dead front type with no equipment and wiring on the front door and back door shall be hinges type.
- Removable lifting facilities for each transport unit
- Designation plate for each MCC
- Inscription plate for each module.
- Length of each transportable unit not more than 2.4M

Compartment design
- Pilot devices operable from the front
- Operating height not to exceed 2000 mm
- Vertical wire way to accommodate all cables
- Components and devices accessible from front
- Protection against accidental contact with live parts while maintaining a compartment and keeping others in service

- Antirusting, undrilled removable gland plates to be provided

- Cable entry from bottom unless otherwise specified

- Compartment door interlocked with the main power isolating device for safety with provision for defeating it by authorised person

- All compartments to have covering at the bottom to preclude entry of dust, rats, lizards etc.

- Space of about 200 mm to be left vacant at bottom throughout the length of the MCC for ease of cabling.

- Power circuit isolation device to have facility for padlocking in the off position with the door closed.

Incomer and Bus coupler panels:

- Manually operated

- Main incoming load break switch/circuit breaker shall be rated for at least 125% of maximum demand taking into account the spare feeders and shall be suitable for the specified fault level. Max. rating of incomer/bus-coupler shall be 1250 A.

- Incomer shall be equipped with:
  
  - Three current transformers
  - One moving iron ammeter with selector switch
  - One moving iron voltmeter with fuses and selector switches.
  - ON/OFF/Trip indicating lamps
  - The bus couplers shall have ON/OFF/Trip indication lamps

- Incomers and bus couplers shall be electrically interlocked to prevent parallel operation of the transformers

- Ratings of incomers and bus coupler shall be same.

Feeder Modules:

- Feeders for all drives shall consist of Switch-fuse units/MCCB's, contactor, overload relay as main power components to ensure Type-2 protection as per IS 13947.
- Ammeter to be provided for all continuously/intermitting running motors beyond 15 kW rated drives.

- On/Off/Trip Indication lamps for each drive

- Over-load reset push button operable from outside

- The short-circuit release of MCCB's shall be selected so as to avoid tripping during starting of drives.

- Control supply of each module shall be taken through 2-pole miniature circuit breaker (MCB) with minimum short circuit rating of 9 kA.

- Warning markers "CAUTION EXTERNAL VOLTAGE' shall be provided for terminal blocks where voltage appears from external source.

- At least 30% of feeder control modules covering the range of motors used subject to minimum of two modules in each bus section shall be provided as spare. Spare modules shall be completely wired up.

- 10% of control terminals in each module shall be provided as spare subject to a minimum of two.

**Busbars and terminations:**

- Busbars of electrolytic copper or aluminium.

- Power busbar joints shall be bolted type with spring washers. Bolts and washers shall be galvanised or cadmium plated.

- Busbars shall be 3 phase and neutral running horizontally or vertically.

- Busbar sizes to be selected in accordance with nominal current rating of incoming CB or load break switch and for full short-circuit power.

- Busbars shall be insulated by colour coded PVC sleeves.

- Neutral bus shall run on insulators with facility for connection to earth busbar.

- Earth bus shall run throughout the length of MCC at bottom and for each vertical section.

- Busbar configuration shall be red-yellow-blue for three phases AC power and red blue for DC control supply from front to back or top to bottom or left to right as viewed from front.
- Temperature rise not to exceed 40 degree C above the peak ambient temperature of 50 deg C

- Removal of busbars shall be possible without disconnecting external cables.

003 Specifications of Major Components

Air circuit breaker:

- Drawout, triple pole, electrically operated air break, trip free type.

- Shall operate satisfactorily up to symmetrical breaking capacity, which shall be not less than system short-circuit level.

- Making capacity 2.55 times breaking capacity.

- The contacts shall be adjustable to allow for wear, easy replacement with minimum movable parts.

- Easily removable arc chutes for effective arc quenching.

- Mechanical trip button, integral with the breaker shall be provided at the front.

- Padlocking facility in ‘OFF’ position.

- Operating handle interlocked with the front cover for safety.

- All breakers to have thermal, magnetic and under voltage releases.

- Triple pole, ambient temperatures compensated adjustable, direct acting thermal release.

- Triple pole, direct acting, adjustable up to 12 times rated current short-circuit trips with time delay up to 0.3 seconds for discrimination obtained through rugged and non-aging mechanical means. The timing device shall be independent of power supply.

- Under voltage releases to have inherent delay to prevent tripping on transient voltage dips

- 2 NO + 2 NC auxiliary contacts for interlocking and indication purposes.

Load break switch-fuse unit:

- Double break, drawout type, capable of breaking eight times the rated current
- Isolator shall break the circuit positively even if mechanism springs fail.

- Incoming terminals suitable to receive the required number and size of aluminium cables directly.

- Padlocking facilities in 'On' and 'Off' positions

**Motor protection moulded case circuit breakers:**

- Complete with thermal and magnetic releases selected so as to allow trouble free starting of the motor.

- Features to minimise the let-through energy \((I_xI_{xt})\) in the event of short circuit on load side.

- Minimum short circuit rating of 40 kA

- Motor protection MCCB selection suitable for fault level at the point of application. No fuse back up acceptable.

- Provided with minimum 1 NO + 1 NC auxiliary contacts for indication/interlock purposes.

- Ratings selected shall be at least 125% of the full load current of the motor.

**Magnetic contactors:**

- Shall conform to IPSS
  - Shall be capable of interrupting ten times the rated current for rated size up to 100A and eight times the rated current for larger sizes.

- Suitable to carry the prospective short circuit currents without damage or injurious heating till the protective device operates.

- Coil shall be designed for AC. No economy resistors.

- Insulation for coils shall be class 'E' or better.

- Shall pick up positively at voltage between 85% to 110% of rated value.

- Drop out shall be between 75% and 40% of rated value.
- For frequently reversing drives, AC 3 rating selected shall be 50% higher than full load current of the motor at the specified duty cycle.

- Derated AC4 ratings shall be selected for inching and plugging operation of the drive.


- DC contactors shall be provided with adequately rated magnetic blow out coil for effective arc quenching.

- For reversible drives, mechanically as well as electrically interlocked contactors shall be used.

**Thermal overload relay:**

- Triple pole, ambient temperature compensated, inverse time lag, hand reset type, bimetallic with adjustable setting and built in single-phase protection.

- Shall conform to IEC:292-1

- At least one make and one break contact with ratings same as for auxiliary contact of the contactors.

- The relay shall be able to withstand prospective short circuit-current without damage or injurious heating till the motor protection MCCB clears the fault.

- Auto tripping shall be indicated on the MCC.

- Reset push button operable from outside

  **Magnetic overload relay:**

- Triple pole, adjustable time lag feature or of instantaneous type

- Provided with a latch and hand-reset feature or autoreset with flag indication.

- At least 1 NO + 1 NC auxiliary contacts, ratings same as auxiliary contacts of the contactor.

- Adjustable current setting and time delay calibrated between nominal current and twice nominal current ratings.
Thermister protection:
- To be provided for slipring motors of essential drives and torque motors/Roller table duty motors
- PTC with sharp knee characteristics and high signal to noise ratio.

Current transformers:
- Bar type primaries and 5A (max) secondary with thermal and dynamic ratings corresponding to the units with which they are used.
- Measuring CT accuracy class 1.0.
- Protective CT accuracy class 10 P 10.
- Control transformer
- Dry type 415V/240V, primary taps at $+2.5\%$, $+5\%$.

Indicating instruments:
- Shall not damage by passage of fault current or existence of over voltage for the maximum permitted duration of fault conditions.
- Flush mounting, square dial with zero adjusting device for external operation
- Accuracy class 1.5
- Ammeters above for drives above 15 kW shall be CT operated.
- Voltmeters protected by fuses placed as close to the busbar as possible.
- Maximum reading 600% of IFL for motor feeders
- Size of voltmeter and ammeter for incomer 144 x 144 mm.
- Size of ammeter for motor feeders 72 x 72 mm.
- Contactor rating and cable sizes for the low voltage general purpose induction motors shall be selected as per appendix -1.
03.03.04 Power Resistance

- Resistor design to meet arduous heavy duty industrial and steel works application, unbreakable, rigid and resilient rust less of following technical specifications:

  a) Material - Grid punched from chromium steel alloy with temperature coefficient 0.016% deg. C normal permissible continuous operating temperature of over 500 degree C.

  b) Duty rating-10 minutes rating of BS: 587 and conforming to IPSS No. 1-10-002-82 and addendum No 1 to IPSS (March 1985).

  c) Construction - Every turn of every grid is fully supported so that adjacent turns and adjacent grids can neither vibrate nor distort into mutual contact. The complete grid is spot welded to its neighbors thus eliminating slacken support due to heating and cooling and is mounted on mica insulated high tensile steel tie rod and mica creepage washers. A tripping point is formed on each grid by a hole in the welded portion which is double thickness and absolutely flat.

      All grids shall have either zinc alloyed or cadmium plated surface for permanent weather proofing. Highest quality mica and porcelain insulated terminals are to be used throughout.

      The thermal loading of the resistance box should uniform.

  d) All metal works for the housing shall be degreased, derusted and passivated before applying two coats of stove enamel.

      The terminals shall be easily accessible at the lower most stack.

  e) Enclosure Class IP-30 or better

  f) Testing shall be carried in accordance to BS: 587.

03.04 Functional Group Control Level

03.04.01 Programmable Controllers

The equipment shall confirm to IPSS: 2-07-015

001 Basic design particulars

  Basic Units

  - Central processor minimum 32 bit microprocessor based
Memory

- EPROM
- RAM with battery backup

Input units shall be suitable for accepting the following:

- Discrete inputs
- BCD inputs
- Analogue inputs

Output units shall be as follows:

- Discrete outputs
- BCD outputs
- Analogue outputs
- Timer units through software or hardware
- Counters for up, down or up-down counting
- Programming unit with built-in keyboard and CRT
- Power supply unit shall be built-in and stabilised

002 Environmental Classification

- The equipment shall be suitable for continuous duty under the following conditions:

- Temperature while operating
  
  | Lower limit  | 0 degree C |
  | Upper limit  | 60 degree C |

- Temperature while not operating (storage)

  | Lower limit  | 20 degree C |
  | Upper limit  | 75 degree C |

- Relative humidity

  Daily average 80 to 90% (10 h) and 65 to 90% (16 h)

  Maximum 98%, not occurring simultaneously with maximum temperature.
003  **Power Supply System**

- 415 V, 3 phase, 4 wire or 240V, single phase, tapped from line and neutral, 50 Hz earthed neutral system.

- Symmetrical fault level 40 kA, rms

- Voltage variation: +10%, -15%

- Frequency variation: (+/-)5%

004  **Built-in power supply units**

- Suitable for the power supply system as specified above.

- Independent units for the following:
  - For CPU and associated electronic units
  - For sensing the status of input devices
  - For driving outputs if outputs are relays

- Insulation level 2.5 kV for 1 minute.

- Protective features:
  - Surge voltage protection
  - Fuse protection in the input and output circuits
  - Electronic over current protection
  - Thermostat protection against over temperature

005  **Central Processor unit**

- Provided with dual CPU's with hot stand by.

- Modular and plug-in type

- 32 bit microprocessor based

- Scan time between 2 msec to 5 msec per one K instructions or better
- Provision to latch desired outputs.

006 Memory Units

- Modular and plug-in type
- Word length 8 bit/16 bit
- Expandable in blocks of 4K
- Minimum size 16K
- EPROM/Magnetic core/RAM with battery back-up
- Back-up battery shall be as follows:
  - Rechargeable Ni-Cd batteries with necessary charging circuit
  - Able to sustain memories for a minimum of 14 days with no power applied to the controller.

007 Input Units

- Modular and plug-in type
- Insulation level of 1.5 kV
- Individual fuse for each unit shall be provided for protection against cable fault/earth fault.
- Input interrogation voltage 24/48/110V DC (built-in) preferable.
- Discrete input units shall have the following:
  - Time delay of about 10 millisecond to filter out noise and contact bounce
  - Optocoupler to galvanically isolate the input device from the decision making logic of the controller
  - LED status indication
- BCD input units suitable for four digit input
- Analogue input units shall be as follows:
- Suitable for 4-20mA/0-10V inputs
- With necessary A/D converter having 12 bit resolution.

008 Output Units

- Modular and plug-in type
  Discrete output units shall be as follows:
  - Isolated output with two separate terminals for each output.
  - Rated for 240V, 2A, 50 Hz (15A for 50 milli-second to take care of the in rush current of the contactor coil).
  - Galvanically isolated by optocoupler
  - With LED status indication
  - With insulation level of 1.5 kV
- BCD output units shall be as follows:
  - Suitable for four digit output
  - Rated to drive seven segment displays used
  - With insulation level of 1.5 kV
  Analogue outputs shall be as follows:
  - Suitable for 4-20mA/0-10V outputs
  - With necessary D/A converters having 12 bit resolution
  - With insulation level of 1.5 kV

009 Timers

- OFF delay and ON delay
- From 20 milliseconds to few hours
- Accuracy (+/-)0.1% of the set value (+/-) 10 milliseconds or better
010  Counters
- Count-up down or up and down
- Count from 0000 to 9999

011  P.C Based Programming Unit
- Suitable for developing programmes in ladder diagram/block diagram or statement form
- With necessary key-board and CRT
- With facility for loading the programme developed on EPROM and cassette/floppy
- Ultraviolet eraser for EPROM
- Preferably with built-in RAM and battery back-up for development of programme without connecting to the programmable controllers.

012  Self Diagnostic Features
- Parity errors, cycle errors and under voltage
- Failure in central processor unit, memory and power supply.
- Indication of type of failure
- Automatic turning OFF of all outputs or optionally holding of all outputs in their last state on failure detection.

013  Terminations
- All inputs and output wired upto easily accessible terminal blocks rated for 660V
- Suitable for terminating upto 2.5sq. mm. copper conductor industrial control cables.

014  Additional Features
- Fully programmed
- Connection of field devices with input units through ordinary multicore copper control cables up to a length of 500 m.

- Connection of remote input/output units to programmable controller through multiplexer wherever substantial saving in cabling is envisaged.

- Communication among PLCs and higher level automation communication bus.

- Communicate with computer in distributed hierarchical control system and operator consoles/display units.

- Printer to get hard copy of the programme developed

015  Optional Features

- Test sockets on input modules for input simulation

- Switch to disable all outputs of the controller during start-up/debugging

- Fuse failure indication for outputs

- Provision to connect VDU/Printer for alarm annunciation to accept set points, data display and logging

016  Constructional Features

- Unitised construction

- Floor mounted, free standing and indoor type

- Sheet steel clad

- Dust and vermin proof

- Suitable to withstand vibrations as per application

- All modules plug-in type

017  Enclosure

- Conforming to IP-41 class, for equipment located in Air-Conditioned room.
- Conforming to IP-52 class for remote I/O cubicle located in MCC/control rooms and IP-54 class for remote I/O cubicles located in shops/bays.

018 Mounted Spares

- Min of 20% of I/O modules used of (with atleast one module of each type) input and output shall be offered as spare for each programmable controller and the same shall be mounted in the cubicle suitably.

- 20% spare memory capacity shall be provided

019 Miscellaneous requirements for programmable controllers

- Programmable controllers shall be housed in air-conditioned rooms although these are suitable for normal industrial environment.

- A programming unit, a cassette loader and a printer shall be provided for every main techno-logical plant unit. These shall be supplied either as tabletop mounted or as portable units as per the plant requirement.

- Cassettes loaded with frozen programme of each PC shall also be supplied. These shall be pro-perly identified and housed on cubicle for ready use.

03.04.02 Uninterruptible power system

001 Basic particulars for design

Basic details:

- Features and performance in line with IEEE 446 and configuration as per fig 45 of IEEE 446.

- 125% of the rated output for 15 minutes

- Suitable for connecting to a 415 V, 3 phase, 50 Hz, 4 wire, grounded neutral system with a symmetrical fault level of 40 kA rms.

- Three / Single-phase voltage and frequency controlled output, as required.

- With isolating transformer, rectifier, inverter unit and necessary DC batteries.

- Dual redundancy system with automatic static bypass and common DC battery.

- The load shall normally fed from the inverter.
- DC battery shall be sealed maintenance free Lead acid with plate cells type.

- Battery shall be suitable to maintain the power supply for atleast 30 minutes in the event of main failure.

- Electronic bypass switch to connect the system to the mains supply without interruption to the load in the event of inverter failure.

- Necessary distribution board for distribution of power from UPS output to individual consumers.

Permissible variations:

Mains power supply system

- voltage : + 10 % , -15 %
- frequency : +3% , -6%

- Harmonic distortion : 2 %

- Output of the uninterruptable power supply system while delivering a load of its rated capacity

- voltage : (+/-) 5 %
- frequency : (+/-) 0.1 %

Protective features:

- Earth fault monitoring and protection

- Thermal overload protection

**002 Transformer**

- Rating suitable for the application

- Dry type, with class H insulation

- ± 2.5% with tappings on primary

**003 Rectifier**

- Dual rectifier with each unit rated for supplying both inverter load and battery charger load.
Rectifier unit shall consist of minimum six-pulse bridge connection

- With necessary smoothing reactor and filters
- Automatic boost and float charging control

Protective features:

- Maximum current limiting
- Automatic reduction of current limit in the event of cooling fan failure
- Boost charging and float charging current limiting

Indications:

- Rectifier ON
- Battery runout timer/counter
- Low battery voltage or blown battery fuse
- High battery voltage
- Charging failure
- Failure in line voltage or auxiliary supply
- Blown fuse, single phasing or over current
- Fan failure
- Battery on float charge /boost charge.

Inverter

- With input circuit consisting of battery contactor, battery filter and smoothing reactor
- dc/dc converter for voltage control
- Inverter proper and control electronics
- Series reactor and parallel filter
- Output transformer.
Protection against the following:

- Abnormal output voltage
- Abnormal link voltage
- Over current on output
- Over current on input or commutating failure
- Low battery voltage
- High transformer temperature
- Auxiliary supply failure
- Fan failure
- Logic failure
- Clock failure

Indications:
- Inverter On
- Inverter reserve synchronised

Meters:
- output voltage: Phase-neutral & between phases
- output frequency
- Ammeter in each phase
- Battery current and voltage with indication of status in charge or discharge

005 Constructional Features

Static by-pass switch:
- Static switch automatically switches the load to the reserve power supply or the mains whenever there is failure in inverter supply to the load.

- Fast acting inverter contactor shall connect the inverter output to the load.

- High-speed fuses shall be provided for protecting the thyristor against accidental overload.

  Indication:
  - Load on inverter
  - By-pass on load
  - Reserve within limits

  Alarms:
  - Reserve out of limits
  - Load on reserve
  - Static switch off

  Construction details:
  - Unitised construction
  - Free standing, floor mounted and indoor type
  - Dust and vermin proof
  - Sheet steel clad

  : Min 2.0 mm thick for panels
  : Min 1.6 mm thick for doors and side covers

  - With illumination lamps, door switches space heaters and sockets for soldering
  - All control block plug-in type with test sockets
  - Units shall be self contained and serviceable
006 **Enclosure and ventilation**

- Enclosure conforming to IP-41 class
- Units shall be provided with cooling fans and louvers at the bottom sides.
- Individual ventilation ducts for each unit shall be provided.

03.04.03 **Mimic panel boards**

- Sheet Steel (minimum 2.5 thick) with acrylic materials
- Free standing, floor mounting, dust and vermin proof with access from rear.
- Rear doors bolted type with suitable gaskets
- Mimic diagram shall present comprehensive picture of the process
- Mimic diagram shall be painted on acrylic / polyprolene / fibreglass / thermoplastic material strips and symbols having suitable colour and thickness not less than 5 mm.
- Lamps and other equipment shall be replaceable from front.
- Inscription plates shall be made of corrosion resistant metal, preferably stainless steel with inscriptions in English.
- Every mimic board shall have its own supply
- Enclosure class shall conform to IP-54.
- Shall have its own microprocessor-based controller for multiplexed communication with programmable controller wherever considered economical.
- Terminals suitable for 2.5 mm² conductors with 20 % spare terminals
- Lamp test push buttons.
- Internal wiring with 1.5 mm² copper conductor

03.04.04 **Control Desks**

- Sheet steel (2.5 mm thick) construction
- free standing, floor mounting pedestal mounting or trunion mounting, dust and vermin proof
- hinged top cover with latching facilities in open position and removable side covers
- control switches, push buttons and indication devices mounted on top cover and wired upto terminal blocks using extra flexible appropriately insulated wires.
- construction and switch layout to provide comfortable operation
- swiveling type desks to be connected appropriately to prevent conductor breakage due to wire flexing
- Enclosure class IP-41 for control room installations and IP-54 for outdoor installations
- Terminals suitable for 2.5 mm² conductors with 20% spare terminals.
- To be painted as per standard procedure agreed.
- Long test push button
- Internal wiring with 1.5 mm² copper conductor

**03.04.05 Local Control Box**

- Sheet steel (2.0 mm thick) construction.
- Wall/structure mounted type
- Hinged door, dead front type.
- Enclosure class IP-55.
- To be painted as per standard procedure agreed.
- Internal wiring with 1.5 sq.mm. copper conductor.

**03.04.06 Electronic Weighing System**

Electronic weighing system shall be microprocessor based complete with load cells, weighing electronics, large displays, calibration units etc. Facilities shall be provided to interface the weighing system with other microprocessor based systems/computer. Digital indication shall be provided on the mimic in addition to indication available on CRT.
Large display units/small display units shall be provided as required.
Self diagnostic features shall be provided.
Load cells shall be of magnetoelastic type/strain gauge type as per requirement.
Load cells shall be suitable for overload up to 200% of their nominal load.
Accuracy of weighing system shall be ±0.1% or better.
Standard weights shall be provided for auto calibration.
Weighing system for cranes
Salient features:
- Load cells shall be of magneto-elastic type/strain gauge type.
- Cable reeling drums for weighing equipment shall not have slip rings.
- Information of ladle weight shall be sent to the main control room via VHF communication system to computer.
- Large digital display shall be provided.
- Other features as given for electronic weighing system.

03.05 Cables

03.05.01 Types of cables

Cables of following grades and general specifications shall be used taking into consideration the application requirements:

001 6.6 kV (UE) XLPE cables

6.6 kV (UE) heavy duty power cable, 3-core, with compact circular stranded (rm/V) Al. conductor with extruded conductor shielding of semiconducting material, XLPE insulated, with insulation shielding over individual cores consisting of extruded semiconducting compound followed by lapped semiconducting material and copper tape, cores stranded together with a holding tape provided with a common covering of extruded inner sheath of type ST1 compound, galvanised round steel wire armoured
and PVC outer sheath of type ST2 compound for 6.6 kV system as per IS : 7098 (Pt-II)-1973 as amended upto date.

002 1.1 kV, PVC aluminium power cables

1.1 kV, heavy duty power cable multicore with standard sector shaped (sm) or with compact circular stranded (rm/V) or circular stranded (rm) aluminium conductors as applicable, PVC insulated of type ST2 PVC compound suitable for 85 deg.C. operation as per IS:5831-1984, core stranded together provided with a common covering of PVC inner sheath of type ST1 PVC compound, galvanised round steel wire armoured and PVC outer sheathed of type ST2 PVC compound conforming to IS:1554 (Part-I) - 1988, as amended upto date. Type AYWY.

003 1.1 kV PVC copper control and instrumentation cables.

1.1 kV circular stranded (rm) annealed copper conductor, PVC insulated of type 5 PVC compound suitable for 85 deg.C operation, as per IS:5831 - 1970, cores stranded together provided with a common covering of PVC inner sheath of type 5 PVC compound, galvanised round steel wire armoured and overall PVC sheathed of type 8 PVC compound and multi-core to IS : 1554 (Part-I) - 1988, Type YWY :  

004 1.1 kV special cable

1.1 kV grade heavy duty multicore rubber cable with fine wire tinned copper conductor insulation upto 80 Deg.C heat resistant, made of EPR (Ethylene-propylene rubber), outer sheath made of PCP (Chloroprene rubber), abrasion resistant, oil resistant and flame retardant conforming to IS:434 (Part - I), as amended upto date.

005 Heat resisting cable

Special heat resistant cable with copper conductor, silicone rubber insulation, asbestos or glass braid and lacquered protection, single or multicore, 1.1 kV grade conforming to IS: 9968 (Part-II)- 1981.

006 Trailing cable

Trailing cable, with highly flexible stranded tinned copper conductor, insulation of EPR (Ethylene-propylene Rubber), each individual core protected and covered and overall outer cover of poly-chloroprene Rubber cable shall be conform to IS: 9968 (Pt-I) - 1981.
Flame Retardant Low Smoke (FRLS) Cables

These shall be as per specification mentioned above but with protective system of inner and outer sheath specially designed with thermoplastic or thermosetting materials, superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. These cables shall conform to IEC-332 Part 1, BS 4066, IEEE 383, IEC 332-3 IS: and Swedish chimney test SS 424 - 14-75, class F3.

Cable Selection Criteria

The minimum cross-sectional area of the cables used in LT power circuits shall be 6 sq.mm per core if with aluminium conductor or 4 sq.mm per core if with copper conductor. Maximum cable size shall be 185 sq.mm for motors and 240 sq.mm for incomers to MCCs, PCCs etc. The minimum cable size selected for applications in the power circuits of cranes and other moving mechanisms shall be 10 sq.mm per core, if aluminium or 6 sq.mm per core, if copper.

For power supply to moving mechanisms subject to vibrations, flexible copper cables preferably single core should be used. In these cases, a separate core should be provided for earthing. For hoists with flexible/festoon cable system, power supply shall be through butyle rubber/EPR insulated PCP/CSP sheathed flexible cables. Cables used for circuits of tachogenerators, brakes, solenoids, field windings and secondary windings of measuring transformers shall be copper conductor with cross-sectional area not less than 2.5 sq.mm per core. All control cables shall have solid copper conductors except for mobile and portable equipment where control cables shall be of flexible type. Copper cables shall be used for all cranes/hoists.

For control circuits, PVC insulated and PVC sheathed multicore cables with copper conductors having a minimum cross-sectional area of 1.5 sq.mm per core shall be used. The number of cores may be standardized, as 2, 3, 4, 5, 7, 10, 14, 19, 24. Each core of control cable with 7 core and above shall be numbered at every 1-meter interval.

In multi-core control cables, the following minimum reserve cores shall be kept at the engineering stage:

- Upto 7 cores: One reserve core
- 10 cores: Two reserve cores
- 14, 19 & 24 cores: Three reserve cores

Sequential length marking shall be provided in outer sheath of all power and control cables.

Standard drum length for all types of power and control cables shall be offered.
ISI marking at every meter of cable length shall be provided.

Cores of multi-core control cables shall be serially numbered.

All Power & Control cables shall be armoured except for flexible cables.

03.06  **Erection Specification**

03.06.01  **Guidelines for Design of System and Engineering the Layout of Electrical Equipment.**

001  **General**

The tenderer shall prepare the layout drawings for civil assignment taking into consideration the requirement listed below. In case of total turnkey contract the civil aspects mentioned in following specification shall be adhered to while planning/executing civil work.

002  **Electrical premises**

All electrical premises shall have adequate space to accommodate the electrical equipment from the point of view of operation and maintenance, and conform to IE Rules & Regulations.

The clearance between the ceiling of the electrical room and top of the tallest equipment shall not be less than 1m, 2m where the equipment are to be maintained from top and additional height of lifting tackle wherever required.

Lifting/handling facilities shall be provided. Rolling shutters shall be provided to facilitate transportation of the equipment into and out of the electrical room.

Electrical room located on the top floors shall have erection openings and landings.

All electrical rooms shall have cable basement/cable galleries /cable trenches. The clear height of the basement/cable gallery walkways shall be minimum of 2.1 m for cable tunnels and 3 m for basement/galleries.

The wall of the basement shall have water proofing and draining facilities below ground level.

Cable basement/galleries shall be provided with suitable lighting/ventilation facilities.
24V AC sockets fed from dry type L.V. transformers shall be provided for hand lamp connection throughout the premises including basement and cable tunnels.

Airtight double door arrangement shall be provided for electrical rooms and basement. The stairs to the basement shall be from inside the electrical room.

Compressed air (oil and moisture free) points shall be provided for cleaning purposes at an interval of 30m.

Welding power socket outlets shall be provided within basement at intervals of 60m with minimum of one, where basement is less than 60m long.

Electrical room and cable galleries/basement shall be considered fire hazardous.

Roofs of the electrical premises shall be fully watertight and moisture proof.

Erection openings with removable cover plates shall be provided on the floor of the electrical rooms connecting the basement/cable gallery.

003 Control Pulpits

Location of control posts shall be decided taking care of clear visibility.

All control rooms shall be air-conditioned and temperature shall be 24deg. C.

Inner walls shall be sound proof.

Flooring shall be covered with coloured linoleum of 6 mm thick.

Window glass shall be toughened, heat resistant and of greenish tint, hinged glass to be opened from inside.

Double glass panels, wherever required, shall be provided to make the control post heatproof.

Suitable wire mesh shall be provided for the glass windows for protection against mechanical damage wherever required.
Cable Tunnels

Standard cable tunnel size:

- Full tunnel : 2100 mm (W) x 2100 mm (H)
- Half tunnel : 1500 mm (W) x 2100 mm (H)

Partition door between basement and the cable tunnel shall be air tight and of fire retardant material.

Gradient of the floor at transition from one elevation to another shall not exceed 15 deg. Gradient shall be in the form of ramp.

Floor gradient towards the water collecting pit shall not be less than 0.3%.

Plate inserts (200 x 100 x 6 mm) at an interval of 1500 mm shall be provided on the wall along the length of the tunnel. Three rows of inserts shall be provided at suitable intervals along the height.

Plate inserts shall be provided at an interval of 1.5 m under the ceiling for lighting fixture.

Entries to the cable tunnel shall be provided generally at a distance of 70 m along the length of the tunnel inside the shop.

Tunnel walls shall be waterproof design.

For interplant cable tunnels, long tunnel shall be split into compartment not exceeding 150 m with fire proof partition doors.

All cable tunnels shall be properly ventilated.

Atleast two evacuation exits should be provided in each of the cable gallery and cable tunnel. The distance between any point and exit should not be more than 35m. The distance from dead end of cable gallery/cable tunnel to the exit should not be more than 25m.

All the cable tunnels and cable galleries shall be provided with sump pumps for pumping out seepage water. Sump pumps shall be provided with high level/low level switches for automatic operation.
005  **Cable Shafts**

Cable shafts shall be of either civil or structural design as per requirement.

Landing platform shall be provided at every 5 m of height.

Suitable cat ladders shall be provided in the cable shaft.

Suitable ventilation/lighting facilities shall be provided for the cable shafts.

006  **Cable Installation**

Cables will have to be run partly in walkable cable tunnels or underground trenches and/or surface ducts in the shops and partly along the structures and columns of the buildings.

Where the number of cables to be laid calls for walkable tunnels and cable shafts, same shall be provided. Underground walkable cable tunnels shall have hydro sealing to prevent water seepage.

Cables laid directly in underground, trenches shall be in one layer only, more than one layer is not permissible. For multi-layer installation, concrete surface ducts or walkable cable tunnels shall be used depending upon the number of cables to be laid.

Installation of cables directly buried in ground shall generally conform to the requirements given in IS: 1255 –1983.

For crossing the road/rail track, cables shall be laid in concrete cable ducts, G.I. pipes. 25% spare conduits/pipes/duct openings shall be provided.

Cables in trenches shall be laid on 8 cm of riddled sand and covered with 8 cm of riddled sand. RCC slabs shall be provided for covering these trenches. The maximum trench depth shall normally be 1.5 m and thickness of top cover of 75 mm. If the trench is to cross railway tracks/roads or any load bearing area the cables shall be taken through suitable GI conduits/pipes/ducts.

007  **Laying in tunnels/surface ducts/on structures**

Cable racks for cable trays shall be fixed at a maximum interval of 1.5 m.

Cables leaving the ground/floor shall be protected upto 2-m height by conduits/metalllic guards.

Ladder type cable racks and trays shall be provided to lay cables in tunnels/shafts/cable basements. Cables shall be laid in separate racks according to the voltage/application
classification. Fireproof partitions such as asbestos sheets shall be provided between trays carrying LT & HT power cables, instrumentation cables & telecommunication cables. The cables shall be laid from top to bottom in order of HT on top rack followed by LT cables and other cables on lower racks.

All necessary frame works and fixings for the support of cables and accessories shall be supplied.

Cables shall be suitably protected against heat, and mechanical damages.

Cables at fire partition wall crossings shall be painted with heat resistant paint 2 m on either side of wall.

**008 Structures for Cable Laying**

Cables shall be laid on ladder type cable trays. Ladder type cable trays shall be selected from sizes 200 mm, 400 mm & 600 mm and shall be fabricated from 40x40x3.1 mm MS slotted angles for longitudinal members and 25x5 mm perforated flats for cross members placed at an interval of 250 mm along the length of cable tray.

Supporting vertical racks and horizontal hooks shall be of 50x50x6 mm MS angles. Cable racks and hooks shall be of welded construction.

To avoid damage during cable laying, cable structures shall have no scales, abrasive or rough surfaces or cutting edges.

**009 Clearances Inside the Electrical Rooms**

Back clearance-minimum 1250 mm

Front to front clearance between drawout/semi- drawout panel boards - minimum 2500 mm

Clearance between two panel boards installed in a row - minimum 1000-mm.

Clearances between front of the panel to the wall of the room - minimum 2000 mm.

Clearance between the wall and end of the switchgear/MCC - minimum 1000 mm.

Back to back clearance - minimum 1500 mm. Back to front clearance minimum 2000 mm.

Clearance between the bottom of the ventilation duct and top of the electrical equipment - shall be as per statutory requirement and regulations.
Resistance boxes shall be placed in separate rack or on top of the MCC.

Disposition of control desk, mimic boards, instrumentation panels shall be properly located for visibility and operational convenience.

Profile & dimension and painting of control desk/mimic panels shall be same as for control room for aesthetic design

In any other case, the layout shall confirm to provide clearances as per Indian Elect. Rules.

**010 Transformer installation**

Mineral oil filled transformer shall be installed at +(-) 0.0 level only.

All mineral oil filled transformers shall have oil soak pit around it. These soak pits in turn shall be connected to a common catch pit for collection of oil. The capacity of catch pit shall be equal to the oil content of the biggest transformer.

In case oil filled transformers are located inside the shop, the catch pit shall be outside the shop connected to soak pits by pipes. Also the transformer room shall be enclosed on three sides. Access side may have steel framed gate with expanded metal doors with wicket door provision.

All mineral oil filled transformer shall be separated from switchgear/electrical rooms with partition wall. All transformers and heavy equipment shall have adequate transportation and lifting facilities.

There shall be 1m clearance all around the transformer. The ceiling height of the rooms shall be 1.5 m above the conservator.

**011 Battery installation**

All batteries shall be installed in a separate room. It shall have a water tap and adequate ventilation facilities for acid/alkali fume extraction.

Rooms having battery installation shall have acid resistant floors.

Walls will have acid resistant tiles on the side walls up to 1.5 m height
012 Earthing and lightning protection

Earthing

Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations/ IS code of practice IS 3043-1987 and Indian Electricity Rules, so that the values of the step and contact potentials in case of faults are kept within safe permissible limits.

Parts of all electrical equipment and machinery not intended to be alive shall have two separate and distinct earth connections each to conform to the stipulation of the Indian Electricity Rules and apparatus rated 240 V and below may have single earth connections.

All shops and buildings as well as the electrical sub-stations and electrical rooms shall be provided with a ring main earthing system each. Individual ring main earthing systems shall again be interconnected as a network.

The ring earthing system around each building shall be laid at a distance of approximately 1.5 m from the building and at a depth of approximately 0.8m. The ring shall be bonded at intervals to the building steel structures, reinforcement of building columns and also to pipes, wherever they are crossing. The earth ring shall further be connected at intervals to deep earthing electrodes to achieve a combined earth resistance of less than one ohm.

For the purpose of dimensioning the earthing lines/conductors, the duration of the earth fault current shall be taken as 0.3 seconds.

For different floors in a building, localized ground mats shall be formed and connected to the ground earthing ring through vertical risers. The earthing mat shall be common to both power and lighting installations.

For protective earthing separate conductor shall be used for flow of earth fault current as elaborated below.

The LV side neutrals of the Power distribution transformers shall each be connected to two separate earthing electrodes. They shall also be connected with the neutral bus of the corresponding switchgear and the switchgear neutral bus shall be connected to the earthing ring at two different and distinct points. The fourth core or armour of cables and all conduits for cables shall also be connected to the earthing mains. A continuous earth strip shall be run in each side of cable tunnel and in cable ducts and trenches.

The power supply cables (LT) from the sub-station and the distribution cables to individual motors shall have 4/3.5 cores.
LT power supply cables shall have four cores and the fourth core shall have cross-sectional area of 50% of the other cores generally. The fourth core of the main supply lines shall be connected to the solidly earthed neutral bar in the substation switchgear as well as at the earth bars in MCC/distribution boards.

Separate RF earthing system shall be provided for all electronic equipment like PC"s, weighing panel, instrument panels, computer etc.

Conductor sizes for ground connections:
For equipment ground connections, the minimum conductor sizes used should be as follows:

**High voltage systems - 75 x 5 mm GI flat for:**
Main earthing rings
Main switch-boards HT & LT
Transformers
Star point of earthing resistors
HT motors
Earthing leads to earth electrodes.

**LT System Where the Voltage does not Exceed 650V Normally:**
- 6 Sq.mm Stranded GI wire for :
  - Motors and starters upto and including 2.2kW, shunt limit switches, push buttons and master controllers, Light fitting, JBs, PBs, etc.
  - Instruments and miscellaneous small items protected by fuses of ratings not exceeding 15A.
- 16 Sq. mm Stranded wire for :
  - Motors and starters above 3.7 kW and upto and including 15 kW.
- 25 x 3 mm GI flat for:
  - Motors and starters above 15 kW, and upto and including 45 kW
Control desks, cabinets, LCB, socket outlet isolators, SLDBs/DBs.

- 50 x 6 mm GI flat for:
  - Motors and starters over 45 kW and HT motors
  - Switchboards, MCC, PDB, PCC, MLDB.

- 50 x 6 mm GI flat (minimum) for:
  - Main earthing ring in plant buildings
  - Bonds to crane gantries
  - LT Switchboards and other equipment protected by circuit breakers.

- 65x8 mm GI flat for:
  - LT transformers, substation earthing ring

- 75 x 10 mm GI flat for:
  - 1.6 MVA, 1.0 MVA, 0.63 MVA HT/LT distribution transformers.

Earthing electrodes:

The earthing electrodes shall be of GI pipes 50 mm dia and about 4 mm thickness in one piece provided with water holes and other filling devices. Earthing system for computers and microprocessor based equipment/ PCs shall be distinct and separate from the power and lighting equipment earthing system.

Earthing of electrical equipment on cranes and travelling machines:

Every electrical equipment shall have double earthing.

A ring earthing system shall be provided within the crane/machine to which every electrical equipment shall be connected at least at two places.

The earth ring on the crane/machine shall be connected to the plant earthing system through the gantry rails. Two sets of earth collector brushes shall be provided on each side of crane/machine to connect its earth ring to the gantry rails.

Each end of each gantry rail shall be bonded to the plant earthing system.
In addition, intermediate earthing bond shall also be provided on the rails at every 60 m in case of longer tracks.

Flexible copper bonds shall be provided across any gap in the running gantry rails.

For mobile equipment with flexible cables, one separate copper conductor of adequate size shall be provided for earthing.

Lightning protection

All buildings and plant structures vulnerable to lightning strokes owing to their height or exposed situation shall be protected against atmospheric flash-overs and lightning strokes in such a manner as to eliminate any danger to the personnel employed therein. Stipulations of IS : 2309 - 1969 shall be followed.

A 'Faraday Cage' made of hot galvanised strip steel connected to all buried pipes and steel structures crossing this cage ring shall be laid around each main building or plant unit as earthing device. This shall be separate from the electrical equipment earthing ring main.

All lightning arrester earth leads of the buildings and plant units shall be connected to this cage ring.

Air termination network should cover all salient points of the structure. All metallic chimneys, ducts and the like above the roof of the structure shall be bonded to and form part of the air termination network. Vertical air termination points shall project at least 30 cm above the object on which it is fixed.

Down conductors shall follow the most direct path possible between air termination and earth termination avoiding sharp bends. Down conductor shall have a testing point adjacent to the earth electrode. Each conductor shall have an independent earth termination. All earth terminations shall be interconnected.

Earthing electrodes and grid for lightning protection will be distinct separate from the earthing system for earthing of electrical equipment and at no place will be connected to other earthing system.

013. **Trolley lines and power supply arrangements for cranes**

Trolley line scheme

Trolley lines feeding cranes in the auxiliary shops not directly connected with the production processes, repairs and maintenance shops and storage buildings may be served by a single power supply feeder each.
Crane trolley lines feeding cranes in major production units shall be sectionalised with two separate feeding points. Two fully rated ACB's shall be provided for each incomer feed point to crane DSL. Sectionaliser isolator shall be provided between the two incoming ACB’s with necessary padlocking arrangement. In normal operation the sectionalising isolator shall be OFF.

Isolator panels shall be provided for each repair section for maintenance. Dead zones shall be provided with isolator arrangements to prevent collision between cranes and momentary paralleling to two incomer supplies. Incomer ACB’s shall be provided with earth fault protection and magnetic over current release. The DB's shall be located suitably on the shop floor.

Suitable brackets for trolley line power conductors shall be provided at maximum interval of 3 m.

The sections shall have feeds from different transformers and the sectionalising isolator shall close only in case of failure of one feed to prevent parallel operation of the transformers. Suitable interlocking shall be provided.

Insulation air gap between two sections of a sectionalised trolley line shall be minimum 50 mm for voltage levels up to 500V, but in no case should be greater than the length of the current collector on the crane.

Remote trip push buttons shall be provided at 60m intervals along the bay to enable tripping of the feeder breakers remotely in case of any emergency.

The trolley line system shall be complete with supporting brackets, insulator assembly, power conductors, expansion joints, creepage guards, rigid joints, cable terminal clamps and other accessories.

For compensating (equalizer) strips, copper cable looping shall be provided.

Signal lamps shall be provided just below the trolley lines at 60m intervals as well as at the beginning and end of each section/repair section to indicate whether the trolley lines are energized or not.

Maintenance/repair sections

When two or more cranes are fed from the same trolley line, maintenance (repair sections) shall be provided with sectionalising isolator so that repair or maintenance of any crane can be carried out without disturbing the operation of the other cranes.

For end zones, minimum length of maintenance bay shall be 2 m plus the crane width. For middle zone, the length of hospital bay shall be 4 m plus the width of crane.
Repair section shall be provided with red lamp steady/flashing fixtures at four corners. These fixtures shall be located at crane gantry with manual ON/OFF provision.

Power Conductors

The Power conductors or down shop lead (DSL) shall have 4 conductors, 3 phase, 4-wire system. DSL shall have mild steel angles/rails. For cranes/hoists upto 10 t capacity, the DSL shall have 50 x 50-x 6 mm MS angle. For cranes above 10t upto 100 t, the DSL shall have 75 x 75 x 6-mm MS angles. For cranes above 100 t, the DSL shall have to maintain rail size of 75 lb.

Expansion and section gaps shall be provided in rails at every 30m. The gaps shall be cut at an angle of 30 degree to the rail and shall be 50mm wide. The gaps shall be provided with flexible joints.

Looping cables shall be used in parallel with the conductor rails and aluminium equalising strips shall be provided, wherever necessary, for limiting the voltage drops. However, aluminium equalising strips shall not be used in the hot areas like slag/slabb/stipper yard etc. In such areas, copper cable looping shall be used.

The power supply feeder and trolley line conductors/looping cables shall be selected so as to limit the voltage drop to within 15% of the rated voltage at the crane motor terminals for the short time peak current corresponding to the starting of the largest capacity motor and the maximum continuous operating current of the rest on the system.

Insulators

The insulators used shall have substantial mechanical strength especially against blows and knocks.

The creepage distance of the insulators shall not be less than 80 mm.

The insulators used in the LT/AC system shall have the following minimum flashover value and mechanical strength:

- Dry flashover value : 25 kV
- Wet flashover value : 12 kV
- Ultimate mechanical strength : 1000 kg.
03.06.02 Guide-line for Erection of Electrical Equipment and Accessories

001 General

All the electrical equipment shall be installed with proper care and as per layout drawings. Minor modifications required at site shall be made by the contractor with approval of purchaser representative/Consultant for installation of the equipment. Care shall be taken for proper handling of equipment and undue vibrations shall be avoided particularly in case of sensitive (instrument mounted on panels) equipment.

The contractor shall have valid electrical contractor's license valid for State of Orissa and as well supervisory licence. He shall have in his employment sufficient number of electricians and supervisors holding valid licenses for HV and LV installations. It will be the responsibility of the Contractor to get the installation cleared and relevant drgs. certified/approved by Electrical Inspectors, Factory inspectors, Insurance agencies and other statutory authorities. The Govt. fees and necessary commercial aspects will be taken care by the Contractor.

002 Rotating machines

The erection work of motors shall include checking of all motors before installation including thorough cleaning and checking of bearings, replacement/rectification of defective items, greasing of bearing, if required, making minor modifications in its mounting arrangement, wherever required, assembling and its mounting on the motor base plate or on mechanical equipment, as the case may be, including levelling and alignment, checking insulation resistance and improving the same, if necessary, checking of internal connections etc.

All work associated with revisioning of motor shall also be included such as uncoupling and removing of motor from mechanical equipment, disassembling, cleaning, checking of insulation resistance and improving the same, if necessary, regreasing and replacing defective items/bearings on foundation, wherever required, reassembling, placing, levelling, aligning and coupling the revisioned motor with mechanical equipment.

The contractor shall check different parts and assemble the motor at site in correct sequence wherever the motors are delivered in a dismantled state i.e. base frame, bearing pedestals, armature, field frame etc. in separate packages.

Erection, alignment and securing shall be done under expert technical supervision. Straight edges, feeler gauges, dial gauges etc shall be used for aligning purpose.
The height of the shaft of the motors shall correspond to the machine to be driven, if discrepancies are encountered these shall be compensated by inserting machined metal plates under the supports of the motor.

The motors mounted on the movable base frames/base plates shall be connected via intermediate terminal boxes with flexible cables.

After the complete installation of the motors, all bolts and bolted joints of the mechanical and electrical equipment shall be checked to ensure that they are done up tightly by torque wrench. A further check shall be made to ensure that the armature can be easily rotated.

The insulation resistances of the coils and connecting leads within the machine shall be checked against earth by a suitable megger. Insulation resistance if found less, the machine shall be dried to achieve the desired value.

Space heaters of main drive motor required to be installed in motor foundation pits shall be suitably and firmly mounted.

For handling the machine with the crane, the slings, lifting cables etc. shall not be secured around the shaft. However, the armature of disassembled machines may be lifted or supported by the shaft.

The machine shall be lifted or lowered without shocks or quick jerks to avoid any damage.

The system components delivered in separate packages like tank, gear pumps, filters, pressure switches, thermometer, flow regulators, centrifuge etc. shall be assembled at site and installed as per supplier's drawings. The supply and return pipelines along with their supporting structures from the lubrication system to the motor bearing shall be laid/erected by the contractor as per the relevant pipeline routing drawings. Meters and gauges shall be fixed and wired.

003 Sheet metal enclosed panels, open control panels, control desks and boxes

The base frames of all panels, desks, posts etc., shall be welded to structures or to the civil inserts provided on the floor/walls. Fabrication of supports/frames, wherever required, shall be done by the contractor.

The shipping section shall be placed in position before removing the protective covering to eliminate scratch/damage. The shipping section shall be moved by using rollers under the shipping skids wherever lifting cranes are not available. The contractor shall do the assembly at site as per manufacturer's general arrangement drawings and installation instruction. While assembling a complete board comprising several unit type cubicles, the board as a whole shall be aligned. The panels shall be
properly leveled prior to grouting the holding down bolts or welding the panels to the inserts. All interconnection of busbars and wiring between the panels shall be done as per manufacturer's instructions and drawings. Welding work on the panels shall only be carried out after consultation with the purchaser. Damage to the paint due to welding shall be rectified by the contractor.

After mechanical installation of the board is completed, loose instruments shall be installed, wherever required, and wires shall be connected to the instrument. The wiring of intermediate terminal strips between two panels, wherever disconnected for transport, shall also be connected.

**004 Static converters**

The installation shall be carried out as per manufacturers' instructions & equipment layout drawings.

The preservative grease from the metallic parts shall be removed by petrol and with clean markin cloth. Grease from copper parts shall be removed with ethanol and wiped with clean dry markin cloth.

The base frame of panels shall be welded to the civil inserts.

The panels supplied in separate shipping units shall be assembled at site as per manufacturer's drawings/instructions. The unit installation shall be started with the main converter. All the cabinets shall be aligned in a perfectly straight row and each of them exactly leveled. All inter-connections shall be done as per manufacturer's drawings/instructions.

**005 Transformers and Reactors**

The transformer and its accessories and mountings like radiators, conservator, thermometers, silicagel breathers, marshalling box, rollers etc., delivered at site in separate packages, shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's drawings.

Jacks shall never be placed under valves or cooling tubes.

Suitable stopper shall be provided both in front as well as rear of transformer to keep the transformer stationary in its position. For the front wheels such stoppers shall be screwed on the rails.

The oil conservator and the pipes shall be erected as shown in the manufacturer's drawings. All radiator tubes shall be cleaned before installation.
Before the transformer is filled/topped with oil, oil samples shall be checked by the contractor from each container. The oil shall possess the dielectric strength as per relevant IS/CEA. Oil shall be filled upto the mark shown.

The contractor shall also test the oil from each transformer to determine its suitability for use. If required, the contractor shall carry out drying and filtering operations as per IS code of practice to ensure that moisture is completely removed and the oil is free from impurities. This may be carried out by using oil filtering equipment to be provided by the contractor having vacuum as well as heating arrangement. Only after the dielectric strength of oil and other parameters are checked and approved, the external connections shall be made to the transformers.

The dial thermometers shall be screwed to the thermometer pockets after removal of the blind plugs.

All necessary cabling shall be connected before charging of the transformer. This will include signaling cables upto marshalling box and from marshalling box to meters, if not already done, as well as intercabling between surge suppressor cubicle and transformer secondary.

Any modifications to HT and LT terminal box to accommodate the number of cables to be terminated shall be carried out by the contractor.

Naked light and flame shall never be used near the transformer.

006  **Crane Trolley Lines**

While sectionalising, one middle safety section shall be arranged slightly in excess of the crane braking distance so that it can act as a buffer and prevent the danger of crane collector bridging the isolator gap and leading to accidents on other section under repair or maintenance.

Boarding or access platform shall be arranged within the limits of each repair section for approach to the crane.

In the middle of the run between two expansion joints, the rails shall be rigidly fastened.

007  **Miscellaneous Equipment**

Control desks/posts/boxes

Each post shall be mounted at the place of installation in such a way that the operator has both the plant and the post before him.
The installation of control posts/boxes on mechanical equipment must be approved by the purchaser.

In cases where the control posts/boxes are separately mounted near the equipment, the contractor shall manufacture a structural support for the same before mounting the control posts/box.

Resistance boxes

The resistance boxes shall be installed on frames to be welded to civil inserts already provided.

008  Cables Installations

Cable shall be fixed to racks or trays or cleats as required for proper support, accessibility and neatness of installation. Hanging of cables racks over panels shall not be permitted rather no cable shall be laid/pass over any electrical equipment e.g. transformer, switchboards etc. Cable tags shall be provided at a regular interval of 30M. For cable run shorter than 30M one cable tag shall be provided in the middle. These tags shall be in addition to end cable tags. The cable tags shall be marked with cable number, size and voltage grade. Middle tag shall be indicated with destination. The end tag shall be with second terminal point.

Cables shall be clamped rigidly at an interval of not more than 1000 mm in horizontal, and 500 mm in vertical & inclined run and at bends.

In the cable basement/cable galleries, cable structures shall be properly arranged giving sufficient clearance for movement of personnel from one part of the basement/gallery to the other. It shall also be possible to escape easily in case of fire.

Cable passing through water/scale pit/acid fume etc. shall be laid in PVC pipe with PVC junction boxes and pull boxes etc Where cable racks or trays cannot be erected or the number of cables on the route does not justify their use, cables shall be cleated direct to walls or structural steel work.

Perforated trays shall only be used where necessary for the support of a number of small cables. Each tray shall be firmly supported at suitable intervals and shall carry the weight of its cables without sagging. Trays shall be painted and where the surfaces or edges are cut or otherwise impaired during erection, they shall be made good by coating with aluminium paint.

Small cables may be bunched together under one saddle provided that in any bunch all cables have sheaths of the same material. The number of cables shall not exceed four wide and two deep.
Not more than one cable shall be drawn into one conduit unless otherwise agreed. After the cable has been drawn in, the conduit shall be sealed by an approved means.

After complete installation of racks and trays etc. it shall be painted with a primer of red oxide(zinc chromate) and a top coat of finishing paint as approved.

Fire protection barrier as approved by purchaser shall be provided between HT cables on racks laid on top and LT cables on racks below the HT cable rack.

All cables shall be tested for proper insulation before start of laying work.

Cables shall be laid in conduits, racks/trays, cable tunnels/trenches, along with structures or buildings, as per cable routing drawing and cable list.

Suitable adjustment shall be made in cable routes, if required at site, with a view to avoid any interference with any part of building, structures, equipment, utilities and services with the approval of the purchaser.

While laying cables, care shall be taken that kinks, twists or mechanical damage do not occur to the cable.

All bends in cables shall be made with due consideration to the minimum permissible bending radius of the cables.

Loops shall not be allowed to be formed during the laying of the cables. When being pulled, the cable shall not be allowed to drag drawing along the ground or over a second cable already laid. Special care shall be taken while pulling through an opening where other cables have already been laid. Only approved cable pulling devices shall be used.

No joints shall normally be made at any intermediate point in through run of cables unless the length of the run is more than the standard drum length. In such cases where jointing is unavoidable, the same shall be made inside proper bases having plastic moulds and shall have moulded epoxy resin construction. Provision shall be made for earthing continuity at the joint. Cable splicing and jointing shall be done in accordance with the relevant IS, code of practice and manufacturer's instructions. Insulation resistance of cables shall be checked before cable jointing.

Adequate length of cables shall be pulled inside the switch boards, control panels, control desks, etc. so as to permit neat termination.

All cables shall be neatly dressed without interlocking or cross overs. While laying the cable vertically, these shall be clamped at suitable intervals. Horizontal runs shall be rigidly secured to trays on racks/hangers in all the places where the direction of the
route changes as well as at cable terminations or joints. The clamps shall not be done up so tight that the insulation is damaged or deformed.

Cable markers shall be provided on either side of road crossing at each turning and at 30 m intervals at straight runs for underground cables.

Where cables are required to cross roads, surface drains and water, oil, gas or other pipe lines, they shall be taken through reinforced spun concrete or steel pipes.

Entry of cables from underground to the buildings or trenches shall be through pipe sleeves. After laying of cables, the sleeves shall be sealed with bitumen or epoxy compound with sand matting and cement plaster to make them fully water tight.

Special consideration shall be given for protection of cables against chemical and mechanical damage.

All cable entry openings in the equipment shall be sealed and made vermin proof. All cable openings in walls and floors shall be sealed after laying of cables by a weak mixture of asbestos and cement mortar.

All cables shall be provided with identification tags indicating the cable number in accordance with cable lists. Tags shall be fixed at both ends of the cable and at 15 m spacing for straight runs as well as on both sides wherever cables are crossing walls/floors. The tags shall be of aluminium/PVC with numbers punched/painted on them and securely attached to the cables by non-corrosive wires. The shape of tags shall be round, triangular and rectangular for control, medium voltage and high voltage cables respectively.

Glanding shall be done for direct entry of both power and control cables into the panels by the contractor. Compression type brass or aluminium alloy cable glands shall be used.

The cables shall be terminated in accordance with relevant connection diagram. Termination and clamping shall be carried out in such a manner as to avoid strain on the terminals.

All power cable terminations shall be by means of crimping type cable lugs. For flexible conductors, soldered termination shall be adopted. In case of aluminium power cables termination on copper bus bars, suitable aluminium copper bimetallic washers shall be used. Corrosion inhibiting grease shall be used for aluminium cable terminations. All 0.5 sq.mm control cable termination shall be made by crimping using pin type insulated copper lugs. The 0.5 sq.mm copper lugs shall be supplied by the contractor.
Suitable numbered and coloured letter interlocking type ferrules shall be provided for end termination of power and control cables.

Control cable entering switch boards, control panels, control desks etc. shall be neatly bunched and strapped with PVC perforated straps and suitably supported to keep it in position at the terminal blocks. All spare cores of each cable shall be segregated, marked spare, neatly dressed and suitably tapped at both ends.

When the cores of two or more multicore cables take a common route, cores of each cable shall be separately bound and the separate bundles neatly bound together.

Individual cores of control cables shall have plastic interlocked type coloured ferrules with engraved numbers at both ends of the circuit for identification.

The contractor shall be responsible for correct phasing of motor power connections and shall interchange connections at the motor terminals box, if necessary, after each motor is test run.

The trays shall be earthed and rendered electrically continuous by welding the trays to the grounding strip at not less than two places from both sides of the tray.

Exposed conduits

Exposed conduits shall be laid along walls, floors, ceilings, on steel supports etc. as per working drawings/site requirements in consultation with the supervisory personnel. The conduits shall be neatly run and evenly spaced.

Fixing of conduits to the supports on wall, column, structure shall not be done by welding. Exposed conduits shall be adequately supported by racks, clamps, straps etc.

Jointing of conduits shall be done only in straight portion and not in bend portion.

The contractor shall have available at site bending facilities for conduits as well as dies for threading conduits of diameters and threads corresponding to the standards. The threaded ends of conduits shall be painted with anticorrosive paint. The outer ends shall be smoothened free of burrs and sharp edges. Bushings shall be fitted at both ends of conduits.

Flexible metallic conduits shall be used for termination of connections to motors and other electrical equipment like pressure switches etc. which need to be disconnected at periodic intervals.

All conduits shall be effectively connected to the earth terminal of the equipment where it terminates.
Both ends of conduits shall be suitable earthed. Earthing continuity to be maintained by means of flexible wire wherever two conduits are joined with sockets.

Approved conduit bending machines to be arranged by the contractor shall be used for bending conduits in the field. The radius of any conduit bend shall be as per standards for cabling. Bends shall be free from cracks, crimps or other damage to the pipe or its coating.

010 Earthing

Earthing connection to equipment subject to movement, vibration and shocks, shall be through flexible stranded conductors.

The termination of strips to the equipment shall be done by bolting and the wires shall be terminated by compression lugs. Bolt connected contact surfaces shall be tinned. Jointing of strips shall be done by welding for proper continuity. All contact surfaces shall be thoroughly cleaned of dust and oil and after jointing, the joints shall be given bitumen paint.

Earthing conductors laid directly in ground, shall be coated with one coat of bituminised paints, be wrapped with one layer of bitumaetic tape laid on half lapped and shall have a final coat of bituminised paint to prevent corrosion.

Earthing conductors run on walls/floors/cable and equipment structures etc. shall be supported at suitable intervals and painted with black oxide paint.

All joints in the branch connections except at earthing electrode shall be welded and painted black.

At road /rail crossings earthing strips shall be laid through conduits /concrete ducts.

Special earthing shall be provided for all electronic equipment as per manufacturer's recommendations / practice.

03.07 Repair Network

03.07.01 General

A repair network shall be laid to cover all the units/buildings of main technological plant for providing power to maintenance tools, tackles and telphers.

Welding switch socket outlets shall be provided at every 60m distance in conveyer galleries and atleast one at every working platform of junction houses. The number of
welding socket outlets for main technological plant units shall be decided based on requirement, approach etc. Generally the socket outlets shall be provided in such a manner so that using 30m flexible cable with welding set, total plant area can be covered. Upto three switch socket outlets shall be looped per feeder circuit. Sheet metal clad switch fuse units shall be provided for feeding power to telphers.

The welding switch socket outlets and switch fuse units shall be fed from separate distribution board.

03.07.02 Distribution boards

- 415V, 3 phase, 4 wire, 40 kA (short time rating for 1 sec.) indoor type.
- Board shall be single front, metal clad, front matched dust and vermin proof, fully compartmentalised and extensible on both sides, IP51 type enclosure.
- Shall have base channel of size ISMC 75.
- Shall have isolated busbar chamber for main busbar at the top, running through out the length of the board chamber shall have removable cover.
- Cable alley shall have sufficient space for aluminium power cables and bottom cable chamber shall be left free completely isolated from the vertical busbars.
- Busbars shall have same cross section through out the length. Rating of the neutral busbar shall be 50% of the main busbar. Earth bus bar shall run in bottom chamber throughout the length of the panel.
- Shall have Moulded case circuit breaker triple pole, air break type with independent manual quick make and quick break type. MCCB shall be capable of breaking rated current at 0.3 pf at rated voltage. MCCB shall withstand the fault current envisaged for 415V system.
- All feeders shall have ON/OFF lamps and 96 sq. mm size ammeter
- Incomers of board and outgoing shall be MCCBs.

03.07.03 Switch socket outlets

- 415V, 100 A, 3 pole load break switch
- 3 phase and one earth pin socket
Switch socket interlocked so as to prevent insertion or withdrawal of plug when switch is "ON".

Facilities for terminating two cables of 3.5 x 70 sq. mm aluminium cables.

**03.07.04  Cables**

- Incoming to distribution board 3.5 x 185 sq.mm. cable.
- Outgoing feeders to switch sockets 3.5 x 70 sq.mm for 100A sockets,
- Outgoing to telphers as per requirement.

**03.08  Illumination**

**03.08.01  Equipment Mounted Illumination**

The equipment lighting wherever required shall be provided particularly where precision work is required.

Equipment shall be properly illuminated with incandescent lamp/fluorescent tubes.

The fitting shall be complete with shade, switch and terminal box.

The switchgear MCC panel light shall be provided with door limit switch.

Wiring shall be carried out with PVC insulation, PVC sheathed 650/1100 V grade armoured cables with aluminium conductors. In floors, medium duty galvanized pipes/conduits conforming to IS:1239-1990 shall be use.

The cable from lighting distribution board shall be included upto lighting fixtures.

**03.08.02  Area Illumination**

The plant shall be provided with necessary indoor and outdoor lighting system. Indoor lighting shall constitute general and emergency lighting.

All units shall be provided with general lighting with illumination levels commensurate with the tasks to be performed and to facilitate convenience and efficiency of operation and maintenance personnel working in the various shop floors, platforms and areas. Emergency lighting shall also be provided to ensure safety of personnel and equipment in case of failure of general lighting, in shop areas in strategic location, control room etc.
For hazardous areas acid proof/explosion proof increased safety light fittings shall be
used as applicable.

Maintenance factor for design of illumination in dusty area shall be 0.6. For control
room, maintenance factor shall be 0.7.

Proper segregation of lights shall be made so that lights not in use during off time may
be conveniently switched off.

24V AC socket with lighting transformer shall be provided for hand lamp connection
through out the premises including cable basement/tunnels/shafts.

03.08.03 Lighting Power Supply

Lighting distribution system shall be distinct and separate from the LT main
distribution.

001 General Lighting

Lighting points shall be supplied at 240V, AC through 415V, 3 phase, 4 wire, 50 Hz,
earthed network. In the cable tunnels lighting circuit shall be 24V.

Different circuits shall be used from different source. The whole lighting network shall
be balanced as far as possible. Maximum use shall be made of HPSV lamps and
fluorescent tubular lamps. However, in the high bay areas where HPSV lamps are
used, 20% of the light fittings shall be with incandescent lamps and be connected from
emergency power source to take care of loss of illumination during restrike time of
discharge lamps after a supply failure.

In unmanned premises, normally the intermittently installed lights shall be `ON' with
separate control. All other lights shall be made `ON' or `OFF', whenever required.

002 Emergency Lighting

In case of indoor illumination, separate lighting circuit shall be provided as emergency
lighting circuit. Emergency lighting circuit shall be through MCC/PDBs so that in case
of failure of power in lighting DBs circuit, these lights can continue to glow. 20% lights
shall be connected to this circuit. Balance lights shall be connected through lighting
circuit.

Portable Emergency lighting including built-in battery, battery charger & lamps shall
be provided in strategic areas like control rooms, staircases, entry of cable
tunnels/basements, escape routes, etc. for safety.
03.08.01 Maintenance lighting

For maintenance lighting, power supply shall be fed from 240/26.5V small capacity step-down transformers to the 24V socket outlets.

03.08.04 Outdoor lighting

Flood lights for area lighting shall be mounted on towers/poles or building structures. Tower height shall be kept to an average of 22m.

Street/road lighting and boundary wall lighting shall be provided with HPSV/fluorescent lamp fittings mounted on poles of 9m to 11m height.

Neon aviation obstruction lights shall be provided on chimneys and other such tall installations as per regulation.

03.08.05 Power Factor Improvement

Power factor of all the light fittings shall be improved so that it is not less than 0.90. Power factor shall be improved by providing capacitor banks with discharge resistor in the light distribution or by providing capacitors with individual fittings.

03.08.06 Lighting Distribution Boards and Panels

The main lighting distribution boards shall consist of two incoming triple pole and neutral MCCB with a bus-coupler and required number of outgoing triple pole and neutral MCCBs. Sub-distribution boards shall consist of one number triple pole and neutral incoming MCCB and required number of miniature circuit breakers for outgoings.

The boards shall be designed for the required short-circuit level of 40 kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-41. For outdoor use, the protection for distribution board shall be IP-54. Thickness of sheet steel enclosures shall be 2mm minimum.

Number of outgoing feeders in MLDB’s, SLDB’s shall be provided as per requirement keeping 20% spare feeders. Each outgoing MCB in LDB’s shall be of 15A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB.

Individual control in office buildings shall be through single pole tumbler switches. In those areas where group controls are required, rotary switches shall be provided.
External area lighting including street/road lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through photo cells or timers. Flood light towers shall be fed through 415/240V, 3 phase, 4 wire circuit with individual fittings distributed at 240V, single phase, with control and protection located at bottom of each tower. Rewireable fuse in a sheet steel box shall be provided near each fitting to facilitate removal of lamp in off position.

In high bays walkway shall be provided for maintaining light fittings. At other places suitable ladder/platform/approach shall be provided for maintaining/replacement of light fittings.

03.08.07 Cables and Wiring

Wiring shall be carried out with PVC insulated, PVC sheathed 650/1100V grade armoured cables with aluminium conductors while crossing floors/wall, medium duty galvanised pipes/conduits conforming to IS:1239 –1990 shall be used.

Pull boxes of suitable dimensions wherever necessary shall be provided.

For heat zones silicone rubber insulated heat resistant cables shall be used. The minimum size of the cable used shall be 4 sq.mm. aluminium conductor.

Office buildings, laboratory buildings shall have concealed wiring using PVC conduits. In heat zones ie. in the areas where ambient temperature is 60 degree C and above, heat resistant cables shall be used inside metallic/GI conduits.

Area and street lighting cabling shall be carried out with armoured cables directly buried in ground. For street/road lighting, 415/240V, 4 core, underground cables shall be provided. Cables shall be run along the road side in cable trench as per standard specification and connections to individual poles shall be tapped from alternate phase and neutral to balance the load as far as possible. The minimum size of the cable shall be 6 sq.mm aluminium conductor.

03.08.08 Small Power Socket Outlets

240V, 3 pin (2 pole and earth) socket outlets of suitable ratings with plug tops and interlocked switches in sheet steel enclosure shall be provided in all the units at interval of 30m or part there of for hand tools, water coolers, exhaust fans etc.

Socket outlets shall not be provided in explosion hazardous areas.
03.08.09 Type of Fittings

All the high bays shall be provided with highbay fittings. The control gears of HPSV fittings shall include HRC fuse, ignitor, pf improving condenser.

Cable tunnels will have 240V A.C Bulk-head lamp fittings.

Industrial type fittings with 40W fluorescent tubes shall be used for sub-stations, workshops, cellars, gallery, transformer cells etc.

In office buildings, control rooms and buildings with false ceilings, decorative type fluorescent tube light fittings shall be used, as per specific requirement.

In all explosion hazardous areas, flame proof fittings with HPMV or incandescent lamps shall be used, as per specific requirement.

In dust vapour laden areas, totally enclosed type dust and vapour proof fittings either with HPSV or fluorescent tubes shall be used.

Street/road and boundary wall lighting shall be carried out using street light fittings with HPSV lamps.

Area lighting shall be with HPSV flood light fittings.

Standard wattage of lamp:

<table>
<thead>
<tr>
<th>Type</th>
<th>Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorescent</td>
<td>40W</td>
</tr>
<tr>
<td>HPMV</td>
<td>80,125, 250, 400, 1000W</td>
</tr>
<tr>
<td>HPSV</td>
<td>70,150, 250, 400W</td>
</tr>
<tr>
<td>Incandescent</td>
<td>100, 200, 300, 500, 1000W</td>
</tr>
</tbody>
</table>
03.08.10 Illumination Levels and Types of Lamps

The levels of illumination and types of lamps selected shall generally conform to the following:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Area</th>
<th>Lux level</th>
<th>Type of fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Office buildings, control rooms</td>
<td>300</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Instrumentation rooms</td>
<td>300-500</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Computer room</td>
<td>500</td>
<td>Recessed decorative Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Laboratory building</td>
<td>300</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Compressed air station</td>
<td>150</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Mills, CCP, and other high bays and operating floors</td>
<td>200</td>
<td>HPSV</td>
</tr>
<tr>
<td></td>
<td>Working platforms</td>
<td>100</td>
<td>HPSV/ fluorescent</td>
</tr>
<tr>
<td></td>
<td>Oil cellars, tunnels and access platforms</td>
<td>60</td>
<td>fluorescent/ Incandescent</td>
</tr>
<tr>
<td></td>
<td>Conveyer galleries</td>
<td>60</td>
<td>HPSV</td>
</tr>
<tr>
<td></td>
<td>Battery room</td>
<td>100</td>
<td>Corrosion resistant Vapour proof incandescent</td>
</tr>
<tr>
<td></td>
<td>Pump house, repair shops and substation</td>
<td>150</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Covered storages</td>
<td>100</td>
<td>Fluorescent/HPSV</td>
</tr>
<tr>
<td></td>
<td>Road, boundary wall and area lighting</td>
<td>20</td>
<td>HPSV</td>
</tr>
<tr>
<td></td>
<td>Electrical rooms</td>
<td>200</td>
<td>Fluorescent</td>
</tr>
<tr>
<td></td>
<td>Cable galleries and cable tunnels/cable basement</td>
<td>60</td>
<td>Incandescent</td>
</tr>
<tr>
<td></td>
<td>Chimney top</td>
<td>-</td>
<td>Neon aviation lamp</td>
</tr>
<tr>
<td></td>
<td>Transformer rooms</td>
<td>60</td>
<td>Rail type fluorescent</td>
</tr>
<tr>
<td></td>
<td>Toilet blocks</td>
<td></td>
<td>Rail type fluorescent</td>
</tr>
</tbody>
</table>

03.08.11 Ceiling fans/exhaust fans/Air conditioners

1400 mm sweep ceiling fans shall be provided for office buildings and other social buildings. Atleast one no. of fan shall be provided for every 10 sq. metre area. The ceiling fans shall be complete with electronic regulator.

Exhaust fans for toilets, battery room etc. shall be provided with their control devices (MCBs) & louvers.
Each Air-conditioner shall have local starter box consisting of MCCB, with over-load & short-circuit trip protection.

03.08.12 Miscellaneous items

Items such as brackets, hangers, clamps, junction boxes, etc which are required to make the lighting installations complete in all respects shall also be supplied.

Individual starter shall be provided for each air-conditioner, exhaust fan and mancooler.

03.09 Ventilation and Air-Conditioning of Electrical Premises/Control Rooms

03.09.01 General

The ventilation and air-conditioning system supplied shall be complete with all necessary central air-conditioning plants, packaged air-conditioners, fresh air filters, fan units, air ducts, monitoring and regulating equipment and electrical power supply equipment to complete the job complete in all respects. Necessary safety interlocks shall be provided to stop the fans in case of fire and to prevent spread of fire. The equipment shall meet the requirement listed in equipment specification under part-I.

03.09.02 Switchgear Rooms Without Electronic Equipment

All substations, switchgear rooms and MCC rooms which do not house any electronic equipment but contain only electrical equipment, shall be pressurised with fresh air and the maximum temperature of air at exit shall be maintained within 45deg.C. This shall match with the duty conditions of electrical equipment in the rooms. Where a large number of electrical equipment are involved, adiabatically cooled air washer system shall be provided to maintain room temperature at 40deg.C.

03.09.03 Electrical rooms with electronic equipment

The electrical rooms housing electronic equipment, PCs, remote I/Os, electronic weighing panels including telephone exchange equipment shall be air-conditioned with pressurisation to maintain the following conditions:

- Room temperature : 35Deg.C
- Relative humidity : Not more than 50 %
- Pressurisation : 2-3 mm WC

03.09.04 Rooms for instrumentation and automatic control system equipment (Levels 2 and 3)
These rooms shall be air-conditioned with pressurisation to maintain the following conditions:

- Room temperature : 21 to 24Deg. C
- Relative humidity : 50 to 60%
- Pressurisation : 2-3 mm WC
- Temperature gradient : 2Deg. C/h

03.09.05 Control Rooms/pulpits

The control rooms/pulpits shall be air-conditioned to maintain the following conditions:

- Room temperature : 24Deg. C
- Relative humidity : 50-60%
- Pressurisation : 2-3 mm WC

03.09.06 Cable Basements/Tunnels

These shall be ventilated with fresh filtered air to cable basements and fresh air to tunnels to maintain temperature of air at exit so as not to exceed 45deg.C and pressurised - ventilation of cable basements and tunnels shall not be combined with other premises. Cable tunnel ventilation shall be sectionalised to maximum length of 150m.

Temperature rise shall be limited to 3-5 deg. C above atmospheric dry bulb temperature subject to a maximum of 45deg.C at the exit of air from these premises.

Ventilation and air conditioning system shall be interlocked with fire detection system for safety.
03.10  FIRE DETECTION, ALARM & PROTECTION SYSTEM

03.10.01 Automatic Fire Detection-Cum-Alarm System and Manual Push Button Type Fire Alarm System

Automatic fire detection cum alarm system shall be provided for all electrical/oil premises mentioned below:

- Cable tunnels and cable shafts/cable galleries (for electrical and instrumentation)
- Motor houses, control rooms (electrical and instrumentation) & data logging rooms/computer rooms/automation rooms/micro processor rooms, instrumentation rooms.
- Switchgear rooms and electrical substations.
- Electrical rooms
- Transformer rooms
- Oil cellars
- Cable shafts

Any other area considered fire hazardous.

In all the electrical premises except transformer rooms, smoke detectors viz. ionization type as well as photo-electric type in 1:1 ratio within the one detector coverage area, with cross zone arrangement shall be provided.

In oil premises and in transformer room etc., rate of rise-cum-fixed temperature heat detectors shall be provided. The system shall have self monitored microprocessor panel incorporating the latest technological developments. The automatic fire detection cum alarm system shall operate taking into consideration the air change/air velocity of the ventilation system.

Fusible link type heat detectors shall be provided for the oil premises, where automatic deluge valve type fire extinguishing system are provided. Smoke detectors and heat detectors shall be installed as per latest relevant BIS-2189 and NFPA Codes. Minimum two numbers of detectors for the smallest premises shall be provided. One set of potential free "NO" contacts shall be wired to the nearest telephone DB terminal box for connecting to central fire station.
In addition, each zone shall also be provided with manual push button stations connected to its zone card. Two separate and isolated detection circuits will be provided in each fire zone which will have alternative ionisation and photo-electric type fire detections.

In case of detection of fire, the fire signal (Audio-visual alarm) shall appear in the main control panel located in the constantly manned place and shall be repeated in the main fire station. Audio-visual alarm shall also appear inside & outside fire indication panel installed in that particular area to caution the people working in & around that area.

There shall also be interlocks to shut off the exhaust ventilation system and simultaneously closing the damper. The fire signal from one detection circuit will operate the audio-visual alarm whereas on confirmation of fire from the other detection circuit will switch off the ventilation drives as well as actuate discharge of extinguishers, if any.

The detectors used shall be approved by either Under Writers'Laboratories or FOC, UK.

The fire alarm panels shall be provided with emergency power supply by battery along with charger.

Cables used for the system shall be flame retardant low smoke (FRLS) type of 2.5 sq.mm copper cables and run in conduits wherever they run in hazardous areas like cellars etc. Audio visuals alarms shall be provided for different shops.

Automatic fire detection-cum-alarm system will comprise of smoke detectors (Ionisation and optical type), Rate of Rise-cum-Fixed Heat Detectors/Fusible Link type fixed heat detectors, cable, main control panel, response indicator panels, repeater panel, power supply to the panel and system from main supply, standby power supply from batteries, battery charger, suitable exhaust system for battery fumes, hooters, etc. Provision shall be kept in the main control panel to repeat the fire signal in the main fire station.

Manual Push Button Stations (glass covered, glass cover broken to press the PB), shall be provided at various places for an alarm in case of fire.

The total system shall be designed, supplied, erected and tested as per relevant TAC, BIS and NFPA Codes.
03.10.02 **Passive Fire Protection Facilities**

- Fire doors and fire escapes shall be provided at every 100 m. In case of fire detected in a particular area, the ventilation system for that area shall be automatically switched off from the control panel of the fire detectors and audio-visual alarm signal shall appear in the affected zone.

- Outgoing cable opening and cable ducts from the electrical switchgear rooms and cable floors shall be closed with fire proof doors.

- Fire protection for outgoing cable openings, cable ducts and tunnels shall consist of mineral fiber panels 6 cm thick mineral wool, flammoplast KS paint, flammoplast KS stopper and accessories or equivalent fire retardant materials. All cables crossing fire partition walls shall be painted with heat resistant paint, atleast 2 m on either side of the partition wall. In addition to this heat resistant painting shall be applied for 1 m length at an interval of 20m.

- Partition walls with fire resistant doors shall be provided at an interval of not more than 30 m in cable galleries and cable basements. Each area shall be provided with separate ventilation duct with electrically operated dampers. In case of fire in a section/zone the corresponding dampers shall be automatically closed.
### TABLE - I

**SELECTION OF POWER COMPONENTS & WIRING FOR CONTINUOUS DUTY CAGE MOTOR DRIVES**

<table>
<thead>
<tr>
<th>Motor Rating at S1 (KW)</th>
<th>Minimum rating of Switch in Amp</th>
<th>Minimum rating of Contact (AMPS)</th>
<th>Minimum size of copper wire/flat in sq.mm for internal power connection</th>
<th>Minimum size of power cable termination sq.mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 3.7</td>
<td>32</td>
<td>30</td>
<td>4</td>
<td>4 x 6</td>
</tr>
<tr>
<td>5.5</td>
<td>32</td>
<td>30</td>
<td>4</td>
<td>4 x 6</td>
</tr>
<tr>
<td>7.5</td>
<td>32</td>
<td>30</td>
<td>4</td>
<td>4 x 6</td>
</tr>
<tr>
<td>11</td>
<td>63</td>
<td>45</td>
<td>6</td>
<td>4 x 10</td>
</tr>
<tr>
<td>15</td>
<td>63</td>
<td>45</td>
<td>10</td>
<td>4 x 16</td>
</tr>
<tr>
<td>18.5</td>
<td>63</td>
<td>70</td>
<td>16</td>
<td>4 x 35</td>
</tr>
<tr>
<td>22</td>
<td>125</td>
<td>70</td>
<td>16</td>
<td>4 x 35</td>
</tr>
<tr>
<td>30</td>
<td>125</td>
<td>110</td>
<td>35</td>
<td>3.5 x 50</td>
</tr>
<tr>
<td>37</td>
<td>125</td>
<td>110</td>
<td>35</td>
<td>3.5 x 50</td>
</tr>
<tr>
<td>45</td>
<td>250</td>
<td>170</td>
<td>50</td>
<td>3.5 x 95</td>
</tr>
<tr>
<td>55</td>
<td>250</td>
<td>170</td>
<td>70</td>
<td>3.5 x 120</td>
</tr>
<tr>
<td>75</td>
<td>250</td>
<td>250</td>
<td>95</td>
<td>3.5 x 185</td>
</tr>
<tr>
<td>90</td>
<td>250</td>
<td>250</td>
<td>30x5</td>
<td>2(3.5x120)</td>
</tr>
<tr>
<td>110</td>
<td>400</td>
<td>400</td>
<td>30x5</td>
<td>2(3.5x120)</td>
</tr>
<tr>
<td>125/132</td>
<td>400</td>
<td>400</td>
<td>40x5</td>
<td>2(3.5x120)</td>
</tr>
<tr>
<td>160</td>
<td>400</td>
<td>400</td>
<td>40x5</td>
<td>2(3.5x185)</td>
</tr>
<tr>
<td>200</td>
<td>630</td>
<td>630</td>
<td>30x10</td>
<td>3(3.5x185)</td>
</tr>
</tbody>
</table>
## COLOUR CODE FOR ELECTRICAL EQUIPMENT

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION OF EQUIPMENT</th>
<th>COLOUR</th>
<th>PAINT SHADE NO. AS PER IS 5 : 1991</th>
<th>EQUIVALENT RAL CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I.</strong></td>
<td><strong>MOTORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>11 kV/6.6 kV motors</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td>2.</td>
<td>415 V LT AC motors</td>
<td>Light admiralty grey</td>
<td>697</td>
<td>7001</td>
</tr>
<tr>
<td>3.</td>
<td>Large custom built DC motors</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td>4.</td>
<td>DC 460 V motors</td>
<td>Azure blue</td>
<td>104</td>
<td>5000</td>
</tr>
<tr>
<td>5.</td>
<td>DC motors up to 250V</td>
<td>Oriental blue</td>
<td>174</td>
<td>5018</td>
</tr>
<tr>
<td><strong>II.</strong></td>
<td><strong>MOUNTED ELECTRICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Equipment installed on or along with</td>
<td>Same as that of motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>motors viz. Tacho generators, brake etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Equipment installed on mechanism but</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>separate from motor viz. Limit switches,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pull chord switches, belt sway switches,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>speed switches, load cells, photo electric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>relays etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>III.</strong></td>
<td><strong>TRANSFORMERS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Outdoor transformers including their</td>
<td>Dark admiralty grey</td>
<td>632</td>
<td>7012</td>
</tr>
<tr>
<td></td>
<td>associated equipment/panels installed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>outdoor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Indoor transformers</td>
<td>Dark admiralty grey</td>
<td>632</td>
<td>7012</td>
</tr>
<tr>
<td>SL. NO.</td>
<td>DESCRIPTION OF EQUIPMENT</td>
<td>COLOUR</td>
<td>PAINT SHADE NO. AS PER IS 5:1991</td>
<td>EQUIVALENT RAL CODE</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------------------------------------------</td>
<td>-------------------------</td>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>IV. SWITCHGEAR OF SUBSTATIONS</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>1. 33 kV/6.6 kV switch boards and busducts</td>
<td>Light admiralty grey</td>
<td>697</td>
<td>7001</td>
</tr>
<tr>
<td></td>
<td>2. 415 V switch board, battery charger &amp; DCDB</td>
<td>Brilliant green</td>
<td>221</td>
<td>6010</td>
</tr>
<tr>
<td></td>
<td>V. CONTROL GEAR</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>1. All control panels e.g. thyristor panels, PLC, relay</td>
<td>Light admiralty grey</td>
<td>697</td>
<td>7001</td>
</tr>
<tr>
<td></td>
<td>panels, MCC, etc. including crane control panels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Instrumentation panels</td>
<td>Opaline green</td>
<td>275</td>
<td>6021</td>
</tr>
<tr>
<td></td>
<td>3. Lighting distribution and power distribution board</td>
<td>Light admiralty gray</td>
<td>697</td>
<td>7001</td>
</tr>
<tr>
<td></td>
<td>4. Fire fighting panel</td>
<td>Post office red</td>
<td>538</td>
<td>3002</td>
</tr>
<tr>
<td></td>
<td>5. Local control box</td>
<td>Same as that of motor</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>6. Control desk</td>
<td>Light gray</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>7. Pulpit equipment</td>
<td>Light gray</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>8. Telecommunication panel</td>
<td>Smoke gray</td>
<td>692</td>
<td>7014</td>
</tr>
<tr>
<td></td>
<td>VI. MISCELLANEOUS EQUIPMENT</td>
<td>Light grey</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>1. Junction boxes</td>
<td>Light gray</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>2. Conduit/pipe pull boxes</td>
<td>Light gray</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td></td>
<td>3. Light fittings</td>
<td>Light gray</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td>SL. NO.</td>
<td>DESCRIPTION OF EQUIPMENT</td>
<td>COLOUR</td>
<td>PAINT SHADE NO. AS PER IS 5 : 1991</td>
<td>EQUIVALENT RAL CODE</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>4.</td>
<td>415 V Welding sockets</td>
<td>Brilliant green</td>
<td>221</td>
<td>6010</td>
</tr>
<tr>
<td>5.</td>
<td>230 V Power sockets</td>
<td>Light orange</td>
<td>557</td>
<td>2000</td>
</tr>
<tr>
<td>6.</td>
<td>24 V transformer sockets, lamp sets etc.</td>
<td>Canary yellow</td>
<td>309</td>
<td>1016</td>
</tr>
<tr>
<td>7.</td>
<td>Earthing strip</td>
<td>Black</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
04.01  General

Adequate and latest state-of-art technology based Instrumentation and control system shall be provided for all the shops/units of the plant, with a view to achieve safe, reliable, efficient and trouble-free operation of the plant as well as safety of the plant equipment and operating personnel. The design, engineering, manufacture, assembly and testing as well as performance of instrumentation & control equipment shall conform to the relevant IS / IPSS / BS/ IEC/ ISA standards, unless otherwise specified in the General Technical Specification for Tender. All equipment supplied and all work done including system design and detailed engineering, shall also comply with the statutory requirements of Government of India and the State Government. ISA symbols shall be used for preparation of Process & Instrumentation diagrams.

04.02  Environmental Specification

All instrumentation & control equipment and their accessories, including those to be used in air-conditioned control rooms, shall be rugged, industrial grade and suitable for use in tropical environment. These equipments shall be suitable for operating continuously under the environmental conditions indicated below:

<table>
<thead>
<tr>
<th>Field instruments</th>
<th>Control room instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0 – 60°C</td>
</tr>
<tr>
<td></td>
<td>0 – 50°C (minimum)</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>0 – 95%</td>
</tr>
<tr>
<td></td>
<td>0 – 80 % (non-condensing)</td>
</tr>
</tbody>
</table>

04.03  Basic Design Considerations:

04.03.01  General

Design of instrumentation system shall take care of the following:

1. Latest state-of art and proven technology
2. High accuracy, reliable performance, modular design
4. Easy testing & calibrating facilities in both local & remote mode.
5. Flexibility for maintenance work to be carried out while the process is on.
6. 4-20 mA DC signal system.
7. Maintenance platforms with suitable approaches for each field device.

8. Aesthetically & ergonomically designed control rooms.

9. Fail safe features.

10. Safety to the plant equipment and operating personnel.

11. Provision for future expansion in design & selection, e.g. sizing of final control elements, flow sensors, space inside the control room, space on the panels/cabinets/desks etc.


13. Final control elements shall be with electric, pneumatic, hydraulic or hybrid actuators depending on application requirement. Final control elements shall have local valve position indicators and valve position transmission to control room.

14. Steam, nitrogen, water or compressed air lines shall be provided for purging and cleaning purposes, wherever necessary.

15. For measurement & control of critical parameters, dual redundant devices shall be provided.

16. Uninterruptible Power Supply (UPS) system shall be considered for automation equipment & associated field devices.

17. All pressure, differential pressure & flow transmitters shall be two- wire, true Smart type with HART protocol operating on 4-20 mA DC principle with 24 V DC power supply and shall be able to communicate with DCS/PLC/PC & hand held calibrator.

18. Memory of hand held calibrator shall be minimum 12 MB and shall be supplied with precision 250 ohm resistance.

19. All recorders shall have chart speed adjustable from 20 mm/h minimum to 360 (approx) mm/h. Chart speed for fast response recorders (e.g. for molten metal and slag temperature in steel plants) shall be of 3600 mm/h minimum.

20. All instruments shall have standard ranges. Ranges for indicators shall be selected so that normal value shall be indicated in the middle third of the scale.
21. In hazardous area applications, electronic/electrical instrumentation equipment shall be suitable for hazardous area classification as per IEC. These equipment shall be intrinsically safe conforming to CENELEC standard and certified by appropriate statutory bodies (FM, BASEFA etc.). Intrinsically safe systems shall be designed using zener/IS barriers. Where intrinsically safe design is not feasible, ex-proof equipment/enclosure, certified by statutory bodies like CMRI shall be supplied. Other acceptable safety procedures (e.g. increased safety procedure, pressurisation etc.) shall be used, wherever applicable. Required documentation/certificates shall be submitted in conformance with all such features.

22. All transmitters shall have built-in digital output indicators calibrated in engineering unit of flow, pressure, level, temperature, differential pressure etc.

23. Isolator cards shall be provided for isolation of instrument signals, wherever necessary.

24. Transmitters shall be housed inside cabinets, wherever these are not installed inside any room.

25. All field-mounted instruments shall be of suitable weatherproof construction, as per details indicated for respective items.

26. Wetted parts of the instrumentation equipment shall be selected so as to withstand physical and chemical properties of the service fluid coming in direct contact with the instrument.

27. Colour codes for pipelines, cables, lamps, and panels shall be followed for the plant as per industry/plant standard.

28. All the manufactured/fabricated items / impulse pipes & fittings shall be properly painted as per requirement & standard practice, depending upon nature of environment in which these are to be installed. Selection of primer and finish paint shall be done as per relevant IS standard or equivalent international / industry standards.

29. All fittings & accessories shall be new & rust protected. All flanged type instruments shall be supplied with companion flanges, nuts, bolts & gaskets.

30. Instruments used on oxygen lines must be oil and grease free and shall be marked ‘for oxygen use’ and colour coded blue.

31. Whenever corrosive atmosphere is present, all instruments and associated equipment exposed to such a medium shall be designed & protected to withstand the adverse effects.
32. Wherever instrumentation equipment is installed underground, suitable approach, sufficient space for maintenance, drainage, ventilation and illumination shall be provided.

33. All instrument ranges shall be standardized over the whole plant for local and remote instruments by the expression “(1, 2, 4, 6, 8, 10, 12, 15, 50) x 10^n”, where n = 1, 2, 3, etc.

34. Necessary certificates from appropriate authorities shall be submitted for all applicable items.

35. Continued availability & supply of Instrumentation & control equipment including their spares parts & consumables shall be guaranteed for a minimum period of 10 years.

36. In case, Instrumentation & control equipment are supplied from foreign sources / manufacturers, care shall be taken to select only those vendors who have competent associates/ partners / representatives in India with ability to provide required technical support & after sales service.

04.04 Temperature Measurements

1. The following types of primary sensing elements shall be used, depending on temperature of process fluid:

   a) Pt-Rh 13% / Pt (ISA Type “R”)
   b) Pt-Rh 10% / Pt (ISA Type “S”)
   c) Pt-Rh 30% / Pt-Rh 6% (ISA Type “B”)
   d) Chromel – Alumel (ISA Type “K”)
   e) Chromel – Constantan (ISA Type “E”)
   f) Copper – Constantan (ISA Type “T”)
   g) Iron – Constantan (ISA Type “J”)
   h) RTD (Pt 100)
   i) Radiation Pyrometers

2. All signals meant for control room / panel mounted instruments shall be 4-20 mAADC through microprocessor based temperature transmitters. RTD shall generally be used for measurement of -200 °C to 300 °C temperature range & thermocouples for higher temperatures.

3. RTDs shall usually be three-wire type. Four-wire type RTDs shall be used, whenever specifically required by purchaser / consultant.
4. Temperature transmitters or secondary instruments used with thermocouples shall have automatic cold junction compensation. All temperature transmitters shall be SMART type HART protocol. Enclosure class of temperature transmitter shall be IP 67.

5. Resistance thermometers (RTD) shall be used for cryogenics and low temperature in general.

6. Thermocouples shall normally be mineral insulated (i.e., extruded MgO) type. However, for applications exceeding 1100°C, lead type ceramic insulation shall be provided. Ceramic insulation shall be of recrystallised alumina (Al2O3-99.7%) as per DIN VDE 0335.

7. Thermocouple assembly shall be spring-loaded to ensure positive contact with thermowell.

8. Measuring junction of thermocouples shall be grounded or insulated depending on the type of electric system or safety protection requirement.

9. Separate conduits or cable entries shall be provided where duplex thermocouples are used.

10. Thermocouple calibration shall be in accordance with IS, DIN, IPTS or equivalent standard:

11. For Pt-Rh / Pt thermocouples, Linearisation shall be done in secondary instruments, DCS/PLC or using separate Linearisation card in temperature transmitter.

12. Thermowells fabricated out of bar stock having sufficient mechanical strength shall be provided to enable maintenance work of thermocouple / RTD without affecting production.

13. AISI 316 shall be used as thermowell material, unless other special material is required due to process fluid and conditions. For temperature range between 800°C – 1100°C, Inconel 600 shall be used as thermowell material. For temperature more than 1100°C, ceramic thermowell shall be used. Ceramic material shall be selected based on the process environment.

14. Any pipe of less than 4” nominal diameter, shall be expanded to 4” size to install thermowell.

15. Thermocouples shall be complete with compensating leads, installation fittings. The indicators, controllers shall have broken sensor protection.
16. Interconnections to/from thermocouples to temperature transmitter shall be made via compensating cables of thermoelectric characteristics matched with thermocouple.

17. Bimetallic type thermometers having minimum dial size Φ150mm shall be used for local indication of temperature. Temperature gauges with smaller dial sizes may be used for machine mounted applications.

18. For bimetal type thermometers, external dial reset facility shall be provided for zero adjustment.

19. Capillary tubes, wherever used, shall be of stainless steel material with flame-proof PVC, neoprene or steel armour, as suitable for the application.

20. In case, compensating leads are to be laid on the top of the furnace/hot surface, these shall be asbestos covered with mesh shielding or other suitable insulating materials. Mineral insulated cables shall also be used for such applications.

21. Compensating cables connected to transmitters shall not be through terminal blocks but shall be directly connected.

22. A protection tube consisting of a gas-tight ceramic sheath, preferably reinforced with stainless steel, shall be provided with Pt-Rh/Pt thermocouples, unless some other special construction is specified.

23. Radiation pyrometers shall be used when:
   a) Measured temperature is beyond the practical operating range of thermocouples.
   b) Environment will contaminate or seriously limit the life of the thermocouples.
   c) Target is not easily accessible.
   d) Average temperature of a large area is to be measured.

24. Normally, the radiation pyrometer shall respond to 98% of the target temperature.

25. Radiation pyrometers shall be provided with scavenging air or nitrogen to keep their lens clean and shall be water-cooled or air-jacketed when the surrounding temperature exceeds 50°C.
26. Isolation valve shall be provided before radiation pyrometer for on-line maintenance of radiation pyrometer.

04.04.01 Molten Steel Temperature Measurement System

1. For molten steel temperature measurement, disposable type immersion thermocouples having response time of less than 3 seconds shall be used. The corresponding temperature measurement system shall be complete with lance assembly, adapter, disposable thermocouple cartridge and two-way connector for the lance.

2. For immersion type hot metal / steel temperature measurement, shielded flame proof and heat resistant compensating cables shall be provided.

3. Temperature measurement system shall be microprocessor based.

4. Linearisation required for R & S type thermocouple shall be done in microprocessor based temperature measurement system.

5. 4 – 20 mA analog output for the measured temperature shall be provided for hooking up to DCS/ PLC.

6. 4 ½ digit type digital indication shall be provided in the temperature measurement system panel. This digital indicator shall retain the last value until the next measurement cycle is initiated by inserting the thermocouple probe in the lance.

7. One printer shall be provided in the temperature measurement panel for printing the measured temperature along with the heat no. Heat no. will be downloaded to the measurement system from DCS/ PLC through RS 232C/ RS 422/ RS 485 link.

8. Ready, measurement and measurement complete/ probe open signals shall be displayed in the measurement system panel with green, yellow and red LED indication.

9. In the field, one local control box, 200 mm jumbo display for temperature indication and red, yellow and green lights for measurement complete/ probe open signal, measurement and ready status display shall be provided. Measurement complete/ probe open shall also be indicated by blowing horn.

10. Power isolation switch at local control box end shall be provided.
11. 24 V DC signals and 230 V AC signals shall be segregated in the local control box and microprocessor based temperature measurement system panel.

**04.05 Flow Measurement**

**04.05.01 For Fluids:**

1. Normally orifice plates, magnetic flow meters or vortex flow meters shall be used for flow measurement of industrial service fluids, depending on the merit of the application. Positive displacement, turbine and Coriolis flow meters shall be used in custody transfer measurements and in processes, where high measurement accuracy is required. However, other types of flow meters may also be used when necessitated by particular technical requirements.

2. Vortex flow meters shall be generally be used for steam/gas service, upto 8” line size.

3. Magnetic flow meters shall be used for fluids having conductivity greater than 5 μS/cm.

**04.05.01 Differential Pressure Type Devices**

1. Normally, concentric square-edge type orifice plates shall be used.

2. For better accuracy, the Beta (β) ratio of concentric type orifice plates shall not preferably exceed 0.6. However, in no case, β shall exceed 0.7.

3. Concentric square-edge plate thickness shall be determined as follows:

   - 2 to 12” (i.e., 50 to 300 mm) 3.18 mm
   - 14” and above 6.35 mm
   - For temperature >316°C
     - 2 to 8” (50 to 200 mm) 3.18 mm
     - 10” & above 6.35 mm

4. Quarter-circle and conical entrance type orifice plates shall be used with viscous fluids.

5. Eccentric or segmental type orifice plates shall be used with dirty fluids.
6. Flow nozzle, venturi or averaging pitot tube may be used in high flow applications or where the allowable pressure-drop is low.

7. All orifice plates shall normally be made of AISI 316 material, unless otherwise called for by process requirement.

8. For line size below 2”, carrier-ring type orifice plate with corner tapping shall be used.

9. For line sizes greater than 2”, orifice plate with flange tapping shall be used.

10. Corner or D & D/2 type tappings shall be used only when flange tapping is not viable due to pressure loss or other considerations.

11. All orifice plates shall be fabricated with a collar, which shall extend outside the mounting flange.

12. Tag no., orifice plate bore diameter, upstream (+) and downstream (-) side marking, and plate material shall be engraved on the handle of the orifice plate.

13. Flanges shall be in accordance with ANSI B16.36 and of minimum Class 300 rating upto line size of 24”. For line sizes above 24”, flanges in accordance with IS 6392, and of suitable rating shall be used.

14. Tag no., flange size, flange rating and flange material shall be engraved on all flanges.

15. Gasket material for orifice plates shall be suitable to withstand physical and chemical properties of process fluid and shall be matched with the pipeline standard, as required.

16. Supply of orifice plate assembly shall include the orifice plate, flanges, stud-bolts, nuts, jackscrews, gaskets, pressure tapping nozzles and plugs.

17. Drain / vent hole correction shall be as per ISA RP 3.2.

18. Orifice plate or flow nozzle shall be installed as per standard, but not less than with straight pipe lengths of 10 times pipe internal dia. (10 D) on the upstream and 5 D on the downstream, free from bends, tees, branch pipes and control valves, etc. Upstream and downstream straight pipe lengths shall be as per section 1.1 of BS 1042. 1981.

19. Control valves shall be installed after the orifice plates in the direction of flow.
20. All flow meters shall have drainage valves except in oxygen and nitrogen service.

21. Corrosive media shall be separated from transmitters by separating chambers with valves for isolation.

22. For steam flow and flow of liquid at temperature greater than 120°C condensation chambers of identical dimensions shall be used. Condensation chambers shall be installed as near to flow sensor as possible.

23. Depending on specific requirements/applications, averaging pitot tubes with multiholes (eg, Annubar type) placed in the direction of fluid stream may also be used. The calculations and design shall be as per manufacturer’s standard.

24. For DP based flow measurement in pipe line sizes of ½” to 1-1/2”, integral orifice type flow meters shall be used.

25. IBR certification shall be provided for steam and vapour applications, as per IBR standard.

26. All flow meters on inter plant pipes for gas balance system shall have an accuracy of 0.5% f.s.d. or better.

27. In contaminated water lines / gas / orifice plates shall be installed in bypass line with isolation valves. So that on-line maintenance shall be possible.

28. Generally, metal tube type rotameters shall be used. Glass-tube enclosed type rotameters may be used up to 3 kg/cm² process pressure, if the process fluid is air, inert gas or water.

29. For line size greater than 2”, bypass type rotameters shall be used, instead of on-line mounted type.

**04.05.02 For solids:**

1. Generally, flow measurement of solids in powdered, amorphous or granular form shall be done using ultrasonic type or load-cell based weigh-hopper type or nucleonic type sensors, depending on the merit of the application.

2. For measurement of mass flow of suspended solids in liquids or slurries, nucleonic type instruments shall be used.
04.05.03 **Vortex Flowmeters:**

For selection of vortex flow meters, following to be taken into account:

1. Reynold’s no. shall be at least 20000 and minimum flow velocity shall be as specified by manufacturer.
2. Vortex flow meters shall not be considered in wet gas application.
3. Vortex flow meters shall not be considered for viscous, waxy or erosive services.
4. For gas application, the bluff body shall be in horizontal position to avoid condensate and for liquids in vertical lines the flow shall be upwards to keep the line full.
5. A location with minimum pipe vibration shall be selected. The pipe shall be supported at both ends, as necessary.
6. If pressure and temperature compensation are required for gas flow application, the pressure tapping shall be placed as close as possible to upstream of flow meter. The temperature tapping point shall be located at least 5D on the downstream of flow meter.
7. Straight length requirement shall be as specified by manufacturer. If meter size is smaller than the line size, concentric pipe reducers shall be used. Eccentric reducers shall not be used as they disturb the flow profile.
8. All vortex flowmeter shall be SMART type with HART protocol. Local display of vortex flowmeters shall be calibrated in engineering unit.
9. Accuracy of the vortex flowmeter shall be ± 1% or better.
10. Sensing technique of the vortex flowmeter shall not be thermistor based.
11. Necessary calibration unit for checking the electronic unit of vortex flowmeter shall be provided.
12. Enclosure class of vortex flowmeter shall be IP 67.

04.05.04 **Electromagnetic Flow Meters:**

1. Selection of Electromagnetic flow meters, shall be decided based on the following:
   
   a) Liner material shall be selected based on service. Generally, for liner material PTFE shall be used.
   b) If gases are entrained in the liquid, meter shall be installed in vertical process line.
   c) While installation it shall be ensured that flow tube is always completely filled with liquid.
   d) Straight length requirement of minimum 5 D in the upstream and 3 D in the downstream shall be provided for water services. However, for other services it shall be designed as per manufacturer’s recommendation.
   e) Installation of electromagnetic flow meters shall be avoided near large conducting surface e.g. metal surfaces. (Large surface may interfere with magnetic field of instrument thus affecting accuracy).
f) Pulsed DC excitation shall be provided for field excitation of Electro magnetic flowmeter. Power & signal circuits of magnetic flowmeter shall be completely isolated from each other.

g) Minimum one no. of grounding ring for metallic pipelines and minimum two nos. of grounding rings for non-metallic pipelines shall be used for installing the magnetic flow meter.

h) Selection and sizing of electro-magnetic flow meters flow characteristics published by the manufacturers shall be followed. Allowable flow velocity shall be considered based on the specific merit of the service, allowable pressure drop, cost effectiveness and as per manufacturers recommendation. However, 2 to 3 meter/sec flow velocity shall be considered for optimum results.

i) In case tube sizes are lower than the process pipelines reducers and expanders constructed preferably from the same as pipeline material shall be used. Such reducers and expanders shall be designed with 8(eight) degree downward and 5(five) degree upward angle respectively.

j) All magnetic flowmeter shall be SMART type with HART protocol. Accuracy of magnetic flowmeter shall be ± 0.3% or better. Local display shall be calibrated in engineering unit.

k) In contaminated water lines, magnetic flowmeter shall be installed in bypass line with Isolation valve.

l) Sensor & transmitter of the magnetic flowmeters shall separated in all cases.

m) Magnetic flowmeter shall be provided with built-in auto zero facility for ensuring stable zero point.

n) Separate earthpit shall be provided exclusively for earthing of magnetic flowometers. Preparation of such earthpits shall be governed by the general methodology as described in IS 3043, 1991 or relevant international standards.

o) Necessary calibration unit for checking the electronic unit of magnetic flowmeter shall be provided.

p) Enclosure class of magnetic flowmeters shall be IP 67.

04.05.05 **Coriolis Mass Flow Meters:**

1. For selection and sizing of coriolis type flow meters, following shall be taken into account:

   a) If required flow rate cannot be handled by one meter, two or more meters can be used in parallel.

   b) Selection of wetted part materials shall be carefully chosen to suit process fluid.

   c) SS shall not be used for liquids containing Halogen. Hastelloy tubes shall be used for all application containing Halogen.

   d) Coriolis mass flow meters shall not be used in two-phase fluid application.
e) Pressure drop across flow meter shall be selected, ensuring no cavitation occur under any process condition.

f) Flow meter support shall be as per manufacturer’s recommendation.

04.05.06 **Ultrasonic Flow Meters:**

1. For selection of Ultrasonic flow meters, following to be taken into account:
   a) Ultrasonic flow meters shall be used in clean liquids and gases.
   b) Ultrasonic flow meters shall be used where pressure drop is not allowed.
   c) On critical services Ultrasonic flow meters with insertion probes shall have retraction mechanisms to allow on stream maintenance.
   d) Clamp on type shall only be used for liquid metering.

04.05.07 **Turbine flow meters.**

1. Turbine meters for custody transfer shall have two pick-up coils for use with an electronic pulse integrity input circuit in read out system.
2. Turbine type meters shall have flanged connections
3. Strainers shall be provided immediately upstream of turbine meters
4. In liquid service, adequate filtering and degassing shall be provided.

04.05.08 **PD Meters:**

1. Positive displacement type meters shall have flanged connections.
2. PD meters shall not be selected for use in non-lubricating liquids e.g. LPG.
3. Strainers shall be provided immediately upstream of PD meters.
4. In liquid service, adequate filtering and degassing shall be provided.

04.06 **Pressure Measurement:**

1. Either bourdon tube (spiral or helical), bellows or diaphragm type sensing element shall be used in pressure gauges/ switches, depending on the process service.
2. The pressure gauges shall be designed in accordance with IS 3624.
3. Pressure gauge accuracy shall be ±1.0% of span or better. Accuracy shall include the combined effect of linearity, hysteresis and repeatability.
4. The element and other wetted part materials of pressure gauges/ switches shall be of AISI 316, unless process media necessitates use of other materials.
5. Movement material of gauges shall be of AISI 304. Outer casing and bezel material shall be either made of die cast aluminium with epoxy coating.
6. Pressure gauges shall have external zero adjustment facility and minimum IP55 housing.

7. The sensing element of pressure gauges/switches shall withstand the specified over-pressure (i.e., at least 125% of span) for at least 30 minutes, without affecting their elastic characteristics.

8. Pressure gauges shall have dial size of 150 mm diameter. Gauges of smaller dial size may be used for machine mounted applications.

9. Pressure gauges/switches used in pulsating pressure applications (e.g. delivery side of pumps, compressors, etc.) shall be provided with externally adjustable pulsation dampener or snubber.

10. Wherever the process temperature exceeds 70°C, pressure gauges/switches shall be equipped with pigtail syphon of the same material and schedule as the process pipeline.

11. Wherever the process pressure exceeds 50 kg/cm², solid front type pressure gauges shall be used (i.e., a metal partition shall be provided between dial and element).

12. Window material of the pressure gauge shall be of shatterproof glass.

13. For pressure measurement in slurries, viscous and corrosive fluids, diaphragm seals of suitable material shall be provided along with pressure sensing devices. Diaphragm seals shall be integral with the gauges/switches, unless otherwise specified.

14. The sealing liquid for diaphragm seal shall be an inert liquid compatible with process fluid and its temperature.

15. Depending on process application, suitable chemical seal along with capillary of required length shall be provided.

16. Diaphragm seal type pressure gauges/switches used in applications where the temperature exceeds 100°C, shall have bourdon/bellows type element. The bourdon/bellows shall be selected to withstand temperature upto 200°C.

17. However, in vacuum service, if the temperature exceeds 200°C, diaphragm seal shall not be used.

18. The working range of pressure switches shall be selected in such a way that the set pressure is between 35% and 65% of the range.
19. The switch enclosure shall be weatherproof to IP 65. Additionally, in hazardous areas, switch enclosure shall be explosion-proof conforming to IS 2148 and suiting to the area-classification of the hazardous area.

20. Dry contact type micro switches with minimum rating of 240VAC, 5A / 110VDC, 0.4A shall be used for pressure switches in non-hazardous area applications.

21. In hazardous areas, hermetically sealed micro switches with minimum rating of 240 VAC, 5A / 110VDC, 0.25A shall be used.

22. Pressure switches shall have an accuracy of at least ±2% of span and repeatability of at least ±1% of span.

23. Accuracy of DP gauges shall be ± 1.5% of span. Accuracy shall include the combined effect of linearity, hysteresis and repeatability.

24. Pressure gauges shall be supplied with three-way gauge cock. DP gauges shall be supplied with 3-valve manifolds of AISI 316 material of suitable pressure and temperature rating. The above items shall be in addition to the process isolation valves/root valves at the process tapping point.

**04.07 Transmitters**

1. Pressure, flow, differential pressure and level transmitters shall be rugged, industrial, microprocessor based ‘Smart’ type. Transmitters shall work on 24 V DC power supply having 2-wire, 4-20 mA DC output & ‘HART’ protocol based digital communication.

2. Accuracy of all transmitters shall typically be 0.1% or better, of calibrated span for turn-down ratio of minimum 10:1 and rangeability of 100:1. Accuracy shall include the combined effects of linearity, hysteresis and repeatability. In any application, the worst case error (WCE) consisting of static pressure effect, temperature effect, humidity effect and stability (1 year) shall not be greater than 0.75%, unless specified otherwise. Zero and span adjustments shall be non-interacting to each other.

3. Total response time (including dead time and time constant) of the transmitters shall be less than 100 ms.

4. Transmitters shall be suitably compensated against any thermal effects in the process medium.
5. Transmitters shall be able to withstand a minimum over pressure of 150 % of the rated pressure.

6. All the transmitters shall be weather-proof to IP-67.

7. Zero suppression & elevation features, built in surge protection and provision for selection of different damping levels shall be provided in each transmitter. Absolute pressure transmitters shall have provision for compensation of barometric pressure.

8. All transmitters shall have integral local linear digital indicators calibrated in engineering unit. DP transmitters for flow applications shall have built-in square root extractors. Local indications shall be adjusted / calibrated through hand held calibrator.

9. Power supply effect on transmitters shall be less than ± 0.05 % of calibrated span/10 V.

10. Pressure transmitters shall be supplied with 2-valve manifolds of AISI 316 material. Flow; DP and level transmitters shall be supplied with 3-valve manifolds of AISI 316 material having suitable pressure and temperature rating. Standard zero suppression / elevation facilities and output reversal facility shall be available for all transmitters. All the required accessories for mounting shall also be supplied with the transmitters.

11. One hand-held calibrator with required software, rechargeable battery and battery-charger shall be supplied for calibration checks of the transmitters.

04.08 Level Measurement

04.08.01 General

Selection of primary elements shall be based on the service conditions. A general guideline is given below. However, selection of particular type of sensor shall be decided on the basis of application requirement.

1. For Liquid Service
   i) Pressure / differential pressure type level transmitter with/without diaphragm seals
   ii) Float or Displacer type level transmitters
   iii) Ultrasonic type
   iv) Radar type
   v) Vibrating fork type
   vi) Gauge glasses
vii) Magnetic level gauges
viii) Capacitance type
ix) Conductivity type
x) RF Type
xi) Time domain reflectometry type

2. For Solid Service
   i) Ultrasonic
   ii) Nucleonic
   iii) Load Cell (weighing) system
   iv) Electromechanical servo gauges
   v) Tilt switches
   vi) Capacitance switches
   vii) Vibration rod
   viii) RF Type
   ix) Time domain reflectometry type

3. For sumps
   i) Conductivity switches
   ii) Capacitance switches
   iii) Bubbler Tube System

4. Tank gauging
   i) Servo gauges
   ii) Radar

5. Level instruments shall have weatherproof, dust and corrosion resistant enclosures of minimum IP-65 grade.
6. Additionally, explosion-proof enclosures shall be provided for hazardous area applications.
7. In Tank Gauging applications, communication port shall be provided in level instruments, for connectivity to a computer.

04.08.02 Gauge Glasses

1. All gauge glasses shall normally be steel armoured reflex or transparent type. Magnetic level gauges may also be used when liquid temperature permits and liquid specific gravity is greater than 0.9.
2. Reflex gauges shall be used on clean, clear, non-corrosive liquids.
3. Transparent gauges shall be used for the following applications:
i) Interface service
ii) When the process is dirty or viscous
iii) For corrosive medium, (such as caustic, hydrofluoric acid and steam applications above 250 PSIG), transparent gauge glasses shall be used with internal mica or plastic shield to prevent chemical attack or discoloration of the glass.

4. If the process is a solvent that can dissolve the internal coating of the chamber of the reflex gauge, thereby reducing the effectiveness of the prisms, reflex gauges shall not be used.

5. Reflex gauge glasses shall not be shielded

6. Transparent level gauges, in general, shall be equipped with minimum 40 W illumination and switch (ex-proof for hazardous area).

7. For high temperature applications, level gauges with flexible end tube coupling or expansion loops (top/bottom) shall be used to take care of high temperature expansion.

8. Large chamber type gauge glasses shall be used for boiling / evaporating and heavy viscous liquids.

9. Gauge glass material shall be toughened borosilicate glass having adequate resistance to thermal and mechanical shock.

10. Gauge glass body and cover shall be made of carbon steel with rustproof finish, unless otherwise specified.

11. Gauges shall be provided with safety ball check offset type gauge cocks, vent and drain connection (with 1/2” vent & drain valves), nipples, caps etc.

12. Gauge glasses shall be provided with top and bottom or side connections. Where side connections are specified, the gauge glasses shall have two connections at each end, 180° apart, with one connection at each end plugged.

13. Unless otherwise specified, gauge cocks shall be of the quick-closing type with bolted bonnet, outside screw and renewable seats.

04.08.03 Displacer Type & DP Type

1. External displacer type instruments with rotatable head shall usually be used for level measurement upto 1200 mm (48”), wherever process permits.
2. Displacers shall be made of AISI 316 with Inconel torque tube, unless otherwise specified or unless the process calls for any special material.

3. Side-side flange connection shall normally be used. Heat insulator / finned extension shall be used for temperatures above 230°C.

4. All such instruments shall have drain valves and vent plugs.

5. Stilling wells shall be provided for internal displacer type level instruments.

6. Differential pressure transmitter shall be used for level measurement in boiler drums and in other cases, where displacer type instruments are not suitable (e.g. level measurement beyond 1200 mm, applications requiring purge or where liquid might boil in external portion).

04.08.04 **Vibration Fork**

Vibration fork type level switches shall generally be used instead of float type level switches. Further, external cage type construction shall generally be used. Process connection to the cage shall be 1” socket weld type, unless otherwise specified.

04.08.05 **Ultrasonic**

1. Ultrasonic type level transmitters shall be microprocessor based and shall use digital signal processing technique for signal conditioning. Possible to calibrate through universal HART calibrator.

2. Suitable protection box for mounting ultrasonic type level transmitters shall be provided for mechanical protection & dust. Swiveling arrangement shall be provided for proper aiming/ focusing of ultrasonic type level transmitters.

3. The transmitter shall have facilities for storing the echo profile, manipulation of the echo profile to remove noise, multiple profile-averaging etc.

4. The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signal due to heavy dust or fill-stream interference.

5. In very dusty applications or in silo / bunker, etc. filling applications, high power and long range (i.e., low frequency) transducer shall be used to overcome the detrimental effect of the dust. This type of instrument shall not be used for level measurement in process medium consisting of particles of sizes (- 6 mm diameter).
6. The sensor shall have inbuilt temperature sensor for ambient temperature compensation.

7. Chemical compatibility of the sensor material with the process material shall be ensured, to avoid corrosion.

8. In applications, where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e. repetitive, pulsating displacement at its face shall be used to remove the material build-up).

9. Ultrasonic transmitters shall be supplied along with necessary calibration & noise suppression software, HART to RS 232C modem, plug connector, cable, etc. for connection to a desktop PC/ Laptop.

**04.08.06 Nucleonic Type**

1. Nucleonic sources shall have adequate shielding to limit radiation level at any point on the surface to below 6 milli-Roentgen per hour. At the same time, nucleonic type measurement systems shall not be excessively bulky or heavy.

2. Nucleonic sources shall have facilities for complete shielding during shipping, storage and transportation (in the form of rotary shutter, etc.).

3. The supplier shall furnish necessary certification of nucleonic type instruments from statutory bodies, as applicable.

**04.08.07 Capacitance & Conductivity Type**

1. Capacitance / conductivity type probes shall be as follows:
   
   i) Rod type : for length upto 2000mm.
   ii) Rope type with gravity weight : for length exceeding 2000 mm.

2. For level measurement in non-conducting tanks or sumps or when the tank profile is non-linear, capacitance type instruments shall be provided with a reference electrode / ground probe.

3. Capacitance type level probes may be used for both switching as well as for continuous level measurement in liquids.

4. Capacitance type level probe shall not be used for level measurement in solids when there is likelihood of material build-up on the probe. Capacitance type level probe shall not be used in liquid service where there is a chance of dielectric value change (due to oil spillage etc.).
04.08.08 Radar Type

1. Radar type level instrument shall be used when the physical properties of the medium between the sensor and the measured interface may vary.

2. The Radar type level instrument shall be microprocessor based and shall use digital signal processing techniques for signal conditioning. Possible to calibrate through universal HART calibrator.

3. Level instruments mounted in fixed roof type tanks shall have no stilling wells.

4. Suitable antennae shall be considered by supplier.

5. Wetted part materials of the sensor shall be chemically compatible with the process media to avoid corrosion.

6. Necessary software, cables, connectors, HART to 232C converters etc. For calibration, noise suppression, etc. of Radar type level transmitters through windows based desktop PC / Laptop shall be supplied.

7. Suitable protection box for mounting radar type level transmitters shall be provided for mechanical protection & dust. Swivelinng arrangement shall be provided for proper aiming / focussing of radar type level transmitters.

04.08.09 Time Domain Reflectometry Type (TDR)

1. TDR type level measuring system shall be mainly used.

   i) For level measurement of Liquids, interface in immiscible fluids, granules & fine powders
   ii) For medium having dielectric within 1.8 to 100.

2. Co-axial type, twin rods, twin cables, single cable / rod type probes shall be selected depending on tank height, properties of medium/media & application.

3. For interface level measurement top layer shall be of lower dielectric and minimum difference of dielectric between top & bottom layer shall be as per manufacturer’s recommendation

4. For adhesive/sticky in nature materials, coated probes as per manufacturer’s recommendation shall be used.
04.08.10 **Radio Frequency (RF) Type**

1. Radio frequency (RF) continuous/ point level measuring system, based on capacitance or admittance shall be used for level measurement of liquids, slurries, granulars, and liquid-liquid interface.

2. RF transmitter shall be
   i) Smart type
   ii) Self-calibrating type i.e. as the level rises in the vessel, the span is set automatically and electronically by the smart transmitter.

3. For high temperature application, remote mounted transmitters shall be used.

4. RF type shall also be used for detection of absence or presence of liquids, slurries, interfaces and granulars.

5. One hand-held calibrator with rechargeable battery and battery-charger shall be supplied.

6. It shall be possible to calibrate RF transmitters using calculated or known levels of capacitance directly entered by the hand held calibrator.

04.08.11 **Others**

Tilt Type, paddle type, bubbler type, electromechanical type, etc. level instruments may also be used, depending on application specific requirement.

04.09 **Gas Analysis System**

1. The gas analysis system shall be complete with the following units:
   i) Gas sampling probe, complete with filters, isolation valves, ring heaters, insulator jackets etc, as required. Dual probes shall be used, wherever required as per process criticality.
   ii) Gas preparation & conditioning system including sample conditioning, pumping, cooling, cleaning, drying etc. as applicable along with filter panels, scavenging panels complete with valves, tubing, fittings, accessories etc, as required.
   iii) Gas analyzer panel with analyzer instruments, monitoring devices viz, flow, pressure, temperature etc, tubing, fittings, accessories, as required.
iv) UPS & non-UPS type electrical power supply for the complete gas analysis system, complete with isolation transformer, Circuit breakers, MCBs, relays, 24 V DC regulated power supply units, earthing system etc, as required for efficient performance of the analyzer system.

v) Calibration equipment with calibration gas cylinders. Facility for both automatic & manual mode of calibration shall be provided. Cross sensitivity correction shall be provided wherever applicable.

2. Suitable display unit with key-board/ switches shall be provided on the analyzer panel front for monitoring & display of different parameters, status of analyser & sample conditioning equipment etc.

3. Condensation monitors, complete sampling system shall be designed & supplied by the analyser manufacturers only. All components & fittings of the analyser & sample conditioning system shall be of reputed make, preferably imported.

4. Before the filter unit, SS isolation valves shall be provided for each probe to facilitate online changing of the filter unit. Sample gas coolers shall be provided with redundant sample gas path & peristaltic pumps.

5. Sampling of dusty, hot, dry, cold or wet gases shall be done using dual probes with automatic switchover and with intermittent purging facility.

6. Analyser shall be microprocessor-based and the analyser PLC shall do all related sequencing & logic functions. Analyser PLC shall preferably have the same series & model no. as envisaged for the main unit / plant to ensure reliable & trouble-free communication.

7. System & application software for configuring and diagnostics of the analyser PLC shall be provided.

8. Response time of the Analyser system shall be designed to comply with process requirements.

9. Unless otherwise specified, accuracy of analyzers shall be within ±1% of span. Repeatability of analyzers shall be within ±1%.

10. Where there is a possibility of choking of analyser inlet filters, automatic inert gas purging facility initiated by the analyser PLC shall be provided.

11. All solenoid valves used in gas analysis system shall have manual override.
12. Separate analyser room shall be provided in the vicinity of gas sampling points. However, storage of calibration gas cylinders shall be arranged outside the analyser room. Room CO monitoring unit shall be provided in the analyser rooms.

13. Analyzers in explosion hazardous area shall be installed in ex-proof shelters.

14. Exhaust tubing shall be provided for the sample gas after analysis and will be either vented into atmosphere at safe elevation/distance, or fed back into the process stream. Gases containing hydrogen shall have separate outlets.

15. Analysis system of Hydrogen & other explosive gases shall bear the approval of statutory body.

16. Wherever analysis of harmful gases has to be done, unmanned gas analyser room with proper air conditioning facility shall be planned. At least one inert gas and/or steam purging point with flexible hose connection and isolation valve shall be provided at the entry point of this room.

17. In analysis of explosive gases (or gases forming an explosive mixture), approval of design and installation of analyser system shall be obtained from competent authority.

18. Poisonous and explosive gas detection systems shall have safety-limit alarm annunciation. Safety limits of different gases shall be as per OSHA norms.

19. Normally, the following types of gas detectors/sensors shall be used. However, type of sensor shall be selected, depending on the application:

   i) Electro-chemical cell
   ii) Semiconductor/solid state cells
   iii) Thermal conductivity
   iv) Paramagnetic
   v) Catalytic
   vi) Non-dispersive Infra-red radiation type

20. **Liquid Analysis System:**

   i) Analysis of pH or Oxidation–Reduction Potential (ORP) of industrial liquids shall be done using a measuring electrode and reference calomel electrode sensing system. The type of electrodes shall be selected based on the electrochemical and physical properties of the liquid.
ii) Material of construction of conductivity analysis cell shall be based on the chemical corrosion activity and physical properties of the process medium. The type of electrodes shall be selected based on the electrochemical and physical properties of the liquid.

iii) Buffer solution shall be provided along with the analyser for calibration purpose.

04.10 Control Valves

1. Control valves shall be provided with by-pass valves, except where the valves are used in split-range service.

2. Control valve characteristics shall be chosen in accordance with process requirement.

3. Control valves shall be sized in accordance with ISA-S75-01.

4. Valve sizing software, wherever used, shall be submitted alongwith sizing calculation.

5. Control valves shall be sized so that at minimum and maximum flow, the valve lift is always between 10% to 90% for equal% and 20% to 80% for linear characteristics.

6. All control valves shall be provided with hand wheel.

7. Wherever required (such as, in high temperature applications) or wherever specified, hard-faced or stellitied valve trims shall be provided.

8. In extreme temperature applications, seal-welding of threaded seat-rings, etc. shall be done.

9. In very low temperature applications, valve trim materials shall be chosen to have adequate cold impact strength.

10. ‘Trim’ of a control valve shall include those parts of body assembly (excluding body, bonnet and bottom flange), which are exposed to and in contact with, the process medium. These parts shall consist of but not be limited to the seat ring, valve plug, plug stem, plug guide bushing and cage.

11. Valve guide bushing shall be of sufficiently hard material to resist side-thrust on the valve plug.

12. For temperature applications below 200°C, ‘Teflon’ valve packing shall be used.
13. For temperature applications exceeding 200°C, ‘grafoil’ packing shall be used.

14. Steam / electrical tracing shall be provided to control valves, wherever process demands.

15. Control valves in steam service shall be provided with IBR certification.

16. Valve body size shall be minimum 25mm. However, reduced trim may be provided with 25mm valve body, if the process demands.

17. Globe type control valves shall be in general be used in throttling applications.
   i) Valves of 1” to 4” size shall be single-seated type.
   ii) Valves above 6” size shall be single-seated cage type.

18. Extension-bonnets shall be provided in control valves for services above 200°C or below (-) 30°C, or as recommended by the manufacturer.

19. Other types of valves (e.g. butterfly, eccentric-disk, ball, V-notch ball type, etc.) shall be used only when operating conditions do not allow globe type valves.

20. For high viscous liquids, V-notch ball valves shall be used.

21. Single-seated globe and angle type valves shall have heavy top guiding.

22. Double-seated valves, wherever used, shall be cage-guided type with pressure balance.

23. Large size piston-operated and diaphragm-actuated type control valves or dampers shall be provided with positioners. Such valves or dampers shall have signal bypass facilities for manual local operation.

24. Butterfly type control valves shall be designed for maximum opening angle of 60°C. The maximum permissible opening for eccentric disk type control valves shall be 90°C.

25. Noise generated from operation of control valves shall be limited to OSHA specified levels.

26. However, the maximum allowable noise is 85 dBA SPL. In case, the predicted noise level during calculation exceeds 85 dBA, the control valve shall be treated for noise. Only source treatment of noise shall be resorted to.
27. Control valve leakage class (in accordance with ANSI FC 70.2 / API) shall be selected as per process requirement.

28. Valve stem-position indicator shall be provided for all the control valves.

29. All diaphragm-type control valves shall have hysteresis (without positioner) less than 2% of spring range.

30. Fire-safe valves, wherever required, shall be as per API 607 and design shall be as per API-6D

31. Control valve accessories, such as solenoid valves, positioners, limit-switches, air-filter regulators etc., shall be firmly mounted on the valve body or yoke and shall be properly tubed using PVC-jacketed copper tube.

32. Solenoid valves installed in the control air supply line shall be of Universal type having minimum class ‘F’ insulation and shall be continuously rated direct-acting type. Solenoid valves shall be full-bore type with minimum bore size 3 mm.

04.10.01 Actuators

1. Actuators shall be sized for shut-off differential pressure.
2. Actuators shall be pneumatically operated, unless otherwise specified.

a) Pneumatic Actuators:

1. For spring-opposed diaphragm type actuators, the spring shall be corrosion-resistant and cadmium or nickel-plated.

2. Actuator operating range shall be 0.2 to 1.0 kg/cm$^2$.

3. Valve positioners or boosters may be considered for actuators for the following applications:
   
   i) To split the controller output to more than one valve.
   ii) To amplify the controller output beyond the standard signal range (i.e., 0.2-1kg/cm$^2$), in case of actuators with greater thrust or stiffness.
   iii) To achieve minimum overshoot and fast recovery in control action, as in the case when long control air lines have to be used.

4. In all the above applications, whether or not a positioner or booster is to be used, shall depend on the speed of response of the system.
5. Wherever required, boosters shall be used for systems with a fast response (e.g., pressure and flow control loops etc.) and positioners shall be used for relatively slower control loops (e.g., temperature and level loops etc.).

6. Actuator casing and diaphragm shall be designed to withstand atleast twice the maximum pneumatic operating pressure of the control valve.

b) Electrical Actuators:

1. The actuator shall have electric motor and gear box assembly for having low speed and high torque output.

2. The motor of electrical valve actuator shall be intermittent duty, high torque and high slip motor.

3. Gear mechanism shall be self-locking type.

4. The standard fitment of electrical actuator shall include as minimum:
   i) Torque and end limit switches (2 NO + 2 NC for each limit switch.)
   ii) Intermediate limit switches as specified. (2 NO + 2 NC for each limit switch.)
   iii) Continuous remote position transmitter.
   iv) End travel indicator
   v) Overload protector by a thermostat embedded in the motor winding

5. Power supply to actuator shall be through fast acting fuse switch unit or fast acting circuit breaker.

6. Local control box with open/close, emergency stop pushbutton, local/remote selector switch and open close indication shall be provided.

7. Power supply shall be 240 V, 50 Hz, single phase or 415 V, 50 Hz, 3 phase, 4 wire.

8. Insulation class of motor shall be selected as per NEMA standard depending on ambient operating temperature

9. Separate cable entry & gland shall be provided for power supply, control signals and position transmitter.

10. In explosion hazardous area use of electrical actuator shall be avoided. However, in case, electrical actuator has to be selected, shall be ex-proof type.
11. Regulating duty motors shall be generally selected as per following guidelines:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Ambient. temp. in °C</th>
<th>Duty cycle of motor, in %</th>
<th>Starts per hour</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-30 to 40</td>
<td>100</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>40 to 60</td>
<td>100</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>60 to 70</td>
<td>100</td>
<td>516</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-30 to 40</td>
<td>50</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>40 to 60</td>
<td>50</td>
<td>315</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>60 to 70</td>
<td>50</td>
<td>258</td>
<td></td>
</tr>
</tbody>
</table>

For example, if 100% duty cycle motor is selected for 1200 start/hour use between ambient temp. range of (-) 30 to 40 °C, then the same motor can be used for 630 starts/hr only, if ambient temperature range is increased to 40-60 °C. Similarly, if 50 % duty cycle motor is selected then the start / hr of 1200 will be reduced to 600.

04.10.02 Positioners

1. Valve positioners, wherever required, shall be side-mounted on the control valves and shall be direct-acting type, unless otherwise indicated.

2. Wherever the operating range of the actuator is the same as that of the control signal, the positioner shall be provided with an integral bypass switch.

3. All valve positioners shall have integral pressure gauges to indicate input supply, control signal and positioner output pressures.

4. All pneumatic connection points shall be of ¼” NPT(F), in accordance with ANSI B 20.1. In case they are different, suitable adapters shall be provided.

5. Positioners shall have corrosion-resistant linkages and rugged brackets.

6. Control valves positioners shall have repeatability within 0.5% of stroke, for a given input signal.

7. Valve positioners shall be SMART type with HART protocol.

04.10.03 Limit Switches

1. Limit switches, wherever specified, shall be suitable for mounting on the valve and shall be supplied along with all mounting accessories.

2. Limit switch enclosures shall be weatherproof to NEMA 4, or suitable for the specified hazardous area classification.
3. Limit switches shall be SPDT type, silver-alloy-plated, hermetically sealed and rated for minimum 240 VAC, 2A.

4. Flying leads are not acceptable. Terminal blocks of limit switches shall be located inside the switch housing.

04.11 **Cv Analyser**

1. The Calorific value analyser system shall be complete with the following units, as applicable:
   i) Tar separator
   ii) Sampling gas pump.
   iii) Silica gel container
   iv) Gas preparation (cleaning, cooling, drying etc.) unit consisting of: Water pot with drain valves, Ball valves, Water separator with automatic drain facility, Chemical Filter, Mechanical Filter, Aerosol Filter, Pressure reducer etc.
   v) Steam purging facility
   vi) Analyser calibration equipment with calibration gas cylinders.
   vii) Automatic calibration and correction unit (wherever necessary)
   viii) Cooling air fan, Ceramic Burner, Safety pilots for burner, Thermopile, Pressure governor.
   ix) Mimic panel with LED indication (if required).
   x) All necessary internal monitoring devices (for flow, pressure, temperature etc.)
   xi) The sampling system shall be suitably designed considering gas composition and its impurities.
   xii) Analyser shall be microprocessor based.
   xiii) Manufacturer’s software for configuring and diagnostics of the analyser shall be provided and loaded in the system for ease of maintenance.
   xiv) Analyser system shall be designed to have dead time less than 15 seconds for the entire system and maximum possible accuracy.
   xv) Unless otherwise specified, accuracy of analysers shall be within ± 1% of span. Repeatability of the analysers shall be within ± 1%.
   xvi) Wherever, there is a possibility of choking of analyser, inlet filters, purging facility etc. shall be provided.
   xvii) All solenoid valves, if used in analysis system, shall have manual override.
   xviii) Separate analyser room shall be provided in the vicinity of the gas sampling points. However, storage of calibration gas cylinders shall be arranged outside the analyser room. Exhaust facility shall be provided in the analyser room. Tenderer shall indicate whether air conditioning facility is required for Cv analyser.
   xix) Analysers in explosion hazardous area shall be installed in ex-proof enclosures.
xx) Suitable exhaust tubing shall be provided for the fluid under analysis, taking care of all safety means.
xxi) In analyses of explosive gases (or gases forming an explosive mixture), approval of design and pipe routing of the sampling system shall be obtained from the competent authority (viz, the Chief Controllers of Explosives, Nagpur).
xxii) Zero & span gas cylinders shall be provided as per the requirement.
xxiii) Analyser panel shall have suitable digital display facilities in engineering units.

04.12 Flame Detector

1. UV type flame failure detector, suitable for the intended application shall be offered. Swiveling arrangement shall be provided for proper focussing of the flame detector.
2. The detector shall have self diagnostic facility.
3. For alarm output, potential-free contact (1 NO + 1 NC) shall be provided.
4. Suitable panel for housing the complete electronic system at field shall be supplied.

04.13 Control Panels/Cabinets

1. Panels shall be totally enclosed; flush-front, freestanding upright floor mounted type with welded construction. Panels shall be mounted on box-type base-frame.
2. Panels shall be made of cold rolled cold annealed (CRCA) sheet steel with thickness as follows:-
   
   Front face, gland plate, equipment mounting plate and other load-bearing sections : 3mm
   Door, top, bottom and side faces : 2mm

3. Sizes of panels and cabinets, as approved by purchaser / consultant, shall only be supplied.
4. Height and colour of new panels, to be installed in any existing room, shall match with existing panels. Otherwise, panel height shall be 2250 mm. with an additional 100x50x6 mm base channel and 15 mm thick anti-vibration pad on top. The panel / cabinet shall have minimum depth of 600 mm.
5. If the width of a panel exceeds 600 mm, double-door type construction shall be provided. Otherwise, panels will have a single door.
6. Panel doors shall have flush-type and lockable door-handles.

7. Panel doors shall have mesh-covered louvers at top & bottom, for air circulation. Additionally, wherever necessary, push-pull type circulating fans shall be provided for cooling of equipment inside.

8. In general, mounting height of instruments in the panel shall be as follows:
   i) Miniature instruments (bottom levels matched):
      • Bottom row - 1000 mm
      • Middle row - 1350 mm
      • Top row - 1600 mm.
   
   ii) Annunciator : 1900 to 1950 mm (bottom levels matched):
   
   iii) Push buttons : 800 mm center line (excluding base channel)
   
   iv) Hooter (for alarm) : Outside cabinet - preferably at panel top.

   Panel-mounted instruments conforming to DIN size and mounted in the same row shall have their bottom levels matching.

9. All equipment inside the panel shall be located in such a manner that their terminals and adjustments are readily accessible. Panels shall be dust and vermin proof. Panels installed in control rooms shall be weatherproof having minimum IP42 degree of protection. Suitable gaskets shall be provided, for this purpose.

10. Panel / cabinets located in the field shall have minimum IP-54 degree of protection. Pressurised local cabinets shall be installed in dusty areas. Pressurisation shall be achieved inside the cabinet by introducing clean (i.e., dust-free) air.

11. A space of at least 1.5m shall be provided in front and behind panels / cabinets for ease of operation and maintenance.

12. If the length of a panel exceeds 5m, approach from both sides shall be provided.

13. No process fluid other than air shall be piped to the panel / cabinet.

14. Panels / cabinets / desks etc. shall be supplied in finish-painted, completely wired and tested condition.
15. Panels shall first be chemically de-greased, de-rusted and phosphated. Then, 2 coats of red-oxide shall be applied. Finally, 2 coats of synthetic enameled paint or epoxy-based paint shall be applied to have a non-glossy high class finish with aesthetically pleasing appearance and long life.

16. Colour shade of panels shall conform to RAL 7032. Outside shade of panels shall generally be RAL 7032, unless otherwise specified. The inside of panels shall be of brilliant-white. Panel base channel shall be painted black.

17. However, the supplier shall ensure uniformity of colour and height of all the panels as per customer’s choice, wherever instrument panels are installed along with electrical or other panels in the same room, or also as per existing plant standard, wherever applicable.

18. Panels shall have lifting hooks or eyebolts on the top at the four corners, for ease of transportation.

19. Instrument power supply shall be through a 1:1 isolation transformer to be installed in the instrument panel.

20. The inside of panels / cabinets / local panels shall be illuminated, preferably using incandescent type lamp. The illumination lamp shall be switched on/off using either a door switch or a toggle switch.

21. An inscription plate (with white letters on a black background) containing the tag no. etc. shall be provided for each instrument / device mounted on the panel. Separate nameplates shall be provided for rear-panel mounted instruments.

22. Anti-vibration mounting or shock absorber shall be provided for panel-mounted instruments in vibration-prone areas.

23. ISA symbols shall be used in Mimic panels. Graphic design, colours, materials, etc. used in mimics shall be in accordance with existing plant standard or as per Purchaser’s choice.
24. For panel wiring, following guidelines shall be followed:

**Signal wiring**

1.5mm² PVC insulated, stranded Cu-wire: gray colour

**Power supply wiring:**

For 240/110V, 50 Hz 2.5 mm² PVC insulated stranded Cu-wire, colour code:

- Live : red
- Neutral : black / blue
- Earth : green

For 24 V, DC 1.5 mm² PVC insulated stranded Cu-wire, colour code:

- Positive : brown
- Negative : black / blue

Earth 4.0 mm² PVC insulated stranded Cu-conductor,

- Colour code: green-yellow spiral black / blue

25. Screen wires of screened signal cables from the field shall be earthed at the electronic earth-pit of the control system, which shall be separate and independent with respect to the power supply earth grid.

26. The following points shall be taken care of while deciding the internal layout of instrument panels or cabinets:

1. Electrical voltage higher than 240 V AC/DC shall not be brought inside the instrument panel / cabinet.

2. All internal wiring shall be housed in covered, non-flammable plastic raceways.

3. Separate wiring raceways shall be used for power supply wiring, signal wiring and intrinsically safe circuits’ wiring.

4. Distance between the continuous edges of two adjacent terminal strips shall be minimum 100 mm.

5. Separate terminal strips shall be provided for 24 V DC, 240/110 VAC and intrinsically safe terminals.

6. Distance between cable gland plates & bottom of terminal strips shall be minimum 300 mm.
7. Terminal blocks shall be clip-on type of 'Elmex' or reputed equivalent make.

8. For signal wiring, 2.5mm$^2$ size terminals shall be used.

9. For power wiring, 4.0 mm$^2$ terminals shall be used.

10. A minimum of 20% spare terminals shall be provided, for power, signal and intrinsically safe circuits’ wiring.

11. Power supply terminals (e.g. 240VAC or 110VAC or 24VDC) shall be labeled.

12. In case a bus bar is used for power supply distribution, the bus-bar shall be shrouded with a transparent Bakelite plate.

27. Panels or cabinets shall be provided with the following items:

1. A telephone socket.

2. A power socket (of 240V AC, 15W rating) for soldering, etc.

3. A pair of earthing bolts on either side of the panel (at the bottom) for power earthing.

4. A copper bus-bar (of size 25x3mm.) mounted on an insulated base inside the panel with holes and nut-bolts - for instrument signal earthing (i.e., electronic earthing).

04.14 Electrical System

1. The instrumentation and control system including all field instruments and the process computer shall be provided with a power supply system with provision of continuous availability of power even in case of fault or failure of the local power supply source.

2. Instrument power supply shall be single phase 110/240 V A.C. All instrumentation equipment shall be suitable for power-supply fluctuation within 240V AC, +10%, -15% and 50Hz +3%, - 6%. OR 110V AC ± 10%, 50 Hz ± 3%.

3. Wherever, power supply through UPS is specified, shall be supplied through parallel redundant UPS with 30 minutes of battery back up.
4. 415 V, three phase power may be used to derive instrument power. However, the same shall not be brought inside the instrument panel.

5. A 1:1 isolation transformer shall be installed in the instrument panel or cabinet for isolation of input power supply. A master circuit breaker (with short-circuit protection and overload release facility) shall be installed in the instrument power supply line.

6. Terminals of 110V and above shall be labeled and isolated from terminals of lesser voltages.

7. All electrical systems and installations shall meet the statutory requirements of the Indian Electricity Act and rules & regulations of Central & State Government.

8. No instrument contact shall be used directly for alarm annunciation or interlocking. Contacts after multiplication through relays shall be used for alarms and interlocks.

9. Instrument power supply shall be through circuit breaker (with adjustable short circuit and overload release facility) and isolating transformer. Circuit breakers shall also be provided on the secondary side of the isolating transformer. All 4–wire instruments shall be provided with individual circuit breakers. All PLC loop powered instruments shall be provided with individual fuse in the terminal blocks of PLC.

10. Derivation of necessary voltage grade from the available power supply, as may be required for the offered system & distribution of power shall be carried out by the Tenderer.

11. Power supply equipment for instruments as may be required shall be installed inside the instrument panel.

12. All signal, control, compensating cables & power cables for instrumentation use shall be of armored type. The conductor shall be electrolytic grade tinned copper as per IS 8130 : 1984.

13. All cables shall be PVC insulated and PVC sheathed. Insulation material shall be PVC type C and sheath material shall be PVC type ST2 as per IS 5831 : 1984. Additionally, asbestos, silicone or sintered Teflon sheath shall be provided in high-temperature-prone locations.
14. Instrument power supply and control cables shall be made of multistranded copper conductor of 2.5 mm² of 1.1 KV grade and other details as per IS 1554, Part 1.

15. 500 V grade cables with multi-stranded, twisted pair copper conductor of minimum cross-sectional area of 1.5 mm² shall be used for signal cables. Cable pairs shall be individually and overall shielded.

16. Shield in screened cables shall have 25% overlap and 100% coverage. Shield shall be kept open at the instrument end and to be connected to the electronic earth pit at the control room end.

17. For shielded compensating cable the shield shall be earthed near the point of the circuit ground. For grounded junction thermocouples, this means at the thermocouple head. For ungrounded junction thermocouples this means at the control room end.

18. Incase compensating cables are to be laid on the top of the furnace/hot surface, this shall be asbestos covered with mesh shielding or other suitable insulating material. Mineral insulated cables shall also be used for such application.

19. The individual cores in multicore cables shall be PVC insulated & numbered and/or identified by a definite colour code.

20. All cables, from field JBs to panels/marshalling rack in the control room shall have at least 10% (minimum 1 no.) spare cores

04.15 Pneumatic System

1. Air supply to pneumatic instruments shall be dry and free from oil, dust and moisture as specified below. Air shall be supplied from oil free compressors. The air shall be filtered & dried in a drier and stored in storage vessel of suitable capacity to ensure at least 30 minutes of continuous operation. On the supply line to each shop, pressure gauge shall be provided before and after the pressure reducer. On air supply failure, audiovisual alarm shall be initiated.

2. Instrument quality air shall have following parameters:

   Dust particles size: Not more than 5 micron

   Oil not to exceed: 5 to 10 ppm

   Pressure Dew point: 10°C below the minimum temperature attained in any time of the year at site. However, dew point shall not exceed 4°C.
3. Nitrogen, if used as pneumatic power supply, standby facility complete with air drier, filter and regulator shall be provided.

4. Supply airline to individual instruments shall have air pressure reducers, filters and isolating valves separately for the instrument. These shall be installed as near to the instrument as possible.

5. Compressed air at a pressure of 6 to 8 kg/cm² shall be processed in the air drying and filtration plant to achieve the specified quality of instrument air which could then be supplied to individual or group of pneumatic instruments at a pressure of 5 kg / sq. cm after passing through air filter and regulator.

6. In case, centralized air drying and filtration plant is not provided, specially for small shop units, suitable air drier & filter regulator units with accessories shall be provided at each consumer point for achieving instrument quality air from compressed air.

7. Transmission of pneumatic signals shall be done by 6 mm or 8 mm (for longer distance) by seamless steel tube or properly protected copper tube or armored tube bundles.

8. Distribution of instrument air shall be through air main (bulkhead) with separate supply to each instrument through a valve.

04.16 **Control Room Design**

1. Control rooms shall be aesthetically and ergonomically designed as per modern features with adequate safety features.

2. Doors shall be provided with automatic door closer and double doors shall be provided in dusty atmosphere. Doors shall preferably open outside. Doors shall be made of glass in aluminum frame.

3. Windows shall be made of aluminum frames and the glass panes shall be long, preferably on sheet for each frame. Small glass panes shall not be used. Glass windows shall be about 1,000 mm in height and at 750 mm from floor level.

4. Control room shall have false ceiling, false floor and double wall. Fresh air entering the control room shall pass through chemical filters.

5. The control room shall be air-conditioned with the following parameters:

    Temperature : 21 – 24°C
Relative humidity : 50 to 60%
Dust content : 0.1 mg / m3
No. of air changes : 2 to 3
Positive pressure in the room : about 2 mm of WC

6. Walls shall be paneled with aluminum strips and painted with dust free, wear and fire resistant paints.

7. Floors shall be of linoleum / hard rubber fire-inhibited asbestos filled vinyl floor with antistatic properties.

8. Ample room shall be provided around the instrument panel / boards (minimum 1.5 to 2 m).

9. Control room illumination level shall be adjustable in the range of 250-550 lux and generally maintained at 500 lux. Illumination shall be done with shadow less and glare free concealed fittings.

10. Mounting frames/ inserts for panel mounting shall be provided.

11. Cable troughs or openings in the floor shall be provided to bring the cables to the panels. The opening shall be sealed after completion of erection.

12. Normally gas impulse lines shall not be permitted in the control room. If however, gas lines do enter the control room, proper ventilation shall be provided with more air changes to ensure safety.

04.17 Cable Laying

1. All cables shall be supplied & laid in accordance with the cable schedules and cable layout drawings. Before laying, cables shall be meggred and tested.

2. All armoured cables shall be laid on trays. Un-armoured cables shall be laid in suitable conduits.

3. All cables routes/lengths shall be carefully measured as per site conditions and cut to the required lengths to prevent undue wastage. While deciding cable lengths, adequate extra length of each cable shall be kept at the termination points at both ends.

4. Cable shall have complete uncut lengths from one termination to the other. Joints are not acceptable.
5. Power and signal cables shall be laid in separate trays. A gap of minimum 300 mm shall be maintained between power and signal cables wherever they are laid in parallel in the tray/ duct/ trench.

6. Crossing between signal cables and power cables shall be done perpendicularly.

7. Cables shall be terminated using cable glands. Cable glands and other openings in the junction boxes shall be properly sealed by means of sealing compound to make them thoroughly dust and moisture proof.

8. At junction box and sensor end, metallic (Aluminum) cable tags with cable no., J.B. no. and sensor tag no. shall be used. At control room end, metallic cable tag with cable no. and J.B. no. shall be used.

9. All cables shall be properly terminated using lugs, sleeves, ferrules, etc. for connection to terminal blocks.

10. All cores of electrical cables shall be identified by their wire numbers by means of the PVC ferrules following finalised philosophy. Ends of all PVC insulated unused cores shall be taped with PVC or rubber insulating tape. Use of cloth or other fabric type is not permitted.

11. Each underground cable (either in concrete trenches or buried) shall be provided with identifying tags of made of Aluminum, securely fastened every 30m of its underground length with at least one tag at each end before the cable leaves/enters the ground.

12. Directly buried cables shall be laid underground in excavated cable trench wherever specified in layout drawings. Trenches shall have sufficient depth and width to accommodate all cables correctly spaced. Before cables are placed, the trench bottom shall be filled with 100mm layer of sand and leveled. Each layer of cables shall be covered with 100mm of sand on top and sand shall be lightly pressed. A protective covering of 75mm thick second-class red bricks shall be placed flat on the final layer of sand and cable. The remaining portion of the trench shall be then back filled with soil compacted and leveled. On completion of every group of cable laying, insulation test shall be carried out for every cables. Any cable found to be defective shall be replaced before the next group of cables is laid. Flags/ signboard shall be provided, indicating number of cables, depth and direction, along the cable route, on crossovers/ turnings etc. to mark the cable route.
14. At each road crossings and other places, where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not get damaged by pipe ends after pack filling. After laying, the pipe sleeves shall be sealed using sealing compounds. Wherever the cable is going into coming out of ground duct/ conduits shall be extended in the ground.

15. After laying of all the cables, the cable entry to control room shall be suitably filled and sealed so as to achieve a positive seal against the entry of gas/ water.

16. When laid inside conduits, following guidelines shall generally be followed for selecting the conduit dia:

<table>
<thead>
<tr>
<th>No. of Cables</th>
<th>Conduit diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7 D</td>
</tr>
<tr>
<td>2</td>
<td>3.0 D</td>
</tr>
<tr>
<td>3</td>
<td>3.2 D</td>
</tr>
<tr>
<td>4</td>
<td>3.6 D</td>
</tr>
<tr>
<td>5</td>
<td>4.0 D</td>
</tr>
<tr>
<td>7</td>
<td>5.6 D</td>
</tr>
</tbody>
</table>

$D =$ Outer diameter of cable.

17. For cable sheaths and cores, internationally accepted colour coding shall be followed.

18. Cable trays shall be made up of hot dip galvanized steel plates of minimum thickness of 2 mm.

19. Separate cable trays shall be used for low and high voltage.

20. Each tray shall be provided with 20% spare space.

21. Cables shall be clamped at every 1.5 m distance in horizontal runs and at every 2 m distance in vertical runs, in trays.

22. Cables, which are not laid in the cable trays, shall be laid through protective conduits.

23. Sharp bends in cables shall be avoided. Wherever necessary, junction and pull boxes shall be used.

24. Conduits, junction boxes and pull boxes shall be properly grounded.

25. In hazardous locations, detachable steel plate covers on the tray shall protect the cable.
26. All the cores of the cables shall be marked with ferrules. Metal tags shall be provided at both the ends of the cable for identification.

27. Cables in hot areas shall have asbestos sheaths / covering or other heat protection. After completion of cable laying work, all cable bushings on panels, desks and cabinets shall be filled with sealing compound against the floor.

28. After erection, cables shall be tested for insulation. At least two cables in each sub unit shall be tested.

29. Cables will be identified by corrosion resistant tags.

30. Shield grounding shall be realised at one end of the cable only.

04.18 **Impulse Pipe Laying**

1. Impulse lines shall be kept as short as possible consistent with good practice and accessibility and shall follow installation/hook up drawings.

2. All welding shall be carried out as per welding procedures and codes with electrodes approved by client. Only qualified welders shall carry out welding.

3. For installation of impulse tubes with compression fittings, proper care shall be taken for handling, bending of the tubes and tightening of the fittings. Standard instruction of the manufacturer shall be followed strictly for the above cases.

4. Pipes/tubes shall be bent using pipe/tube benders only. Hot bending of impulse pipes/tubes is prohibited. Impulse line bending shall be circular and smooth. Flat bending shall be rejected. Pipes/ tubes shall be cut using pipe cutting device. Hot cutting will not be allowed.

5. All threaded joints shall be joined with Teflon tape and no other joining component shall be used except on high temperature service, where graphite sealing components shall be used. Pipe threading shall be made using suitable threading machine.

6. Impulse lines shall be properly supported and shall be clamped with the support. Impulse lines shall never be welded with the support, metal constructions and structure of building. Supports shall not generally be taken from process pipes, handrails etc. unless otherwise required.

7. Proper slope in impulse line (minimum 1:10) shall be maintained.
8. Impulse lines for explosive gases and air/inert gases shall not be laid together.

9. Impulse lines shall not be brought inside the control room.

10. Drainage pipes shall be connected to the plant drainage.

11. Impulse pipe sizes, type of fittings, flanges and number of pipes in multi-tubular bundle shall be standardized before engineering and shall be mutually agreed to.

12. Protection shall be provided where damage is likely to occur.

13. At the lowest points of air or gas impulse lines provision for drainage is to be provided.

14. In pipelines for liquids vent is to be provided at the highest points.

15. Horizontally laid steel pipes may be fixed at every 1.5 m and vertically laid ones at every 2.0 m.

16. Impulse pipelines and instruments used for oxygen service are to be degreased and cleaned with carbon tetrachloride.

17. The impulse lines for oxygen shall be clearly marked with colour code.

04.19 Earthing

1. All junction boxes, local cabinets, field mounted instruments (having 110 V AC & above power supply) shall be connected to the nearby earth bus bar through 6 mm² (min.) stranded copper conductor with green sleeve.

2. Earthing network shall be realized with earth electrodes and/or buried bare conductors.

3. Two types of earthing system shall be generally provided:
   i) Main earthing system (ME).
   ii) Electronic earthing system (EE).
   iii) The electronic earth system shall be separate and independent from main earthing system. Main earthing system will be arranged by client.
   iv) The earth electrode(s) for EE shall be of the same type as those for the ME, but, in addition shall be placed in a galvanized steel pipe for a depth of minimum 4m to shield the electrode from surface earth stray currents, which may cause unwanted interference.
4. In general, the earth conductor between EE busbar of cabinets/ marshalling rack up to the earth pit shall be 16 mm² insulated copper conductor.

5. The following shall be applicable for earthing:

- The metallic housing of electronic equipment/junction box/panel shall be connected to the main earthing system.
- The active electronic parts of electronic equipment shall be connected to the electronic earth (EE).
- The shield of the shielded cable shall be earthed to electronic earth at one end only i.e. at control room end.

6. For shielded compensating cable the shield shall be earthed near the point of the circuit ground. For grounded junction thermocouples, this means at the thermocouple head. For ungrounded junction thermocouples this means at the control room end.

04.20 Guidelines for selection of erection materials:

04.20.01 Instrument Fittings:

Carbon steel Fittings

1. Fittings shall be as per ANSI B16.11.
2. Fittings shall be socket-weld type forged pipe fittings of material cadmium plated ASTM A105. The minimum rating shall be class 3000.

SS Tube Compression Fittings

1. Fittings shall be as per ISA RP 42.1.
2. Fittings shall be flare less compression type and of three piece construction with ferrule, nut and body suitable for use on SS tube conforming to ASTM A269 TP316, hardness not exceeding RB 80.
3. Hardness of ferrules shall be in the range of RB 85-90 so as to ensure minimum hardness difference of 5 to 10 between tube & fittings for better sealing.
4. Threaded ends of fittings shall be NPT as per ANSI B1.20.1.
04.20.02 **Instrument Valves**

1. The impulse line isolation and drain valves shall be forged gate/ ball/ globe valves with inside screwed bonnets. CS/ SS valve material shall be used depending on requirement and as indicated in the enclosed installation diagrams.
2. For SS valves, body and trim material shall be ASTM A182 Gr. F316. For CS valves body material shall be ASTM A105 Gr.II and trim material shall be ASTM A182 Gr. F316.
3. For screwed valves packing material shall be teflon only. However, for socket-weld valves packing material shall be grafoil only.
4. Valve hand-wheel material shall be cadmium or nickel plated steel.
5. Minimum valve rating shall be 800 class.

04.20.03 **Impulse Pipes & Tubes**

1. Impulse pipe shall be either sch.40/80 seamless carbon steel pipes (depending on pressure rating) as per ASTM A106 Gr.B with threaded/ socket weld fittings or shall be fully annealed, seamless and cold drawn 316SS tube as per ASTM A269 with compression fittings as per guidelines indicated in typical Installation drawings enclosed with this specification
2. Tube wall thickness shall be 0.065” unless otherwise specified.

04.20.04 **Cable Trays and Conduits**

1. Perforated cable trays with sheet thickness of min. 2 mm shall be used for laying of cables.
2. The width of cable trays shall be so selected that 20% of tray space is available for future use of the complete installation.
3. Conduits used for cable laying shall be as per IS-1239 class medium & galvanized.

04.20.05 **Transmitter Cabinets/Enclosures/ Canopies**

1. Transmitter cabinets/ enclosures/ canopies shall be made of 2 mm thick MS sheet.
2. All cabinets shall be provided with external earthing lugs.
3. Sizes of cabinets/ enclosures/ canopies, as approved by purchaser / consultant, shall only be supplied and outside colour of panel shall be as per RAL 7032 and inside white.
4. Enclosure/ canopies shall be suitable to protect the instrument from direct exposure to sun, rain water & dust.
5. Cabinets shall be provided with lockable door-handles.
6. All equipment inside the cabinet shall be located in such a manner that their terminals and adjustments are readily accessible.
7. Cabinets shall be dust and vermin proof. Suitable gaskets shall be provided.
8. Pressurised local cabinets shall be installed in dusty areas. Pressurisation shall be achieved inside the cabinet by introducing clean (i.e., dust-free) air.
9. Cabinets shall be supplied in finish-painted, as per standard practice, completely wired and tested condition.
10. Cabinets shall have lifting hooks on the top at the four corners, for ease of transportation.
11. An inscription plate (with white letters on a black background) containing the tag no. & application shall be provided below each instrument.

04.21 Installation of Instruments

1. For installation of instruments and primary sensors, standards practice of instrumentation according to the international standard shall be followed.
2. For installation of any kind of special type of instrument/ sensor manufacturer’s recommendation for installation shall be followed.
3. Plugging of extra holes in JBs, panels, cabinets, etc., plugging of extra holes for conduits, filling up the conduits & conduit opening with water proof sealing compound shall be done after completion of erection.

04.22 Calibration

1. All instruments shall be calibrated as per manufacturer’s instructions prior to installation.
2. During the loop checking and commissioning, if required, to obtain the satisfactory performance of the instrument, the same shall be recalibrated as and when required.
3. All instruments shall be calibrated at 0%, 25%, 50%, 75% & 100% of the measured range for both increasing and decreasing values. Discrete instruments, switching devices shall be functionally checked for general performance and specially for assigned set points.
4. Hand-held calibrator shall also be used for calibration checks of transmitters.
5. All calibration reading shall be recorded in proper format and submitted.

04.23 Testing

1. All cables shall be tested for insulation with 1000V/ 500V megger before termination at panel & field. Insulation shall be checked from conductor to ground and between conductors in a cable. All conductors shall also be tested for continuity.
2. All impulse piping shall be tested hydrostatically/ pneumatically to 1.5 times the operating pressure after isolating the instruments. Lines shall be blown after hydro-testing.
3. Instrument air headers (N2) & air supply lines shall be cleaned and tested for leaks at a pressure 6-8 bar, before they are placed in service.

4. For all measurement & control circuits, loop testing shall be properly carried out. For overall integrated loop testing involving Automation System, Tenderer shall work in close co-ordination with the system supplier.

5. All results of site inspection, instrument site calibration, impulse pipe leak test, panel site test report and loop test results shall be recorded in the approved format. These results shall form part of the completion documents. Any work not conforming to the execution drawings, specifications or codes shall be rejected and the Tenderer shall carry out the rectification at his own cost.

6. Magnetic flow meters & Vortex flowmeters shall be tested by injecting frequency signal. Temperature transmitters shall be tested by simulating millivolt signals.

7. All the equipment required for erection shall be brought by Tenderer to site, on returnable basis.

8. All the required testing & calibration equipment shall be brought by Tenderer to site, on returnable basis, for testing & calibration work at site.

9. Quantity of all these items shall be as per actual requirement at site, to meet the erection schedule. All test & calibrating equipment shall be approved by NPL/IDEM/ ERTL authorities.

10. Loop test shall be performed after calibration of all instruments and leak test of instrument impulse lines. It shall be carried out to check the functional performance of all elements comprising the loop thereby ensuring proper connection of the following:

   i) All elements are properly installed, calibrated and function properly.

   ii) All scales are introduced with proper ranges in PLC.

   iii) All alarm units and shut down devices are set properly and accomplish their intended purpose.

   iv) Controller settings for various modes of operation in PLC (proportional band, reset and rate action) are at nominal values.

   v) The action (direct or reverse) of the controller is set as prescribed.

   vi) DP transmitter with PLC in the control room shall be loop tested by applying impulse signal to the transmitter by means of a squeeze bulb and a U-tube manometer at the field and performance of the receiver instruments in the control room checked at 0%, 25%, 50%, 75% and 100% FS inputs.
vii) Pressure transmitter with PLC in the control room shall be loop tested using a dead weight tester and a standard gauge with accuracy better than + 0.1% at field and performance of receiver instrument at control room checked at 0%, 25%, 50%, 75% and 100% FS inputs.

viii) For temperature loops with resistance thermometers in field and PLC control room, known resistance shall be injected at signal cable near the resistance thermometer in the field through decide resistance box and PLC display instruments shall be checked for input signals of 0%, 25%, 50%, 75% and 100% FS.

ix) For temperature loops with thermocouple in field and PLC display in control room, a known milli-volt signal shall be injected at the compensating cable end in the field from milli-volt simulator and PLC display shall be checked for input signals of 0%, 25%, 50%, 75% and 100% FS.

x) In case of control loops, the set point of PID controllers shall be adjusted manually from HMI for output of 0%, 25%, 50%, 75% and 100% FS and control valves shall be checked for rate strokes.

xi) Alarm system shall be checked by simulating abnormal conditions in the field mounted differential pressure switches by shorting the wires at terminals and the function of the alarm system.

04.24 **Commissioning**

1. This activity shall be planned in consultation with & as per the directives of Client/ Consultant.

2. Before commissioning, loop checking for all the measurement & control loops shall be completed and results shall be recorded in approved formats.

3. Initially, the instrumentation equipment & systems shall be checked & tested to establish their specified performance and to ensure readiness for integrated testing with the automation system and commissioning of the plant. All these results shall be properly documented for records.

4. Subsequently, when the plant units are to be commissioned, Tenderer shall actively participate in these activities by providing required manpower in general shift as well as in three shifts round the clock to ensure reliable & trouble-free performance of all the instrumentation equipment & systems supplied by him.

5. All the data/ performance of Instrumentation equipment/ system during commissioning & acceptance tests shall be properly documented & submitted.
05 TELECOMMUNICATION

05.01 TELEPHONE EXCHANGE

05.01.01 General

The telephone exchanges covered in this specification shall be digital electronic type, initially equipped for 200 extensions and expandable up to 500 extensions in future.

Telephone exchange shall be installed to facilitate plant telephone facilities at various locations within the Plant Complex as indicated this technical specification. This telephone exchange shall be exclusively used for communication within the plant complex only.

05.01.02 Design features

1. The exchange shall be designed and built to offer utmost reliability and efficiency in operation, ensuring instant communication by suitable configuration of functional units and use of reliable components.

2. All equipment, material and component supplied shall be newly manufactured and without loose or temporary cabling. Wired options used in the system hardware shall be minimum.

3. All components used in the telephone exchange shall be rated for round the clock continuous operation.

4. The telephone exchange shall employ latest state-of-the art digital switching technology.

5. The telephone exchange shall be microprocessor based, stored program controlled, employing Time Division Multiplexing (TDM) and Pulse Code Modulation (PCM) technique.

6. Sufficient redundancy shall be provided in the exchange control unit & other critical components to ensure uninterrupted operation of the exchange functions even in case of failure of these units / components.

7. All the common processing and control cards required for functioning of the digital exchange shall be duplicated to a 1+1 configuration. The standby cards shall perform the entire functions of the exchange when the main CPU and control cards fail without affecting the functioning of the exchange. Any failure of cards shall be brought to the notice by audio - visual alarm.
8. The exchange shall be provided with modular construction, dispersal of power modules, ringers and interface cards to the respective extension line racks thus helping to localise faults.

9. The exchange shall have the facility for expandability or system up-gradation to meet future requirements without extensive hardware / software modifications. The telephone exchange can be expanded in small steps by plugging in appropriate cards.

10. The exchange shall adopt universal port structure arrangement.

11. The exchange design shall have flexibility for interchanging various cards viz. extension cards, tie-line cards, trunk cards etc without making any modification in hardware as well as the software.

12. The exchange shall be suitable for electronic push button telephones of DP as well as DTMF type.

13. The exchange shall be capable of simultaneously accepting, processing and delivering information in various forms such as voice, data and text in a wholly integrated manner.

14. The exchange shall be designed for simultaneous transmission of voice/data at the transmission speed of 64 Kbps in synchronous mode and 19.2 Kbps in asynchronous mode through 0.51 mm. dia. twin cable.

15. The insertion of voice / data cards for simultaneous transmission shall not reduce the availability of total number of voice and data extension lines at any instant.

16. The exchange shall be designed for a line loop resistance of not less than 1200 ohms. Insulation resistance between components and exchange panel shall be more than 20 K ohms.

17. Speech attenuation shall be less than 1 db. Cross talk attenuation between speech circuits shall be more than 70 db.

18. The exchange shall have all familiar distinct tones, such as dial tone, busy tone, NU tone, ring back tone etc. The tenderer shall furnish complete details of the frequency and duration of different types of tones.

19. Adequate protection of exchange shall be provided against electrical short circuits and heavy current flow as a result of induced or conducted lightning or power systems faults. The exchange shall also be protected against electromagnetic and electrostatic interference.
20. The exchange shall have a PC based maintenance console. Provision shall be kept for all routine tests, measurements and checks of exchange equipment and subscriber lines. The system shall be capable of monitoring its own performance and to detect, analyse, locate and report faults whenever they occur. The console shall also indicate exchange parameters and card level faults.

21. Automatic line testing equipment / facility shall be provided to test the network without physically disconnecting the telephone cable.

22. The system shall be provided with audio and visual alarms for continuous indication of system status. The alarm system shall have the provision of an alarm indicator to indicate the power supply failure and the failure of the alarm circuit.

23. The offered telephone exchange shall have remote maintenance facility to test and monitor the functioning of the telephone exchange from a far off remote location.

24. It shall be capable of inter-working with different types of switching systems existing in the area. No modification will be required in the existing system for this purpose.

25. The exchange shall be compatible to ISDN networking.

26. The exchange equipment shall be provided with interface equipment for interconnection with Public address system and Radio communication (VHF) system of the plant complex.

27. The exchange equipment shall be capable of working without sacrificing the quality of performance during prolonged absence of air-conditioning.

05.01.03 Equipment practice

All equipment shall be housed in an elegant floor mounted cabinet. The cabinet shall be designed for ease of transportation and facilitate easy assembly at site. Doors shall be provided at both front and back of the cabinet for easy maintenance.

The metallic parts of the cabinet shall be rugged in construction and shall be treated with anti-corrosive paints to withstand the tropical conditions & corrosive atmosphere.

Test access points and indications shall be located in the front of the panel.

All incoming cables for entry bay connection shall be plug-in type.

The tenderer shall indicate the various types of cable connectors with detailed particulars.
All component units shall be mounted on plug-in type PCBs to facilitate easy replacement.

Cards of identical functions shall be interchangeable.

All cards and sub assemblies shall be suitably marked for identification on respective locations.

Components mounted on cards shall be designated according to the nomenclature used in the circuit diagram.

Busbars / cables for various supply voltages and signals shall be identified by adopting suitable colour scheme throughout the system.

Fuses, keys are to be located for easy access at a convenient level.

05.01.04 Salient system features

- The exchange shall have the following salient features:
- Non-blocking speech path network employing TDM-PCM technique with no restriction on number of simultaneous calls.
- Redundancy in all critical units such as call processing unit / critical control units, memory modules / data buses / hard disk storage unit and other critical components.
- Modular expansion capability for future expansion possible by simply plugging in additional cards, modules, sub racks and racks.
- In-built, on line diagnostic features with print out or display of faults through maintenance console.
- Flexible extension numbering without changing cabling.
- Distinct ringing for internal calls and trunk calls or operator calls.
- Silent operation.
- Easy and minimum maintenance.
- High reliability.
- Interfacing facility with other exchanges of the plant.
- Compatibility with digital national network.
- Extension to extension dialing.
- Direct outward dialing access to other exchanges.
- Direct inward dialing.
- Changing the subscriber facility through the maintenance console.
- Facility of connecting up computer terminals, screens etc.
- Facility for connecting Public address system.
- Facility for connecting Radio Communication (VHF) system.
- Remote maintenance facility.

**05.01.05 Subscriber facilities**

The following facilities shall be provided for subscribers of telephone exchange.

- Calling between subscriber
- Call transfer
- Executive/secretary facility
- Automatic call back
- Call pick up
- Emergency reporting
- Hotline facility
- Other common features of the latest digital exchanges.
- Conference facility (4 party)
- Internal consultation
- Call forwarding
- Priority interrupt
- Paging access
- Music on hold

**05.01.06 Operator console features**

- Answering incoming calls
- Setting up external calls
- Operator call intercept
- Operator call transfer
- Consultation of calls on hold
- Trunk offering
- Call queuing
- Call waiting display
- Night service
- Last number re-dial
• Automatic call distribution
• Other common features of the latest digital exchanges.

05.01.07 Power supply

The exchange shall work on - 48V D.C. power supply. All auxiliary power supplies required for equipment shall be derived internally from the 48 volts supply.

All direct supplies shall be suitably protected on input and output sides.

Audio-visual alarms shall be provided in case of voltage drops / surges beyond limits at which functional failure may occur.

05.01.08 Equipment details

The Telephone exchange system shall broadly comprise of the following -

• Telephone exchange equipment and peripherals such as PC based maintenance console, printer etc..

• Main distribution frame with protection devices on the exchange side.

• Power supply equipment, including rectifier - cum - charger, back up battery set and interconnecting cables & wires.

• Auto-telephone instruments.

• Sound proof booths for telephone sets.

• Telephone cable network comprising cables, wires, distribution & termination devices and associated erection accessories required for connecting the telephone instruments to the telephone exchange.

001 Telephone Exchange

The telephone exchange shall be cabinet type, equipped for 200 extension lines and expandable up to 500 extension lines at a future date.

The telephone exchange shall be complete with central processing unit, control cards, extension line cards, junction line cards, conference facility card, switching circuits, interfacing modules and devices, required for processing and interconnection of speech, data line and service circuits. The exchange shall also have power supply
modules, PC based maintenance console, operator console, printer, interconnecting
cables, wires, connectors and other auxiliary equipment.

To meet the functional reliability the hardware for the exchanges shall use duplicated
CPU, duplicated memory and memory control, duplicated data bus, high speed RAM
backed by non volatile memory, duplicated hard disc storage and system control and
display panel.

002 Main Distribution Frame

Separate main distribution frame (MDF) shall be considered for each of the telephone
exchange.

Each of the MDF shall serve as a common terminating point of the telephone cable
network. The MDFs shall be compact with systematic wiring and termination,
following a numbering scheme facilitating easy maintenance.

KRONE type MDF complete with protection devices shall be considered. The 500
extension lines on exchange side shall be provided with GD tube to each subscriber
lines for over voltage protection and fuse protection for over current.

The MDF at present shall be capable of terminating 200 pair cable in exchange side
and 400 pairs cable in the extension side (outgoing - field side). Spare capacity to the
tune of 25% shall be provided for terminating additional cables on both the sides of
the MDF.

Fuse mounted tag blocks shall be provided for all the field cables before termination
in the MDF.

The MDF equipment shall be installed in a room adjacent to the exchange room.
Suitable jumpering wires and hardware required to connect the equipment and MDF
shall be supplied and installed by the tenderer.

003 Power Supply Equipment

Power supply to the telephone exchange's power supply equipment and it's associated
devices shall be provided from 240V +/- 10%, 50Hz +/- 5%, single phase, AC supply

The power supply unit for each exchange shall comprise of the following :

- Rectifier-cum-charger - 1 set
- 48 volt battery set - 1 set
The exchange shall work off - 48 V DC obtained through the rectifier cum chargers.

The complete power supply unit shall be designed to support the full load condition of a 500 line telephone exchange.

The rectifier cum float charger shall feed the exchange equipment and back up battery set in parallel float working principle.

The battery set shall work as a back up for providing un-interrupted power supply to the exchange equipment and it's PC based maintenance console in case of AC mains failure. The back up battery set shall be of lead-acid type with its AH capacity sufficient to supply continuous power to the exchange (at its full load capacity) and the PC based maintenance console & printer unit for atleast 8 hours in case of AC mains failure.

Each battery set shall consist of 24 numbers high performance cells of 2 volts each. Each cell shall have vent plugs, buffers, inter cell connectors etc confirming to IS 1652. The 24 cells shall be connected in series to have 48 volts.

The rectifier cum charger shall be suitable for operation to trickle charge as well as boost charge the battery set. The power supply unit shall be designed so as to facilitate charging from "Float" to "Full charge" operation by simple switching in auto as well as manual mode.

The rectifier-cum-float charger set shall be capable of taking the full load of the exchange while float / boost charging the back up battery set as per the requirement.

A switching circuit shall be provided in the rectifier- cum-charger for automatic change-over from rectifier to battery supply in case of AC mains power supply failure.

Necessary protection for overload, short circuit, under voltage and over voltage shall be provided.

The DC output generated by the rectifier-cum-charger shall be adequately filtered before going to the exchange equipment.

Audio - visual alarm shall be provided to indicate any malfunction / failure in power supply system. Audio and visual indications for charging / discharging mode, AC/ DC ON indications shall be provided.

The rectifier-cum-charger and all other necessary equipment and protective devices shall be housed in sheet steel cabinet.
The charger units shall be provided with ammeters and voltmeters to indicate charging / discharging mode, AC / DC “ON” indication.

Necessary accessories required to install the battery sets and charger shall also be provided.

The battery sets shall be installed on a suitable platform in a separate room with acid proof floor. The tenderer shall provide the necessary platform.

004 Telephone Instruments

Telephone instruments shall be rugged in construction suitable for industrial application. The telephone instruments shall be electronic DP / DTMF phones.

The telephone instruments shall be provided with single side release switch.

Following types of instruments shall be considered for the project-

- Standard table top model
- Standard wall mounting model
- Executive secretary model
- Loud ringing audio visual model for sound proof booths

Following types of instruments shall be offered as optional -

- Cordless telephone sets

005 Sound proof booths for telephones

Sound proof booths shall be provided for the telephones to be installed in noisy areas in the shop floor. These booths shall be provided with audio visual indication facilities for incoming calls. A flashing red light, 9” dia. gong bell along with electronic circuitory to initiate the indications shall form part of this facility. An incoming call shall initiate the audio-visual indication.

006 Cable network

a) Cable Network for Telephone Exchange

For facilitating plant telephone connection at various locations within the expansion unit of the plant complex a separate cable network is to be provided. The telephone cable network shall facilitate a total of 200 telephones.
The telephone exchange and its associated devices shall be installed in the Service Building.

The telephone cable network can be divided in the following categories:

- Main & Tie cable network
- Distribution telephone cable network
- Indoor telephone network

The main telephone cable network shall comprise the cabling between the MDF of the telephone exchange and the telephone distribution cabinets in various areas/units of the plant complex.

To strengthen the reliability of the cable network, the distribution cabinets of various areas in the plant complex shall be interconnected through tie cables of adequate capacity.

The distribution telephone cable network shall comprise of the cables and termination devices for facilitating telephone connections in various shops/units/divisions of the plant. The distribution cables shall be laid from the above cabinets to various shop units and terminated there in Telephone distribution cabinets/CT boxes/Distribution boxes.

Indoor telephone cable network shall comprise cabling from cable terminal boxes/distribution boxes up to ceiling rose/tag block for further connection to various subscribers. Single & multi-pair unarmoured PVC telephone cables in concealed conduits/surface conduits/PVC casings shall be used for indoor wiring.

An indicative scheme of the proposed cable network showing all the main cables, cabinets, distribution boxes along with their sizes and number of telephones in various shop complexes/units is shown in TS drawings.

b) Cables for Telephone System

All telephone cables shall have copper conductor. Each conductor shall consist of a 0.51 mm dia. solid wire of annealed high conductivity copper.

The cables shall conform to the latest edition of the following Standard specifications.

ITD Spec. no. S/WT-143 B for Petroleum jelly filled armoured telephone cables.

ITD Spec. no. S/WS-113 C for PVC insulated, PVC sheathed telephone cables.

IS:1554, Part -I & II for armouring & outer sheath of PVC cables.
All PVC armoured and unarmoured telephone cables shall be Fire retardant low smoke type (FRLS Type) having protective system of inner and outer sheath specially designed with thermoplastic or thermosetting materials having superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. The cable will conform to the following standards -

- IEC - 332 (Part 1)
- IEC - 332 (Part 3)
- IEEE – 383
- BS - 4066
- Swedish Chimney test as per 4241475

**c) Cable Distribution Cabinets**

The cabinet shall consist of a framework on which cable terminal boxes are mounted. The outer case of the cabinet shall be of hot dip galvanised mild steel sheet.

The distribution cabinets shall be suitable for both installation by road side in open air as well inside a building on walls / floors.

The doors provided shall be strongly secured to the case of the cabinet with a locking system. Each door shall be provided with hinges, suitably spaced and welded or reveted to the case and the door. The case shall be designed to prevent entry of water into the cabinet during rainy conditions.

The MS sheets used for making the cabinet body shall be of 2 mm thickness.

Angles, channels & flat iron bars used shall be hot dip galvanised. The iron racks, bolts, nuts & other accessories shall be hot dip galvanised before they are fitted on to the cabinet. Screws, fly nuts etc shall be nickel plated mild steel.

Words - "TELEPHONE DISTRIBUTION CABINET" shall be embossed on the external top side of the cabinet.

A 100 pair distribution cabinet shall have the facility of termination of 100 pair 0.51 mm dia conductors in the exchange side & 100 pairs 0.51 mm dia. conductors in the extension line side.

**d) Cable Distribution Boxes (DBs)**

The Distribution Box (DB) shall consist of a hot dip galvanised mild steel sheet cabinet suitable for both indoor and outdoor mounting, wall mounted with a hinged cover and locking arrangement to prevent unauthorised access. The DB shall be dust & vermin proof and protected from weather.
The MS sheets used for making the body shall be of 2mm thickness.

The Distribution Boxes shall be provided with suitable mountings to fit tag blocks. The tag blocks shall be phenolic moulded each having 10 pairs (20 brass inserts) soldered on the brass plate. The brass plate carrying the tag block shall be fitted on the cast aluminum cubicle with 4 brass screws.

A 10 pair distribution box shall have the facility of termination of 10 pair cables in the exchange side & 10 pairs of cables in the extension line side.

The cubicles will be fitted with two brass or plastic nozzle inlet glands for leading in cables.

Words - "TELEPHONE DISTRIBUTION BOX" shall be embossed on the external top side of the box.

e) Telephone Socket

Two pin socket along with plugs (specially designed for telephone connections) shall be provided at the subscriber locations for plugging in telephones.

The incoming cables from the distribution boxes in each block / unit / building shall be terminated in these sockets.

f) Jointing Kits for Petroleum Jelly Filled Cables

Heat shrink jointing kits of Raychem make shall be used for straight & branch jointing of underground multi pair jelly filled telephone cables. Each jointing kit shall comprise heat shrinkable wrap around sleeve, metal canister, channels, retention clips, screen continuity wires, tapes UY connectors & other accessories as required.

05.01.09 Maintenance Facilities

The exchange shall provide automatic monitoring of its own performance and to detect, analyse, locate and report faults whenever they occur.

The system shall verify the proper execution of call handling and exchange software or hardware malfunctions and report on the condition of interfaces and exchange resources such as memory occupation, CPU utilisation etc.

The maintenance console shall be PC based having bulk software loading facility. The PC based maintenance console shall have FDD and HDD and shall work on 48 volt exchange supply. All the programming required to provide various facilities be possible from this unit. Facility shall be available to ensure automatic print outs of all important events and faults.

Provision shall be kept for all routine tests, measurements and checks of all exchange devices and subscriber lines. The console shall also indicate all exchange parameters and card level faults.
Malfunctioning in any part/ control unit/ power supply units of the system shall initiate the audio visual alarms. The equipment shall be provided with audio visual alarms in case of failures with facility for cutting off the audible alarm when required.

Automatic line testing equipment shall form part of the maintenance facility for telephone exchange. It shall be capable of testing the network without physically disconnecting the telephone cable.

It shall be used to test the open loop and closed loop condition of each subscriber, insulation value of telephone cable pair, capacitance, impedance, resistance and foreign potential (AC & DC) for each extension lines. The above values shall be displayed on the automatic line testing equipment.

The telephone exchange equipment design shall be such that any special care on the part of maintenance personnel is absolute minimum and no preventive maintenance is required.

**05.02 LOUDSPEAKER INTERCOMMUNICATION SYSTEM**

**05.02.01 General**

The systems are intended to provide instantaneous, reliable and effective communication as per the technological requirements between various process control points, control rooms, shift in charges, senior operation & maintenance personnel of the Plant complex in high noise level conditions (in the range of 90 to 110 db).

Loudspeaker intercommunication system subscriber stations shall be provided at the locations as per the list given below.

**05.02.02 System Features**

**001**

The system shall be microprocessor based, distributed amplifier type.

The system shall consist of a central exchange, master control station, 32 number of subscriber stations, paging loudspeakers, power supply equipment and interconnecting cable network.

The equipment shall be designed for reproducing high level perfectly intelligible speech and shall have high operational reliability under adverse environmental conditions such as corrosive and dusty atmosphere high temperature, humidity, vibrations and high noise level (in the range of 90 - 110 db) of the Blast Furnace Complex.
The system shall be designed in modular form so as to enable modification / expansion of the system easily as and when required without affecting the installed equipment.

The system shall have sufficient capacity to expand suitable number of subscribers to the tune of 20% of the indicated system capacity. The system with it’s present configuration shall have the capacity to connect a minimum of 32 subscriber stations.

The system shall have the provision for automatic muting of the associated loudspeaker while making announcement to avoid acoustic feedback.

In principle all subscriber stations shall be connected to the central exchange by standard twisted, multi pair PVC insulated, PVC sheathed communication cable.

The interconnecting cable network shall be designed using armoured cables laid on Cable trays. Wherever necessary un-armoured cables shall be laid through GI conduits keeping in view the shop layout & site condition.

The Loudspeaker intercommunication system subscriber stations shall be provided at the locations as per the subscriber list given in Clause no. 6.02 of this section of the Contract specification.

The communication requirements of various subscribers shall be as per the technological chart (communication matrix) enclosed with this technical specification.

The various equipment and component of the system shall conform to the relevant IS / IEC for safety standard, climatic & environmental condition, electrical measurement standard and degree of mechanical protection.

002

The system shall provide the following modes of communication amongst it's various subscribers:

No limitation on number of simultaneous communication channels.

Master to Subscriber call.

 Subscriber to Master call.

 Subscriber to Subscriber call through master.

 Subscriber to Subscriber call through direct dialing.
In Subscriber - to - Subscriber call mode (through direct dialing), a subscriber can call the chosen subscriber by dialing the number allotted for the called subscriber.

In case the called station is busy the calling station shall get a flash of the BUSY LED indicating that the called station is busy. If the called station is free the Green LED shall glow and the subscriber is connected to the called party and communicate with him.

The calling subscriber talks into the microphone and the message shall be heard at called subscriber station through his loudspeaker.

The called party can straight away speak into the microphone in his station. Both the parties can talk and hear at the same time.

Any other subscriber if wants to talk to either of them at that instant of time shall get busy indication for them. On completion of his message, calling subscriber shall normalise his switch board by reset switch.

Group call from a subscriber with a pre-determined number of subscribers. Facility for more than six simultaneous group call shall exist in the system. Group calls can be arranged in priority order.

Group paging shall be possible through master control station.

All party conference shall be possible through the master control station.

In case of emergency all the subscribers of the system can be paged simultaneously.

Priority call for a subscriber by pressing the priority break in. It shall be possible to provide priorities amongst the subscribers / group of a system at any time through the central exchange by suitable change in the software.

Reset facility on auto / manual mode.

Status monitoring indication on each subscriber.

Diagnostic features in built in the system.

Programmable communication chart. The system shall have facility to establish or change interconnection between any one or more subscribers and their facilities as and when required at site through a PC.
05.02.03 Equipment details

001 The loudspeaker intercommunication system shall be microprocessor based, distributed amplifier type and broadly consist of (but not limited to) the following

- Central exchange
- Control desk with master control station
- System main junction box
- Subscriber station of outdoor wall / column mounted type complete with amplifiers, microphones and re-entrant horn type loudspeakers & associated accessories. All outdoor stations shall be provided with weather proof housing and associated erection accessories.
- Desk top type subscriber station complete with handset station, extension amplifiers, box type loudspeaker & associated erection accessories.
- Centralised power supply unit complete with mains power distribution board for the system and back up UPS of suitable capacity.
- Interconnecting cable network
- Junction boxes, mounting accessories & all other erection accessories required for the system and it's cable network.

002 Central exchange

The Central exchange shall be microprocessor based intended for automatic speech path switching and blocking between various subscriber stations connected to the system. The Central exchange shall be provided with all the hardware including system control panel, relay sub-racks, main switch panel, CPU, interface cards, relay control cards, diagnostics modules required for connecting 32 subscriber stations (inclusive 20% spares). However, the system shall be suitable for expansion to connect 64 subscriber station in future.

All switching elements shall be of modular design.

The Central exchange shall be provided with diagnostic features, ie; facility for monitoring and checking the functions of subscriber stations.
The Central exchange shall be of modular design and all the necessary communication and functional modules as well as power supply modules with protective devices.

The Central exchange shall be housed in dust proof, self supporting free floor standing type or wall mounting cabinet with a lockable rear door. Cabinet shall have facility for terminating cables and carry all other devices necessary for switching the desired communication links between the subscribers of the system. All devices assembled and wiring shall be such as to provide easy access for operation and maintenance.

For cable entry the panels / equipment shall be provided with steel gland plates at the bottom with cable glands for fixing armoured / un armoured cables.

The Main system junction box shall have the facility to terminate the signal cable coming from at least 64 subscriber stations in the field side.

### Subscriber Station

Each subscriber's station shall consist of a pre-amplifier, an amplifier, a loudspeaker, a noise compensated microphone, power supply equipment and a switchboard (carrying number of push buttons / switches for station selection & group calls) and junction boxes.

All the subscriber stations shall be suitably interconnected to meet the technological requirement as per technological chart (communication matrix).

The subscriber station shall be either indoor desk mounted type or outdoor wall / column mounted type depending upon the location where it shall be used.

The subscriber stations shall be made of fibre glass reinforced polystyrene or Aluminum die cast to withstand the trying environment of the plant complex.

Each Subscriber station have it’s junction box for termination of incoming and outgoing cables (both signal cable / power supply cable).

All the outdoor wall mounted / column mounted stations shall be dust proof, weather proof / pilfer proof type.

Desk mounted type subscriber station conforming to IP52 shall be used in the Control rooms.

Outdoor stations conforming to IP 55 shall be used in the Shop floors and Junction house areas.

All the junction boxes used for the systems shall conform to IP55.
Amplifier:

The Power amplifier shall be made up of solid state devices with power output to give through associated loudspeaker sound intensity level of at least +3 db above the ambient noise level.

Connections to the loudspeakers, microphone and power supply source shall be in a way to match the requirement of the other control devices of the process station.

Facility to adjust the volume shall be provided.

Facilities to monitor the proper functioning of the amplifier shall be provided.

Output Power : 15 watts r.m.s.
Frequency Response : 100 Hz - 10000 Hz (+/-3db)

Microphone:

The microphone shall be of robust construction matching with the amplifier input and shall be immune to the stray magnetic fields and mechanical vibration.

It shall be of uni-directional response pattern with noise canceling characteristics.

It shall be provided with a goose neck or a suitable mounting matching the arrangement at the control station/indoor stations and shall be in built in the station / hand held receiver type for outdoor stations.

Frequency Range : 100 Hz - 10000 Hz (+/- 3 db)

Microphone amplifier shall be fully solid state and shall have frequency response of 200 Hz to 5000 Hz and the response shall drop off sharply beyond the speech frequency zone to achieve maximum intelligibility under high noise level condition. The amplifier for transmission shall be so designed as to provide uniform sound level at one or more called subscribers.

Loudspeaker:

The loudspeaker shall be of all weather proof sturdy design suitable for operation under rough industrial conditions.

The loudspeaker shall have uniform sensitivity and low frequency cut off having suitable directional response pattern for efficient and high quality speech reproduction.
It shall match the output of the amplifier.

The loudspeaker shall be either industrial re-entrant horn type or box type depending upon the location where the station shall be used. Each loudspeaker shall have a junction box for termination of cables from the station junction box.

The indoor box type loudspeaker shall be housed in sheet steel enclosure suitable for wall mounting and shall have built in volume control facility. It shall have uniform sensitivity with low frequency cut off at 250 Hz.

The industrial horn type loudspeaker shall be weather proof version of die cast Aluminum body with sturdy mounting bracket suitable for mounting on wall/column. The driver unit shall be concealed in the horn to prevent damage due to environmental condition and pilferage.

Peak output power
- 6 watts for indoor box loudspeakers
- 15 watts for outdoor industrial horn type loudspeakers.

**Switch board**:

The switch board shall be either integrated with the subscriber amplifier or separate unit to be mounted along-with the subscriber's other accessories. The switch board shall have push button / switches for station selection, channel selection & group call selection. In addition there shall be display / indication about Power supply ON, channel busy, the number of the called station, calling station & number of incoming priority call pending etc.

**004 Power supply**

All the equipment shall be suitable for operation from a centralised 240V ± 10%, 50Hz ± 5%, Single phase, AC mains power supply. On failure of AC supply the system shall automatically switch over to inverter supply derived from a set of backup battery having suitable AH capacity to meet the power supply requirement of the system for 1 hour. The power supply equipment including the battery bank and main power distribution box shall be installed in a separate room near the Central exchange.

The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage and transients.

**005 Cable Network**
The Loudspeaker intercommunication system shall have a separate cable network for facilitating the provision of subscriber stations as required for the plant.

The signal cables shall be completely separated from wiring of any other circuit of high voltage. When the cables are to be laid in the electrical cable trays of the conveyor galleries, sufficient space shall be maintained (as per the Indian electricity rules) from the cables of the high voltage circuits.

Each subscriber station shall be connected to the power supply unit through a separate cable network using power supply cables of required size.

Each Subscriber station shall be connected to the Central exchange by using multi-pair signal cables through the Main system junction box. The system junction box shall have termination facility for all incoming (cables from the Central exchange) as well as all outgoing cables (cables from the subscriber stations).

Loudspeaker shall be connected to subscriber station by loudspeaker cable.

**The size of the cables are as given below.**

- Power supply cable - 3 core, 2.5 sq.mm, ATC, Armoured PVC
- Signal cable - 5 pair, 0.5 sq. mm, ATC, Armoured PVC
- Loudspeaker cable - 1 pair, 24/0.2 mm, ATC, Armoured PVC

All telecommunication cables shall be made up of annealed high conductivity solid copper conductor.

Armoured PVC cable shall be used when the cable is to be laid on trays in cable tunnels / cable galleries or on cable trays. All the cables shall conform to IS : 694 & IS : 1554 (Part I), 1988.

**006 Ambient conditions**

All the equipment shall be designed to work reliably and effectively under the following ambient conditions

- Temperature : 0 to 55 degree Celsius
- Relative humidity : Upto 90% at 35 degree Celsius
- Environment : Dusty and corrosive
- Vibrations : 25 Hz (+/-) 2 Hz
- Ambient noise level : 90 to 110 db.

**05.03 LOUDSPEAKER TALK BACK SYSTEM**
05.03.01 General

Loudspeaker talk back system shall be provided for facilitating reliable two-way intercommunication between various strategic points of the plant complex. The subscriber stations shall be provided at locations having very high ambient noise level.

The system having the requisite number of subscribers shall be provided in various units of the plant complex for smooth flow of information between process points.

05.03.02 System features

1. The system shall be of distributed amplifier type using latest state-of-art technology.

2. The system shall be designed for perfectly clear and intelligible speech communication and shall have high operational reliability under adverse environmental conditions including high noise levels (90 to 110 db).

3. The system shall be designed for two channels of communication ie; in paging and private modes. In paging mode the announcement from any station shall be heard at all other stations through respective loudspeakers while in private mode close-talk communication shall be possible between two or more stations.

4. The proposed systems shall be configured as an open line system.

5. The system shall be provided with call attention tone facility preceeding all paging / announcement calls.

6. Each communication station shall be provided with indication such as power ON, channel busy, volume control etc..

7. The system shall have provision for automatic muting of the associated loudspeaker in the paging / announcement mode to avoid acoustic feed back.

8. The system shall have the facility to have interconnection with the telephone exchange for speech communication in private mode and paging mode.

9. The system shall be of modular construction for easy expansion of subscriber stations as and when required without affecting the installed equipment.

10. The system shall be designed for continuous reliable operation and of rugged construction to withstand shock and vibration.
11. The system shall be suitable for operation from a centralised 240 V +/- 10%, 50Hz +/- 5%, single phase AC mains power supply. Power supply cable shall be drawn to each subscriber location from this centralised source.

12. The communication equipment shall be designed to work effectively to provide clear speech communication between the subscribers under the following ambient condition:

- Temperature: 0 deg.C to 55 deg.C
- Relative humidity: Upto 90% at 35 deg. C
- Surrounding: Dusty and Corrosive
- Vibrations: 25 Hz (+/-) 2 Hz
- Ambient noise: 90 to 110 db

05.03.03 Establishment of a call

Any person willing to communicate with another person has to go to the nearest subscriber station, lift the handset, press the "PRESS TO PAGE" switch and call for the desired person.

A call attention gong automatically precedes the paging announcement. The paging announcement is heard on all the loudspeakers of the system except that of the calling station. After the announcement the calling person releases the "PRESS TO PAGE" switch and waits for the response of the called person.

The called person can go to the nearest station and communicate with the calling person directly in private mode by simply lifting the handset.

A third person can join the conversation in conference mode. During the private mode the associated loudspeakers are free to receive paging announcement generated by other stations.

05.03.04 Equipment details

001 Each system shall be distributed amplifier type and broadly consist of (but not limited to) the following:

- Subscriber station of both desk and outdoor (pole/wall/structure mounted) type complete with built-in amplifiers, additional extension amplifiers (if required), microphones etc. as per the requirements.
- Industrial horn type / box type loudspeakers.
- Power supply unit.

- Interconnecting cable networks comprising power supply cable, signal cable, loudspeaker cables, Junction boxes, cable termination devices, mounting accessories & other erection accessories for the system.

002 Subscriber Stations

The subscriber stations shall be indoor desk or outdoor wall/ pole mounted type as per the requirement.

Desk mounted subscriber stations conforming to IP 52 shall be used in control rooms, offices, etc. while outdoor stations conforming to IP 55 shall be used for shop floor areas and outdoor applications.

The desk mounted subscriber station shall broadly comprise a desk top hand set station, an extension amplifier and box type loudspeaker. The desk top hand set station shall consist of line amplifier, signal processing unit, function switches, indication lamps, etc. all housed in moulded fibre glass reinforced polystyrene case. The wall mounting type extension amplifier shall consist of a power supply unit and a plug in type power amplifier electronic module.

The pole / wall / column mounting subscriber station shall have die cast aluminum alloy (LM6) housing / fibre glass housing. The station shall broadly comprise of line amplifier, power amplifier, control signal lamps, switches for page / private channels and other functions, noise canceling microphone and receiver hand set, etc. all housed in the above mentioned housing. The subscriber station shall be provided with dust, weatherproof protection cover suitable for outdoor installation. The re-entrant horn type loud speaker shall be used in conjunction with these stations.

Pilfer proof subscriber stations shall be considered for outdoor locations where there is scope of pilferage.

The subscriber station shall also have provision for direct plugging in additional higher wattage amplifier to raise the power output wherever required.

The press to talk micro switch shall be provided in the handset itself. It shall be designed in such a manner that only when this micro switch is pressed the microphone shall be ON.

Amplifiers
The amplifiers shall be fully solid state using integrated circuits/semiconductor devices and shall generally have a frequency response characteristics of +/- 3 db between 60 Hz to 10 KHz and the response shall drop off sharply beyond the speech frequency zone to achieve maximum intelligibility under higher noise level conditions.

The design of the amplifiers shall be such as to limit the effects of external interference. It shall essentially be free from hum and have a total harmonic distortion of not more than 5% at full output.

The amplifier dynamic characteristic shall accommodate the entire dynamic range of sound signal and shall provide optimum fidelity ensuring faithful sound reproduction.

The amplifiers shall be of suitable wattage and impedance to match with the speakers connected to it.

The amplifiers shall be designed to operate from power supply with voltage variation of +/- 10% without much variation in output or gain.

Microphones

Microphones shall be of robust construction matching with amplifier input.

It shall be of noise canceling type with proper directional response pattern to suppress ambient noise.

It shall be designed to limit the non-linear effects caused by external interference due to magnetic fields, mechanical vibration and wind. The microphone shall be immune to the stray magnetic fields and mechanical vibration.

It shall be provided with a gooseneck / suitable mounting / fist type for the indoor stations and shall be in built in the handset for out door stations.

Loudspeakers

The loudspeaker shall have uniform sensitivity and low frequency cut off off having suitable directional response pattern for efficient and high quality speech reproduction.

It shall match the output of the amplifier. Necessary line matching transformer shall be provided for each loudspeaker.
The loud speaker shall be either industrial re-entrant horn type (conforming to IP 55) or box type (conforming to IP 52) depending upon the location where the station shall be used.

The indoor box type loudspeaker shall be housed in sheet steel enclosure suitable for wall mounting and shall have built in volume control facility.

The industrial horn type loudspeaker shall be weather proof version of die cast Aluminum body with sturdy mounting bracket suitable for mounting on pole / wall / column. The driver unit shall be concealed in the horn to prevent damage due to environmental conditions and pilferage.

Peak output power
- 6 watts indoor box loudspeakers
- 15 watts outdoor industrial re-entrant horn loudspeaker

004 Power supply

The equipment will be suitable for operation from a centralised uninterrupted power supply. This power supply source shall be made available to the tenderer for use in the respective control rooms of the units.

The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage and transients.

005 Cable network

Each of the loudspeaker talk back system shall have a separate cable network for facilitating the provision of subscriber stations as required for the plant.

Cables for the LSTB Systems:

The signal cables shall be completely separated from wiring of any other circuit of high voltage. When the cables are to be laid in the electrical cable trays of the conveyor galleries, sufficient space shall be maintained (as per the Indian electricity rules) from the cables of the high voltage circuits.

Each subscriber station shall be connected to the power supply unit through a separate cable network using 3 core power supply cables.

Armoured PVC cable shall be used when the cable is to be laid on trays in cable tunnels / overhead cable galleries / overhead cable trays.
The tenderer shall furnish the specification of the signal cable, power supply cable and loudspeaker cable proposed to be used in the system.

All cables used shall be made up of annealed high conductivity solid copper conductor.

All PVC armoured and un armoured telephone cables shall be Fire retardant low smoke type (FRLS Type) having protective system of inner and outer sheath specially designed with thermoplastic or thermostetting materials having superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. The cable will conform to the following standards -

* IEC - 332 (Part 1)  * IEC - 332 (Part 3)
* IEEE - 383  * BS - 4066
* Swedish Chimney test as per 4241475

**05.04 GENERAL ANNOUNCEMENT SYSTEM**

**05.04.01 General**

The general announcement system shall facilitate announcement / paging over a number of loudspeakers distributed judiciously all over the plant complex.

**05.04.02 Design feature**

1. The system shall be central amplifier type. The amplifiers shall be located in various premises and the announcement points shall be installed in the Main plant control room.

2. The amplifier shall have the capacity of suitable output power inclusive of 50% stand-by capacity.

3. The announcement / paging shall normally be made from the main plant control rooms with provision of a second announcement point in the Shop in charge's office.

4. The loudspeakers shall be operated group wise or all at a time depending upon the requirement.

5. The system having the requisite number of loudspeakers shall be provided for the plant complex for announcement of instructions and smooth flow of information between process points.
05.04.03  System feature

1. The general announcement system shall ensure quality performance using the latest technology in design and manufacture of audio equipment.

2. The system shall facilitate near total reproduction of original speech or music and shall guarantee trouble free operation.

3. The system shall adopt modular construction. The amplifier rack shall be provided with input and output terminals, plated and tinned for good contacts.

4. The system shall be switched on through press – to - talk switch.

5. Suitable protection of the system against accidental wrong connection, over loading, short circuit etc. shall be provided.

6. The equipment shall be of rugged construction to withstand shock and vibration.

7. The system shall be capable of withstanding extreme conditions of temperature and humidity.

8. The equipment shall be suitable for operation from 240V +/- 10%, 50Hz +/- 5%, Single phase, AC mains power supply. The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage & transients.

9. The communication equipment shall be designed to work effectively to provide clear speech communication in the plant under the following ambient condition :

   Temperature - 0 deg.C to 55 deg.C
   Relative humidity - Upto 90% at 35 deg. C
   Surrounding - Dusty and Corrosive
   Vibrations - 25 Hz (+/-) 2 Hz
   Ambient noise - 90 to 110 db

05.04.04  Equipment details

001  Each of the system shall broadly consist of but not limited to the following:

   • Amplifier rack housing preamplifier, power amplifier including working and stand-by capacity with changeover facility, monitoring facilities etc.

   • Microphone assembly

   • Loudspeakers (re entrant horn type / indoor box type) complete with mounting accessories such as poles, mounting brackets.
• Cable network comprising cables, wires, junction boxes, cable termination devices, GI pipes/conduits, and all other cable laying accessories.

002 Power amplifier

The amplifier shall be fully solid state electronics.

The amplifier dynamic characteristics shall accommodate the entire dynamic range of the sound signal and shall provide optimum fidelity ensuring faithful reproduction of speech and music.

The stability of gain shall be fairly high. Reliable and quality components shall be used in its construction to prevent drift in their characteristics.

The amplifier shall be provided with easy to operate filter type volume and tone controls and potentiometer adjustment facility to regulate its input sensitivity.

The amplifier shall be provided with variable high frequency boost for increased clarity of speech and music.

003 Microphone

The microphone shall be of gooseneck desk mounted type offering high sensitivity and reliability and shall facilitate optimum reproduction of speech and music.

It shall be of noise canceling type having unidirectional pick-up pattern and shall prevent acoustic feedback due to reverberation from within the announcement / paging room.

The microphone shall be provided with in-built screen to prevent explosive wind and breathing sound.

It shall be capable of withstanding vibrations and shocks. Adequate protection against penetration of dust and foreign particles into the microphone shall be provided.

004 Loudspeaker

The loudspeaker shall have uniform sensitivity and low frequency cut off having suitable directional response pattern for efficient and high quality speech reproduction.

It shall be of sturdy construction capable of withstanding extreme conditions of temperature and humidity.
The loudspeaker assembly shall be capable of being swiveled in any desired direction, thus allowing flexible beaming of sound.
The driver unit shall incorporate built-in line matching transformer.
The loud speaker shall be either industrial re-entrant horn type (conforming to IP 55) for use on shop floors or box type (conforming to IP 52) for use in control rooms and other such rooms.
The indoor box type loudspeaker shall be housed in sheet steel enclosure suitable for wall mounting and shall have built in volume control facility.

The industrial horn type loudspeaker shall be weather proof version of die cast Aluminium body with sturdy mounting bracket suitable for mounting on wall/column.
The driver unit shall be concealed in the horn to prevent damage due to environmental condition and pilferage.

Peak out put power : 6 watts for indoor box loudspeakers
15 watts for outdoor industrial re-entrant horn type loudspeaker

005 Power supply

The equipment will be suitable for operation from a centralised uninterrupted power supply source.

Uninterrupted power supply for the system shall be made available to the tenderer at a central location (preferably at the telephone exchange). The Amplifier racks for the system shall be installed in the telephone exchange premises and the announcement points shall be from the respective control rooms of the premises where the system is to be installed.

The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage and transients.

006 Cables

The loudspeaker cable shall be 2 core, 24/0.2mm twisted annealed tinned high conductivity copper conductor, PVC insulated and overall PVC sheathed, generally as per IS-694. The cable shall be GI wire armoured or unarmoured as per the requirement.

All PVC armoured and un armoured telephone cables shall be Fire retardant low smoke type (FRLS Type) having protective system of inner and outer sheath specially designed with thermoplastic or thermosetting materials having superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. The cable will conform to the following standards -
05.04.05  Technical parameters

a) Amplifier:

- Input sensitivity: 100 mv
- Bandwidth: 100 Hz to 10 KHz
- Signal to noise ratio: Better than 60 db
- Hum and noise level: Better than 65 db below rated output power
- Distortion: Less than 3% at 1 KHz and at full output power
- Floating outputs: 100v/70V
- Protection: Against open and short circuits and spurious oscillation
- Safety requirement: As per IEC-65/268

b) Microphone:

- Type: Unidirectional, dynamic (moving coil)
- Frequency response: 100 Hz to 10 KHz
- Impedence: 230 - 270 Ohms

c) Loudspeaker:

- Type: Horn/Box enclosure
- Bandwidth: 100 Hz to 10 KHz
- Input voltage: 100V/70V
- Voice coil impedence: 8 Ohms, 16 Ohms
- Sensitivity at 1 KHz SPL: 111 dB +/- 3db per watt at a distance of 1 metre.
05.05 **VHF COMMUNICATION SYSTEM**

05.05.01 **General**

VHF communication system is intended for instantaneous two-way radio communication amongst base station and a number of mobile/ portable hand held transreceiver sets in the plant complex.

For operation and maintenance of the expansion units of the Power plant complex VHF radio communication systems shall be provided in the following departments / shops -

Each of the above department shall be provided with a base station (having 1 working & 1 standby fixed transreceiver set). Each department shall be provided with 6 numbers portable walkie talkies for field use.

In addition to the above 10 sets of walkie talkies shall be provided with DTMF dial pad to interface with telephone exchange.

Telephone interface equipment shall also be provided.

05.05.02 **Design Basis**

1. The equipment shall use synthesised frequency control. The frequency channel shall be easily programmed and provide extremely stable frequency operation. It shall be possible to programme the sets upto 12 channels by use of PROM & E-PROM.

2. The transreceiver sets shall operate on simplex / semi-duplex mode.

3. All controls on the sets shall be positioned in a manner so as to be conveniently operated.

4. Protection against misuse and reverse battery polarity to be provided.

5. The equipment shall be light in weight and designed for low power consumption.

6. The equipment shall be weather proof rugged in construction and designed for continuous and reliable operation under adverse environmental and operating conditions of a power plant complex.

7. The mobile stations to be used in the cranes / moving machines shall be able to take the shocks and vibrations of these machineries.

8. The equipment shall require minimum of maintenance and be easy to maintain.
9. The transreceiver sets shall be designed for having high carrier stability with adequate suppression of spurious emission and a low distortion.

10. The units such as transmitter, receiver, power supply unit shall be mounted on separate PCB for ease of maintenance and serviceability.

11. The transreceiver sets shall have LCD display for visual indications regarding channels with back lighting for operating in a low light environment.

05.05.03 Equipment Details

The VHF radio communication systems shall comprise of the following –

- Fixed transreceiver sets to be used as base stations.
- Portable handset stations
- Walkie talkies with DTMF dial pad to interface with telephone exchange.
- Telephone interface equipment shall also be provided.
- Each of the transreceiver stations complete with connectors, cables, power supply unit, Ni-Cd rechargeable battery, battery charger, suitable antenna units and mast / structure for the base station antennas.

05.05.04 Portable hand held type sets

The transreceiver set shall be compact, lightweight having low power consumption.

The sets shall be fully IC based, modular in nature, synthesised frequency controlled, with multi channel facility.

Each transreceiver set shall comprise of transmitter section, receiver section, a control unit complete with all controls, microphone, speaker, built-in helical antenna and rechargeable 12V NiCd battery all housed in a splash proof cabinet cast from aluminum alloy.

Each set shall be provided with a rugged leather carrying case.

The set shall have the provision for using earphone.

**Technical parameters:**

- Frequency range
  - Frequency synthesised over the range of
  - 134 - 174MHz
05.05.05 **Base / Mobile transreceiver sets**

The transreceiver sets shall be fully solid state modular in design, synthesised frequency controlled, multi channel, based on the latest development in VHF communication field.

The set shall be compact, light weight having a splash proof cabinet cast from aluminum alloy. It shall have low power consumption.

Each transreceiver set shall comprise of transmitter section, receiver section, a control unit complete with all controls, microphone, loudspeaker and antenna unit.

The base station shall be designed to work from a 240V AC mains supply. However a maintenance free battery of suitable capacity along with a charger unit shall also be considered for the base station.

The mobile stations shall be provided with a maintenance free rechargeable 12V NiCd battery for power source.

**The sets shall have** -

- digital channel display.
- provision for connecting external speaker.
- provision for interfacing with telephone exchange.
- provision for selective calling facility.

The transreceiver sets shall be so designed as to be easily configured into fixed base station / mobile stations, as required. The equipment shall be supplied with full range of accessories so that it shall be suitable use as mobile / static applications.

**The set shall be supplied with following accessories when used as a Fixed base station.**
• Desk top type microphone assembly.
• GP antenna / Yagi antenna with RF cable & connectors.
• Power supply unit complete with battery set, charger unit and DC power cable for fixed stations.
• Mast required for the antenna unit.

*The set shall be supplied with following accessories when used as a Mobile station in moving cranes / machineries.*

• Fist type microphone assembly.
• Mounting assembly for mounting in vehicles.
• Antenna assembly with RF cable for mobile use.
• Earphone facility / external speaker.

**Technical parameters**

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<tr>
<th>Parameter</th>
<th>Specification</th>
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<tr>
<td>Frequency range</td>
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<td>RF power output</td>
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<td>Channel spacing</td>
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<td>Less than 5 % at 1 KHz</td>
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<td>Type of antenna</td>
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<td>Operating temperature</td>
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**05.05.06 Battery Charger**

Portable single phase battery charger shall be suitable for charging at least 6 nos. 12 Volts Ni-Cd batteries at a time.

The unit shall comprise a transformer provided with mains voltage tappings, full wave bridge silicon rectifiers and controlling choke. The charger shall be provided with mains isolator switch, rotary switch for selecting different charging modes, flush mounted charging current DC ammeter, supply ON/OFF indication lamp and protective fuses.

The entire assembly shall be housed in a sturdy sheet steel box having proper ventilation arrangement, terminals with insulated knurled screwed knobs for connecting to batteries and provided with mains and battery leads and pair of battery charging clips with marked polarity.
05.06 CLOSED CIRCUIT TELEVISION SYSTEM

05.06.01 General

The Closed Circuit Television Systems (CCTV Systems) will be provided for control and supervision of technological processes at points which are difficult to be observed directly or which require monitoring from a remote control center by the shop manager. This specification covers the Close Circuit Television Systems required for Blast furnace complex.

05.06.02 System requirements

1. The Closed Circuit Television Systems is intended for comprehensive round the clock surveillance of the operation they are intended for, in the shop floors.

2. TV cameras with all accessories will be installed at various locations of the shop floor to view the critical processes of the shop as indicated in the table in next page.

3. Each of the TV camera will be dedicated to a separate TV monitor. The monitors along with all controls of the cameras and it's associated equipment will be installed in the control rooms.

4. All control functions related to the CCTV Systems comprising Cameras, Monitors, Water cooling jacket, blower unit and wipe & wash unit of the weatherproof housing will be effected from the control unit to be installed in the control room of the shop.

5. The TV cameras will be of Charge Coupled Device (CCD) type and these will be mounted in such a manner as to provide continuous monitoring of the critical processes / operation of the shop floor as required.

6. The system will provide clear and sharp picture on TV monitors in industrial lighting conditions at any time of the day or night. The illumination level may vary from 2 to 10 lux.

7. The complete CCTV Systems will work on 240 V ± 10%, 50Hz ± 2 Hz, single phase AC supply. In case any other power source is required, the same will be arranged by the contractor from the above available source. The CCTV system will be provided with an uninterrupted power supply system for feeding stabilized and continuous power supply to all equipment.

8. All equipment for Closed Circuit Television systems covered in this specification will comply with the CCIR standards.
9. The functional requirements (typical – for guidance only) of the CCTV system for the Blast furnace complex is as given in the tables below.

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<thead>
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<th>Camera location</th>
<th>Operation/activities to be monitored</th>
<th>Ambient temperature at camera location</th>
<th>Environ. condition</th>
<th>Scene illumination</th>
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<td></td>
</tr>
<tr>
<td>Cast house 2 operation Cast house 2 operation</td>
<td>80°C</td>
<td>Very dusty</td>
<td>Normal</td>
<td>Motorized zoom</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Near railway track below cast house 1 Ladle placement and safety of working staff</td>
<td>80°C</td>
<td>Dusty</td>
<td>Normal</td>
<td>Manual zoom</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Near railway track below cast house 2 Ladle placement and safety of working staff</td>
<td>80°C</td>
<td>Dusty</td>
<td>Normal</td>
<td>Manual zoom</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

05.06.03 Equipment details

The CCTV system will comprise of the following.

- Colored TV cameras with manual and motorized zoom lenses, as required.
- Camera mounting platforms / structures, as required at site.
- Water cooling jackets, complete with wipe and wash units
- Remote controlled Pan & Tilt units.
- Control console with control units for complete control of the cameras and associated devices.
• Colored TV monitors
• Interconnecting video and control cables
• Un-interrupted power supply unit
• Video distribution amplifiers/Video cable equalizers, as per requirement.
• All other auxiliary equipment, connectors, erection accessories etc. as required.

001 TV Camera

The TV cameras will be compact, of rugged design and suitable for industrial applications.

These will be specially designed and tested to provide continuous good quality video output throughout wide variations in environment conditions like temperature, humidity, shock and vibrations and varying light condition prevalent in the Blast furnace complex.

The cameras will use ½” format interline transfer CCD imager and have virtually zero lag, no image burns and no geometric distortion. These will be of contemporary styling and employ complete solid-state circuitry, ensuring high operational reliability.

The cameras will deliver well defined, clear, high resolution colored picture, with sufficient contrast to allow for good object recognition even in poor light conditions. A highly sensitive automatic light compensation circuit will ensure constant video signal independent of wide variations in light levels.

The cameras will have long life and require virtually zero maintenance in adverse environmental conditions prevalent in the steel plant.

The TV cameras will also possess the following features:

• High resolution.
• Excellent sensitivity.
• Low power consumption.
• Phase adjustable line lock facility.
• All controls like back focus, lens select, phase adjustment, power ON/OFF etc. will be suitably provided at convenient and easy to adjust locations on the camera.
The camera unit will be complete with all electronic circuitry, devices, components, control switches, standard mount for lenses, mounting assemblies etc. The mounting assemblies of the cameras will be individually selected depending upon the special requirements as per actual site conditions.

### Technical Data

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>DESCRIPTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Model no.</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>TV standard</td>
<td>PAL</td>
</tr>
<tr>
<td>d.</td>
<td>Image sensor</td>
<td>½ Interline CCD</td>
</tr>
<tr>
<td>e.</td>
<td>Image area</td>
<td>6.4 mm x 4.7 mm</td>
</tr>
<tr>
<td>f.</td>
<td>Picture elements (Active)</td>
<td>768(H)X494(V)</td>
</tr>
<tr>
<td>g.</td>
<td>Horizontal resolution</td>
<td>500 TV LINES</td>
</tr>
<tr>
<td>h.</td>
<td>Vertical resolution</td>
<td>420 TV LINES</td>
</tr>
<tr>
<td>i.</td>
<td>Minimum illumination</td>
<td>1.5 Lux at F1.2 (depending on the site requirement)</td>
</tr>
<tr>
<td>j.</td>
<td>Synchronization system</td>
<td>Internal &amp; general lock</td>
</tr>
<tr>
<td>k.</td>
<td>Automatic Gain Control</td>
<td>AGC / MGC Selectable (0 to 18 dB)</td>
</tr>
<tr>
<td>l.</td>
<td>Signal to noise ratio (AGC off)</td>
<td>Better than 46 dB</td>
</tr>
<tr>
<td>m.</td>
<td>Video output</td>
<td>VBS, Y/C, 1.0 Vpp composite video signal at 75 ohms load.</td>
</tr>
<tr>
<td>n.</td>
<td>Automatic Light Control</td>
<td>VIDEO DRIVE</td>
</tr>
<tr>
<td>o.</td>
<td>Lens type</td>
<td>Variable focal length, Motorised zoom lens</td>
</tr>
<tr>
<td>p.</td>
<td>Lens mount</td>
<td>C &amp; CS</td>
</tr>
<tr>
<td>q.</td>
<td>Rated temperature range</td>
<td>As per Site condition</td>
</tr>
</tbody>
</table>

**Camera** White balance control (fixed or auto), back focus control,
Controls

lens controls (level and ALC), phase adjustment (0 to 360 degree), back light compensation (on/off), auto shutter speeds (1/50 to 1/10000), fixed shutter speeds (1/120 to 1/4000), sync. mode (internal crystal reference/line lock), focus control, AGC on/off switch selection

002 Camera Lens

The camera lens will be suitable for the camera on which it is to be mounted. The lenses chosen will be fixed focal length/ manual zoom/ remote controlled motorized zoom type so as to meet the specification requirements. The choice of lenses, their focal length and viewing angle will be judiciously done for effective monitoring suited to the specific application requirements in the shop floor. Auto iris lenses with internal spot filters will be used for varying lighting conditions.

Technical Parameter of ½” Manual zoom / Motorised lens

<table>
<thead>
<tr>
<th>SL.</th>
<th>DESCRIPTION</th>
<th>Manual Zoom</th>
<th>Motorized Zoom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model no.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of lens -</td>
<td>Manual Zoom</td>
<td>Motorized Zoom</td>
</tr>
<tr>
<td></td>
<td>Lens format</td>
<td>½” / 1/3 “</td>
<td>½” / 1/3 “</td>
</tr>
<tr>
<td></td>
<td>Focal length and aperture</td>
<td>6-60 mm, F1.2 - 560</td>
<td>6-60 mm, F1.2 - 560</td>
</tr>
<tr>
<td></td>
<td>Iris type</td>
<td>Auto IRIS</td>
<td>Auto IRIS</td>
</tr>
<tr>
<td></td>
<td>Type of mount</td>
<td>C</td>
<td>C / CS</td>
</tr>
</tbody>
</table>

003 Camera Mounting Platform:

The camera mounting platform will be suitable for mounting the camera assembly on walls / column / structures as per the actual requirements at site and keeping in view the area to be covered by the individual camera. The mounting will be with adjustable support so as to have flexibility to move the camera assembly as and when required. Wherever necessary, the contractor may have to fabricate structures / vertical poles to mount the cameras. The structure / platforms/ brackets for mounting all the cameras are included in the scope of the contractor. The contractor will furnish the complete details of structure / platforms / mountings which will
include the construction material, loading capacity, dimensions and weight of the platform/mounting, for the approval of the Purchaser.

004 Water cooling jacket for the camera

All TV cameras will be provided with Water cooled housing.

At the locations where the ambient temperature is high, the protective camera housings will be provided with water cooling jacket to protect the camera against high temperature in areas having ambient temperature up to 60° / 80° / 100° / 120 degrees Celsius. Cooling water will be supplied to the jacket continuously to cool the camera and keep it fully efficient & operational.

Double walled stainless steel housing will be provided for protection of cameras from high temperature. Back cover of the water cooled housing will be detachable so that the camera can be taken out/installed from the rear for service and inspection. Piping for cooling water and purging air must be suitably protected against high ambient temperature/ radiation heat. The glass panes of the housing will be resistant to influences like quick changes in radiation temperatures.

The cooling jacket will have temperature sensor to monitor the temperature of the camera, a toughened glass front, filter & an annunciator. Whenever the camera temperature crosses the upper threshold limit of the desired temperature there will be audio visual indication in the control panel at the operator desk.

A Keshkamat make wiper & washer unit will be installed with the water cooling jacket to keep the front glass of the cooling jacket clean from dust & dirt.

The housing will have enclosure as per IP 56 in accordance with DIN 40050

Technical Parameter

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Material of housing</td>
<td></td>
</tr>
<tr>
<td>Type of camera mounting</td>
<td>C / CS</td>
</tr>
<tr>
<td>Temperature range</td>
<td>60° / 80° / 100° / 120° C</td>
</tr>
<tr>
<td>Cooling water</td>
<td>Industrial grade cooling water at 35° C</td>
</tr>
<tr>
<td>Flow</td>
<td>250 litre / hr at suitable pressure available in the network</td>
</tr>
</tbody>
</table>

005 Pan and Tilt unit
The pan and tilt unit will comprise of pan & tilt head and control unit. The pan and tilt head will be remotely controlled from the control unit.

The pan & tilt head will be heavy/medium duty type, rugged in construction and smooth in operation. The unit will be used to cover large area of interest for surveillance in different directions, as required by the operator.

The unit will be suitable for mounting on walls / column / structures / hanging from ceiling as per the site requirements. The unit will have complete freedom of movement throughout the entire pan & tilt scan. The unit will be completely sealed for all weather proof use.

The pan and tilt units will be designed so as to ensure long operational life. The units will employ electric motors with quick reversibility and dynamic braking characteristics, have rugged worm gears assembly to minimize backlash and ensure drift free operation. It will be possible with ease to reposition the cameras field of view at any time. The limit switches will be employed to control the field of scan. The unit will have manual over ride on the auto mode to enable the operator to choose the area of scan as and when required.

The control unit will be installed in the control room, as per the requirement. It will be designed to move the camera both in horizontal and vertical planes.

**Technical data**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model no.</td>
<td></td>
</tr>
<tr>
<td>Angular travel in horizontal plane</td>
<td>0-355 deg.</td>
</tr>
<tr>
<td>Angular travel in vertical plane</td>
<td>+/-90 deg.</td>
</tr>
<tr>
<td>Operating speed–Panning (no load condition)</td>
<td>6 deg./sec</td>
</tr>
<tr>
<td>Operating speed – Tilting (no load condition)</td>
<td>6 deg./sec</td>
</tr>
<tr>
<td>Maximum load (Load rating to be compatible for camera, lens and housing fitted)</td>
<td></td>
</tr>
<tr>
<td>Braking</td>
<td>Mechanical friction type</td>
</tr>
<tr>
<td>Construction material</td>
<td>Main body - Aluminium casting</td>
</tr>
<tr>
<td></td>
<td>Cover – MS sheet fabricated</td>
</tr>
<tr>
<td></td>
<td>Platform – Cast Al &amp; Cast iron.</td>
</tr>
<tr>
<td>Whether heavy-duty/medium</td>
<td>Heavy-duty</td>
</tr>
<tr>
<td>duty/light duty</td>
<td>Outdoor use</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Whether suitable for indoor/outdoor use</td>
<td>Outdoor use</td>
</tr>
<tr>
<td>Motors</td>
<td>Two phase, Synchronous type</td>
</tr>
<tr>
<td>Rating of limit switches - for pan</td>
<td>5 Amp</td>
</tr>
<tr>
<td>- for tilt</td>
<td>5Amp</td>
</tr>
<tr>
<td>Conductor requirements with size and type of conductor size</td>
<td>6 unshielded</td>
</tr>
<tr>
<td>Power supply requirement</td>
<td>240 V AC, 50 Hz</td>
</tr>
<tr>
<td>Connectors</td>
<td>Amp CPC Type, mate supplied</td>
</tr>
<tr>
<td>Rated temperature range</td>
<td>upto 120° C</td>
</tr>
</tbody>
</table>

006 CCTV Monitors

The CCTV monitors will be suitable for industrial applications and compatible for the TV cameras. These will be of fully solid state type, modular in design, have low radiation and provide a bright, clear, well defined and high resolution picture display on the TV screen.

All controls for power supply on/off, brightness, contrast, color, vertical hold, horizontal hold, etc. will be provided on the front panel behind the flip open protective cover for readily adjusting the video signal. The input and output video connectors for coupling the video input/output to other TV equipment, DC restoration switch and power supply connections will be provided on the rear panel. The monitor will have easy access for servicing and other adjustments.

The video monitor will be housed in a dust-proof metal enclosure with anti-dazzling light shield. It will be suitable for rack mounting / mounting on control console / ceiling hang type as per the site requirement at a convenient viewing angle.

The monitor will be designed to produce high resolution.

The monitor will have the following features:

All controls for power supply on/off, brightness, contrast, color, vertical hold, horizontal hold, etc. provided behind the flip open protective front cover. BNC video input and loop through switcheable 75 Ohm termination, DC restoration switch provided at the rear of the monitor.

Automatic degaussing at power on

Desk type/rack mountable with rack mountable kits
Quick start

Easy access for servicing and adjustments

---

**Technical Parameter**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model no.</td>
<td></td>
</tr>
<tr>
<td>Picture tube size</td>
<td>14 inches / 19 inches</td>
</tr>
<tr>
<td>Scanning system</td>
<td>PAL</td>
</tr>
<tr>
<td>Horizontal resolution</td>
<td>460 TV lines (Centre)</td>
</tr>
<tr>
<td>Vertical resolution</td>
<td>420 TV lines</td>
</tr>
<tr>
<td>Video input</td>
<td>1.0 V pp</td>
</tr>
<tr>
<td>Input impedance</td>
<td>75 ohms</td>
</tr>
<tr>
<td>Power consumption</td>
<td>60 W</td>
</tr>
</tbody>
</table>

**Controls:** Power on/off, LED pilot light, brightness, color, contrast, V-hold, H-hold, impedance – 75 ohm/ high SW, DC restoration SW etc.

**007 Control Console**

The control panel will facilitate easy operation and enable the operator to have a clear and easy view of the pictures transmitted by various cameras.

The design of control unit panel with control devices, switches, keys and other associated equipment will provide the convenience of monitoring and control of the system in a most efficient manner.

All remote controls of camera, motorized zoom lens, pan & tilt, control of blower unit, wiper & washer unit of the water cooling jacket and it's associated equipment will be mounted on one desk mounted type console and will be installed in the control room of Blast furnace.
The control panel will indicate the temperature of the camera (the temperature inside the water cooling jacket) & there will be an audio visual indication in case the temperature violates the desired limits.

The control panel will be rugged in construction and layout of devices, components & circuitry facilitate easy accessibility for servicing and maintenance.

The TV monitors will be mounted on the rack on table top / the hanging from the ceiling of the control pulpits at a convenient viewing angle. Control room at

Video monitor hangers, wherever required, will be suitably provided

008 Video Cable Equalizers

The video cable equalizers will be used to compensate for high frequency losses due to long runs of coaxial cable used between the camera and video monitor.

009 Interconnecting Cables

The interconnection cables will include :-

Coaxial cable for transmission of video signal from camera to the monitor, via. the video switching / distribution unit, as required.

Multi-core control cable for remote control of camera and pan & tilt unit through remote control units from the operator console, as required.

Power supply cable for providing power supply to various equipment.
Multi-core control cable for annunciation of temperature condition in water cooling jacket.

The supplier will furnish detailed technical specification of various types of cables proposed to be used for providing interconnection between various units of the CCTV system.

010 Equipment power supplies

All the equipment of the CCTV system will work on 240 V±10 %, 50 Hz±2 Hz, single phase AC power supply which will be made available to the contractor only at control room. No local power supply will be provided by the purchaser for individual TV cameras or other units of the system.
It will be the responsibility of the contractor to make power supply provision for various equipment of the CCTV system from these sources as per their input requirement. The contractor will also supply and install the necessary power supply equipment required for feeding stabilized power supply to CCTV system.

011 Uninterrupted Power Supply System

An uninterrupted power supply (UPS) system will be supplied and installed by the contractor for providing necessary stabilized and continuous power supply to the complete equipment at the control center. The power supply equipment will include all transformers, chargers, Ni-Cd battery bank (for 30 minutes backup), inverters, distribution boards etc. including all necessary cabling and other accessories.

The UPS system will be designed such that failure of a major component will not affect the system availability while repairs are in progress. The power supply system will be provided with all necessary alarms for enabling the operation staff to detect any malfunctioning or failure of the power supply system. The UPS will be suitably rated to meet the total power requirement of system.

05.07 CABLE LAYING SPECIFICATION

05.07.01 General

Cable shall be laid on racks of concrete cable trench/cable channels/cable tunnels, directly buried in underground trench, in ducts, on racks / trays of the conveyor galleries, in GI pipes, in GI conduits (conduit embedded in walls / exposed on surface), in PVC casings and clamped along structure or buildings as per the site conditions and requirements.

05.07.02 Type of cable to be used

Petroleum jelly filled armoured cable shall be used when the cable is to be directly buried in underground trenches.

Armoured PVC cable shall be used when the cable is to be laid in concrete cable trench / cable tunnels / overhead cable galleries / directly clamped on the walls or structures.

All PVC cables shall be Fire retardant low smoke (FRLS) type.

For internal distribution purpose the cables from the distribution box to the individual subscriber, the cables shall be laid in the following manner:
In office buildings for unarmoured communication cables shall generally be laid through PVC casing / concealed conduits embedded in walls.

In shop floors, substations, control rooms etc communication cables shall generally be taken either through surface conduits along wall/structure or through concealed conduits embedded in wall,

05.07.03 Type of cable laying

1. For interplant cabling communication cables shall generally be laid in the manner as follows:

   Laid on the racks of the interplant concrete cable trench.

   Directly buried in underground trench.

   On the racks of the underground cable tunnels.

   On racks / trays of the overhead cable galleries.

   In concrete ducts / pipes buried in ground where direct burial are not possible due to presence of other service lines.

   Directly on the walls / structures by clamping the cable on to the walls.

2. Laying of cables shall include different types & sizes of cables required as specified in the specification.

3. The tenderer shall have to do any fabrication / modification work involving erection of cable supporting structures(if required), welding, gas cutting etc. at site as per the actual requirements.

4. The installation work shall be carried out in a neat manner by skilled, experienced and competent workmen, with experience in jointing and termination of communication cables.

5. The following general laying conditions / guidelines shall be followed by the tenderer for laying of cables:

6. All cables shall be tested for proper continuity and insulation before laying.

7. Care shall be taken that kinks, twists or mechanical damage do not occur to the cables during laying.
8. All bends in cables shall be made with due consideration to the minimum permissible bending radius of the cables.

9. Care shall be taken that during laying of cables, loops are not formed.

10. While pulling of cables, it shall not be allowed to be dragged along the ground or over a second cable already laid.

11. Cable markers shall be provided on either side of road crossings, at each turning and at regular intervals of 40/50 metres on straight runs for underground cables.

12. Joint markers shall be provided at every joint on the cable.

13. Where cables are required to cross under roads, surface drains and pipelines, they shall be taken through GI pipes.

14. Whenever cables leaves the trench for entering the buildings, they shall be specially protected by means of GI pipe. After cable laying these shall be sealed with bitumen or epoxy compound to make them fully water tight and vermin proof.

15. Cables in underground trench shall be laid with sufficient slack.

16. While taking exposed cables along walls or columns, these shall be fixed at a sufficient height for avoiding damage from operation or handling.

17. In no case the cables shall be left in excavation without providing for satisfactory sealing.

18. All cable openings in the equipment etc. shall be sealed and made vermin proof. All cable openings in walls and floors shall be repaired sealed after laying of cables.

19. Special care shall be taken for protection of cables against mechanical damage. RCC slabs of 40mm thickness shall be provided in the trench to protect the cables from any mechanical damage.

20. All cables shall be tested for their healthy condition after laying.

**05.07.04 Laying of Cables in Underground Trenches:**

Excavation of trench of 1.00 M depth shall be done as per the standard norms.

80mm thick river sand cushion shall be provided below the cable.

Cable of the mentioned size shall be laid above this sand layer.
80mm thick river sand cushion shall be provided above the cable.

RCC protection slab shall be provided as per requirement above the sand cushion.

Cable identification tags shall be provided at every 15 M interval in case of straight runs.

Cable marker shall be provided at every bend, at every road crossings and at every 40/50 M interval on straight runs.

05.07.05 **Laying of Cables on Walls & Structures:**

Perforated aluminum tray with angle iron support shall be provided (wherever required) for cable laying.

Smaller size cables shall be clamped on to the walls / structures. Clamps shall be provided at 1 meter interval.

Plastic / Aluminum cable ties shall be provided at one meter interval.

Cable identification tags on fibre glass/aluminum with nylon cord shall be provided at every 15 M interval.

05.07.06 **Laying of Cables in GI Pipes / GI Conduits:**

Only one cable shall be taken in one pipe in the case of laying cables through GI pipes / conduits. When it is found desirable to install several cables in one pipe total section of cable shall not exceed 40% of the GI pipe internal cross section.

05.07.07 **Laying of GI Pipes / Conduits:**

All conduits/pipes shall be neatly run and evenly placed.

Jointing of conduits / pipes shall be done only in straight portions the tenderer shall have at site bending facility for conduits / pipes and dies for threading of conduits / pipes.

Junction boxes shall be provided after every 10 M run of conduits / pipes, at every bend, at every location where the telephone provision is envisaged.
Ends of conduits shall be provided with threads so that DBs / CTBs / conduits / accessories can be attached at a later date.

No separate bend pieces shall be used, pipes/ conduits shall be bent wherever required.

The bending diameter shall not be less than six times the diameter of the conduit / pipes.

Exposed portion of the thread shall be painted with non-corrosive paint.

The end threads of conduits which will be left for extension / mounting of accessories shall be protected with grease or any other lubricant to prevent rust / corrosion.

16 SWG steel wires shall be provided inside each conduit for pulling cables.

Conduit shall be laid concealed in wall / column at a height of 200 mm from finished floor level.

05.07.08 Installation of Distribution cabinet:

Installation of cabinets shall be done on RCC foundations of 600mm above ground level.

Requisite number of suitably bent GI pipes shall be provided for incoming and outgoing cables.

Termination and sealing of cables inside the cabinet shall be done as per ITD specification.

Provision shall be kept for terminating jumper wires.

05.07.09 Installation of Distribution boxes:

Grouting of the support/welding to iron structures, with frames, shall be done wherever necessary.

Cable glands shall be provided and cables shall be terminated inside the Distribution Boxes as per ITD specification.

Cables shall be tested at both the ends after termination.