CONSTRUCTION MANUAL FOR GRID SUB-STATIONS
CONSTRUCTION MANUAL FOR SUBSTATIONS

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CHAPTER – 1

ELECTRICAL SUBSTATION
a. Introduction

An electrical Network comprises of the following systems:

- Generating Stations
- Transmission Systems
- Receiving Stations
- Distribution Systems
- Load Points

In all these systems, the power flow of electrical energy takes place through Electrical Substations. An Electrical Substation is an assemblage of electrical components including busbars, switchgear, power transformers, auxiliaries, etc. Basically an electrical substation consists of a number of incoming circuits and outgoing circuits connected to common busbar system. Busbars are conducting bars to which a number of incoming or outgoing circuits are connected. Each circuit has certain electrical components such as circuit-breakers, isolators, earthing switches, current transformers, voltage transformers, etc. These components are connected in a definite sequence such that a circuit can be switched off/on during normal operation by manual/remote command and also automatically during abnormal conditions such as short-circuits.

A substation receives electrical power from generating station via incoming transmission lines and delivers electrical power via the outgoing transmission lines. Substations are integral parts of a power system and form important links between the generating stations, transmission and distribution systems and the load points.

b. Functions of a sub-station:

An electricity supply undertaking generally aims at the following:

- Supply of required electrical power to all the consumers continuously at all times.
- Maximum possible coverage of the supply network over the given geographical area.
- Maximum security of supply.
- Shortest possible fault duration.
- Optimum efficiency of plants and the network.
- Supply of electrical power within targeted frequency limits.
- Supply of electrical power within specified voltage limits.
- Supply of electrical energy to the consumers at the lowest cost.

As a result of these objectives, there are various tasks which are closely associated with the generation, transmission, distribution and utilisation of the electrical energy. These tasks are performed by various, manual, semi-automatic and fully automatic devices located in generating stations and substations.

The tasks associated with a major substation in the transmission system include the following:

- Controlling the exchange of energy
• Protection of transmission system
• Ensuring steady state and transient stability
• Load shedding and prevention of loss of synchronism. Maintaining the system frequency within targeted limits
• Voltage control, reducing the reactive power flow by compensation of reactive power, tap-changing.
• Securing the supply by providing adequate line capacity and facility for changing the transmission paths.
• Data transmission via power line carrier for the purpose of network monitoring, control and protection.
• Determining the energy transfer through transmission lines and tie-lines.
• Fault analysis and pin-pointing the cause and subsequent improvements.
• Securing supply by feeding the network at various points.

All these tasks are performed by the team work of load-control centre and control rooms of substations. The substations perform several important tasks and are integral part of the power system.

c. Voltage Levels in AC Substations

A substation receives power via the incoming transmission lines and delivers power via the outgoing lines. The substation may have step-up transformers or step-down transformers. Generally the switchyards at sending-end of lines have step-up transformers and switchyards at receiving-end have step-down transformers. The rated voltage level refers to nominal voltage of 3 phase AC system and is expressed as r.m.s. value between phases. An AC substation has generally 2 or 3 main voltage levels. The long distance transmission is generally at extra high voltages such as 132 kV, 220 kV, 400 kV AC. The Sub-transmission is at medium high voltage such as 33 kV, 11 kV AC.

The choice of incoming and outgoing voltages of substations is decided by the rated voltages and rated power of corresponding lines. Long distance and high power transmission lines are at higher voltages. The nominal voltages are selected from the standard values of rated voltages specified in Indian Standards or relevant national standard.

The standards also specify the following steady state voltage within the limits specified below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Nominal System Voltage (kV rms)</th>
<th>Maximum (kV rms)</th>
<th>Minimum (kV rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>765</td>
<td>800</td>
<td>728</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
<td>420</td>
<td>380</td>
</tr>
<tr>
<td>3</td>
<td>220</td>
<td>245</td>
<td>198</td>
</tr>
<tr>
<td>4</td>
<td>132</td>
<td>145</td>
<td>122</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
<td>36</td>
<td>30</td>
</tr>
</tbody>
</table>

Reference Values of Nominal Voltages in AC Substations are as under:
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Reference Value of Nominal Voltage in RVPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC Substation</td>
<td>765 kV, 400 kV, 220 kV &amp; 132 kV</td>
</tr>
</tbody>
</table>
| 2      | Substation Auxiliaries       | Aux. AC Supply : 33 kV, 11 kV 400 V, 3 ph., phase to phase 230 V AC single phase  
|        |                              | Aux. LVDC : 220 V, 110 V, 48 V DC                                  |

**d. Essential Features of EHV AC Substations:**

A typical EHV AC substation has following essential features:

- Outdoor/ Indoor Switchyard having the EHV/ MV & LV Switchgears/ Equipments, Busbars (main and Jack buses).
- Control and Protection System installed in Control Room Building/ AC Bay Level KIOSK
- Substation SCADA/ Automation System with Substation Ethernet
- Substation Communication System using PLCC, Fiber Optic, OLTE etc.
- Substation Structures with Incoming/ Outgoing Line Gantries for Overhead Line/ cable Terminations
- Auxiliary LTAC Power Supply System
- Battery Room and low voltage dc supply system
- Substation Earthing System
- Fire Fighting System
- Lightening Protection System, Overhead Shielding
- Substation Lighting System
CHAPTER – 2

EHV SUBSTATION TYPES & CONFIGURATION
a. **Substation Types**

i. **Design Considerations of the Substation and Switchyard**

The Substation or Switchyard can be conventional air insulated substation (AIS) of Gas Insulated Substation (GIS) or a Hybrid Substation. The factors to be taken into account for designing substations shall be as under:

a. The choice of site for a substation or switchyard shall be based on technical, economic and environmental factors. The approximate location shall be determined on the grid considerations. The new substation shall enhance the operational flexibility, system reliability and transmission or transformation capacity after becoming a part of the network.

b. Land area required shall be considered based on the present and the future expansion on a 10-15 year scenario.

c. Reactive compensation as indicated by system studies shall be provided. The reactive compensation should be suitable planned for series or shunt type with fixed/ variable and switched/ non-switched options.

d. The selection of switching scheme shall be based upon requirements for operational flexibility, system safety, reliability, availability and cost.

ii. **Air Insulated Substations (Conventional Type)**

a. The switching schemes as per following table shall generally be adopted at different voltage levels in AIS depending on the importance of the installation.

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Voltage Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main and Aux/ Double Main</td>
<td>132 kV &amp; 33 kV</td>
</tr>
<tr>
<td>Double Main and Aux/ Double Main</td>
<td>220 kV</td>
</tr>
<tr>
<td>Breaker and Half Scheme</td>
<td>400 kV and 765 kV</td>
</tr>
</tbody>
</table>

b. In case of AIS, busbar shall be either of the rigid type with tubular aluminium bus conductor or flexible stranded conductor with aluminium conductor steel reinforced (ACSR) or all aluminium alloy (AAAC) or other suitable conductors. The conductor of appropriate rating and the number of conductors to be used in case of bundle conductors shall be selected considering power flow requirements and ambient conditions. For the rigid bus-bar arrangement, aluminium pipe conforming to relevant standard shall be used.

c. Outdoor air insulated substation or switchyard shall be shielded against direct lightning stroke by provision of overhead shield wire or earth wire or spikes (masts) of a combination thereof:

iii. **Gas Insulated Substation**

a. Gas-Insulated Substation (GIS) installations shall generally be preferred to conventional AIS as a techno-economic solution for location where space is a major constraint and also for seismic prone areas. However, techno-economic analysis shall be done to determine the preference for each GIS installation. The GIS shall comply with the relevant standards. The GIS installations shall be outdoor or indoor type.
b. The switching scheme has a large impact on the total cost of the GIS and shall be properly evaluated for a particular project. Single bus with or without sectionalisation and double main bus switching scheme shall be used depending on the voltage level and the importance of the installation. Other type of switching schemes can also be considered based on techno-economic analysis.

c. GIS shall be isolated phase or three phase non-magnetic enclosure type for voltage less than 400 kV. For 400 kV and higher voltage levels, it shall be isolated phase enclosure type.

d. The arrangement of gas sections or compartments shall be such as to facilitate future extension on either end without any drilling, cutting or welding on existing equipment from any manufacturer and without the necessity of moving or dislocating the existing switchgear bays.

e. The design shall be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment shall be protected against all types of voltage surges and shall necessarily include and component or assembly required for this purpose.

iv. **Hybrid Substation:**

In a hybrid substation, the busbars shall be air insulated type. Switchgear for a hybrid sub-station shall have some or all functional units enclosed in SF6 gas insulated housing. A hybrid substation would require less space than conventional AIS but more than GIS. A hybrid sub-station can be considered as techno-economic solution for locations where space is a constraint and also for sub-station renovation or augmentation.

b. **Substation Layout and Busbar Schemes:**

i. **Substation Configuration Considerations:**

The term layout denotes the physical arrangement of various components in the substation relative to one another. Substation layout has significant influence on the operation, maintenance, cost and protection of the substation and these aspects are considered while designing the substation layout. The reasoning behind the connections of components in each circuit and the busbars layout should be understood. Within the framework of the basic requirements, the substation layout can have several alternative arrangements. The substation layouts are selected on the basis of the size, the ratings, importance, local requirements and the prevailing practice of the supply authorities. These include the following:

1. Switching requirements for Normal Operation
2. Switching Requirements during abnormal operations, such as short circuits and overloads.
3. Degree of flexibility in operation, Simplicity
4. Freedom from total shutdown and permissible period of shutdown.
5. Maintenance Requirements, space for approaching various equipments for maintenance, roads, for transportation of main equipments and maintenance equipments.
6. Safety of Personnel
7. Protective Zones, main protection, back-up protection,
8. Bypass Facilities
9. Technical Requirements such as rating, clearances, earthing, Lightning Protection, noise, radio interference, etc.
10. Provision of extension, space requirements
11. Economic Considerations, availability, Imported Equipment and Cost Considerations of Equipments.
12. Requirement of Network Monitoring, PLCC/ Fiber Optic Communication, Local SCADA/Automation and data transmission requirements to Load Despatch centre etc.
13. Compatibility with ambient temperatures.
14. Environmental aspects, audible noise, RI, TI etc.
15. Long Service Life, Quality, Reliability, Aesthetics.
16. Location of PTs/CVTs – It should be such that the distance between the PT/CVT and the Control Room is minimum possible.
17. Location of CTs – It should be such that the CTs remain in circuit, even when the supply is being fed from the auxiliary bus in place of the main bus.

ii. Busbar Switching Schemes:

The choice of busbar schemes for AC yards depends upon several factors mentioned above. The important busbar schemes include the following:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Busbar Switching Scheme</th>
<th>Description</th>
<th>Drawing No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single Busbar</td>
<td>This is the simplest switching scheme in which each circuit is provided with one circuit breaker. This arrangement offers little security against busbar faults and no switching flexibility resulting into quite extensive outages of busbar and frequent maintenance of busbar isolator(s). The entire SubStation is lost in case of a fault on the busbar or on any busbar isolator and also in case of maintenance of the busbar. Another disadvantage of this switching scheme is that, in case of maintenance of circuit breaker, the associated feeders have also to be shutdown.</td>
<td>RVPN/CM/Drg-1</td>
</tr>
<tr>
<td>2</td>
<td>Main and Auxiliary Busbar</td>
<td>This is a technically single busbar arrangement with an additional busbar called “Auxiliary bus” energized.</td>
<td>RVPN/CM/Drg-2</td>
</tr>
<tr>
<td>Scheme</td>
<td>Description</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Double Busbar</td>
<td>In this scheme, a double busbar arrangement is provided. Each circuit can be connected to either one of the busbars through respective busbar isolator. Bus coupler breaker is also provided so that the circuits can be switched on from one bus to the other on load. This scheme suffers from the disadvantage that when any circuit breaker is taken out for maintenance, the associated feeder has to be shut down. This busbar arrangement is used in 220 kV, 132 kV, and 33 kV GIS Substations/ Switchyard.</td>
<td>RVPN/CM/Drg-3</td>
<td></td>
</tr>
<tr>
<td>Double Main and Auxiliary Bus</td>
<td>The limitation of double busbar scheme can be overcome by using additional Auxiliary Busbar, Bus-Coupler Breaker and Auxiliary Bus Isolators. The feeder is transferred to the Auxiliary bus during maintenance of its controlling circuit breaker without affecting the other circuits. This Bus bar arrangement is generally used in new 220 kV AIS Substations.</td>
<td>RVPN/CM/Drg-4</td>
<td></td>
</tr>
<tr>
<td>One and a Half Breaker Scheme</td>
<td>In this scheme, three circuit breakers are used for controlling two circuits which are connected between two busbars. Normally, both busbars are in service. A fault on any one of the busbars is cleared by opening one.</td>
<td>RVPN/CM/Drg-5</td>
<td></td>
</tr>
</tbody>
</table>
ngoftheassociatedcircuitbreakers connectedtothefaultybusbarwithoutaffectinge
continuityofsupply.Similarly,anycircuit
breakercanbetakenoutformaintenance
withoutcausinginterruption. Loadtransferis
achievedthroughthebreakerssand,therefore,
theoperationissimple.However,protective
relayingissomewhatmoreinvolvedasthecentral
(tie)breakerhastoberesponsive
troublesoneitherfeeder
inthecorrectsequence.Besides,eachelementof
hebayhastobere
carryingthecurrentsoftwofeedersomewhat
ratedfortheoperationsofvariousswitching
requirementsandincreasesthcost.Thebreakerand
halveschemebestforthose substations
whichhandlelargequantitiesofpowerandwhere
theorientationofoutgoing
feedersissinopposedirections.
Thisschemegenerallyusedinthe 765 kV
&400 kV AIS substations.

iii. Electrical Layout Plan (ELP):

While planning the layout and orientation of an EHV substation in order to
avoid right of way problem in future, approximate provision should be made
for installation of towers for incoming/ outgoing lines and this aspect should
be considered simultaneously and provision made accordingly in the
construction of emanating transmission lines. It is necessary to consider in the
layout design, the possibility of extension of substation. The line and
transformer bay sequence should, if possible, be fixed minimizing the
possibility of overloading busbars and connecting conductors.

The typical layouts used in the RVPN for various types of substations are
given as under for reference:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Drawing No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Typical 132 kV AIS Substation ELP</td>
<td>RVPN/CM/Drg-6</td>
</tr>
<tr>
<td>2</td>
<td>Typical Sectional Diagram for 132 kV Substations</td>
<td>RVPN/CM/Drg-7</td>
</tr>
<tr>
<td>3</td>
<td>Typical 220 kV AIS Substation ELP</td>
<td>RVPN/CM/Drg-8</td>
</tr>
<tr>
<td>4</td>
<td>Typical Sectional Diagram for 220 kV Substations</td>
<td>RVPN/CM/Drg-9</td>
</tr>
<tr>
<td>5</td>
<td>Typical 400 kV AIS Substation ELP</td>
<td>RVPN/CM/Drg-10</td>
</tr>
<tr>
<td>6</td>
<td>Typical Sectional Diagram for 400 kV Substations</td>
<td>RVPN/CM/Drg-11</td>
</tr>
<tr>
<td>7</td>
<td>Typical 765 kV AIS substation ELP</td>
<td>RVPN/CM/Drg-12</td>
</tr>
</tbody>
</table>
8. **Typical Sectional Diagrams for 765 kV Substations**

9. **Typical 132 kV Hybrid Substation ELP**

10. **Typical Sectional Diagram for 132 kV Hybrid Substation**

11. **Typical 132 kV GIS Substation ELP**

12. **Typical 220 kV GIS Substation ELP**

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**f. Centralized and Distributed Architecture:**

In the earlier substations, the protection relays were not communicable and therefore all the protection and control wiring with inter-locking were to be hard-wired with copper wiring.

With the advancement of technology, Numerical relays were introduced but were on propriety protocols of individual manufacturers. These numerical relays have capability to communicate through the serial communication ports on communication protocols such IEC-103.

Due to communication capability of these relays and Multi-function Transducers (Required for the measurement of Power System Parameters) and Remote Terminal Unit (RTU) and Substation Controllers along-with Computer Hardware and Softwares, data acquisition and monitoring of substation is possible. The combination of these devices is called Supervisory Control and Data Acquisition (SCADA) system at EHV Substations. The communications on such system was generally on the propriety communication protocols and Master-Slave architecture.

With the further advancement of the technology, faster numerical processing of data and availability of faster Ethernet based communication networks on fiber optic cables, the Bay Control Units (BCU) and Bay Protection Units (BPU), Gateways are developed by various manufacturers having such communication ports. The communication protocols are also standardized with IEC-61850. This architecture is based on client- server technology and faster communications between devices are possible with GOOSE messaging. Standardization of Communication Protocols by various manufacturers has lead to inter-operability of devices. Since the communication is possible on the fiber optic network, it is now possible to install these control and protection devices spreading over the switchyard.

In the Centralized Architecture, the control and Protection devices and SCADA system are installed in the control room with all the copper control wiring are to be wired to these panels.

In the distributed architecture, the Bay Level KIOSK/ Sub-Control Rooms are placed suitably in the Switchyard. The Control and Protection Devices (BCU/ BPU) are installed in the panels housed in this Bay Level KIOSK/ Sub-Control Rooms resulting into the reduced control cable wiring/ length and also simplification of trenches towards control room. Control Room requirements
are also reduced with only Computer Hardware/Software and AC/DC Supply system is required to be housed in it. The inter-bay and substation wise communication of devices on fiber optic network with the capability to implement Soft-Interlocks considerably reduce the requirements of control cabling. Civil Requirements are also reduced considerably. A typical architecture of the distributed architecture of Control and Protection with Automation system at substation is enclosed at RVPN/CM/Drg- __.
DISTRIBUTED ARCHITECTURE OF SUBSTATION CONTROL, PROTECTION AND AUTOMATION SYSTEM

Abbreviations:
- C&R: Control & Relay
- Fibre Optic Ring:

NOTE:
- i) Redundant station bus of optical fibre on IEC 61850
- ii) IEDs shall be directly connected to IEC 61850 bus
CHAPTER – 3

SELECTION OF SITE
1.0 SELECTION OF SITE:

1.1 Selection of site for construction of a Grid Sub Station is the first and important activity. This needs meticulous planning, foresight, skillful observation and handling so that the selected site is technically, environmentally, economically, and socially optimal and is the best suited to the requirements.

1.2 The main points to be considered in the selection of site for construction of a Grid Sub Station are given below.

1.3 The site should be:

a) As near the load centre as possible.

b) As far as possible rectangular or square in shape for ease of proper orientation of buses, bars, and feeders.

c) Far away from obstructions, to permit easy and safe approach/termination of high voltage overhead transmission lines.

d) Free from master plans/layouts or future development activities to have free line corridors for the present and in future.

e) Easily accessible to the public road to facilitate transport of material.

f) As far as possible near a town and away from municipal dumping grounds, burial grounds, tanneries and other obnoxious areas.

g) Preferably fairly leveled ground. This facilitates reduction in leveling expenditure.

h) Above highest flood level (HFL) so that there is no waterlogging.

i) Sufficiently away from areas where police and military rifle practices are held.

1.4 The site should have as far as possible good drinking water supply for the station staff.

1.5 The site of the proposed Sub Station should not be in the vicinity of an aerodrome. The distance of a Sub Station from an aerodrome should be maintained as per regulations of the aerodrome authority. Approval in writing should be obtained from the aerodrome authority in case the Sub Station is proposed to be located near an aerodrome.

2.0 REQUIREMENT OF LAND/AREA:
2.1 The site should have sufficient area to properly accommodate the SubStation buildings, structures, equipments, etc. and should have the sufficient area for future extension of the buildings and/or switchyard.

2.2 The requirement of land for construction of SubStation is as under:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Voltage Class of GSS</th>
<th>Required Area (Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>400 kV AIS with Staff Colony</td>
<td>20.0 Hectare</td>
</tr>
<tr>
<td>2.</td>
<td>220 kV AIS with Staff Colony</td>
<td>6.0 Hectare</td>
</tr>
<tr>
<td>3.</td>
<td>220 kV Hybrid GIS</td>
<td>2.0 Hectare</td>
</tr>
<tr>
<td>4.</td>
<td>220 kV GIS</td>
<td>1.0 Hectare</td>
</tr>
<tr>
<td>5.</td>
<td>132 kV AIS with Staff Colony</td>
<td>3.5 Hectare</td>
</tr>
<tr>
<td>6.</td>
<td>132 kV Hybrid GIS</td>
<td>0.5 Hectare</td>
</tr>
<tr>
<td>7.</td>
<td>132 kV GIS</td>
<td>0.25 Hectare</td>
</tr>
</tbody>
</table>

2.3 While preparing proposals for acquisition of private land and allotment of Government land, the area of land for respective Grid SubStations shall be taken into consideration as mentioned in para 2.2 above. While selecting Government land, the requirement may be made liberally but in other cases, where payment is to be made for the land acquisition, the requirement should be restricted to the limit mentioned in para 2.2.
CHAPTER – 4

SUBSTATION DESIGN
SAFETY CLEARANCES:

1.1 The various equipments and associated/required facilities have to be so arranged within the substation that specified minimum clearances are always available from the point of view of the system reliability and safety of operating personnel. These include the minimum clearances from live parts to earth, between live parts of adjacent phases and sectional clearance between live parts of adjacent circuits/bays. It must be ensured that sufficient clearance to ground is also available within the substation to ensure safety of the personnel moving about within the switchyard.

1.2 The Table below gives the minimum values of clearances required for substations up to 765 kV:

### Table for Minimum Clearances

<table>
<thead>
<tr>
<th>Nominal System Voltage (kV)</th>
<th>Highest System Voltage (kV)</th>
<th>Lightning Impulse Level (kV)</th>
<th>Switching Impulse Voltage (kV)</th>
<th>Minimum Clearances</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>12</td>
<td>70</td>
<td>--</td>
<td>Between Phase and Earth (mm) 178 Between Phases (mm) 229 Safety Clearances (mm) 2600 Ground Clearance * (mm) 3700</td>
</tr>
<tr>
<td>33</td>
<td>36</td>
<td>170</td>
<td>--</td>
<td>320 320 2800 3700</td>
</tr>
<tr>
<td>132</td>
<td>145</td>
<td>550</td>
<td>--</td>
<td>1100 1100 3700 4600</td>
</tr>
<tr>
<td>220</td>
<td>245</td>
<td>950</td>
<td>1050</td>
<td>1900 1900 4300 5500</td>
</tr>
<tr>
<td>400</td>
<td>420</td>
<td>1425</td>
<td>1050 (Ph–E) 1575(Ph–Ph)</td>
<td>3400 -- 6400 8000</td>
</tr>
<tr>
<td>765</td>
<td>800</td>
<td>2100</td>
<td>1550 (Ph–E) 2550(Ph–Ph)</td>
<td>6400 -- 10300 13000</td>
</tr>
</tbody>
</table>

* These values of air clearances are the minimum values dictated by electrical consideration and do not include any addition for construction tolerances, effect of short circuits, wind effects and safety of personnel, etc.

* For safety of personnel moving in the switchyard with tools & plant.

### Notes:

1) The values in the Table above refer to an altitude not exceeding 1000 meters and take into account the most unfavourable conditions which may result from the atmosphere.
eric
pressure variation, temperature and moisture. A correction factor of 1.25 percent per 100 Meters is to be applied for increasing the air clearance for altitudes more than 1000 Meters and up to 3000 Meters.

2) “Safety Clearance” is the minimum clearance to be maintained in air between the live part of the equipment on one hand and earth or another piece of equipment or conductor (on which it is necessary to carry out the work) on the other.

1.3 As per Rule 64(2) of the Indian Electricity Rules, 1956, the following safety working clearances shall be maintained for the bare conductors and live parts of any apparatus in any Substation, excluding overhead lines of HV and EHV installations:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nominal System Voltage (kV)</th>
<th>Highest System Voltage (kV)</th>
<th>Safety Working Clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>11</td>
<td>12</td>
<td>2600</td>
</tr>
<tr>
<td>2.</td>
<td>33</td>
<td>36</td>
<td>2800</td>
</tr>
<tr>
<td>3.</td>
<td>132</td>
<td>145</td>
<td>3700</td>
</tr>
<tr>
<td>4.</td>
<td>220</td>
<td>245</td>
<td>4300</td>
</tr>
<tr>
<td>5.</td>
<td>400</td>
<td>420</td>
<td>6400</td>
</tr>
<tr>
<td>6.</td>
<td>765</td>
<td>800</td>
<td>10300</td>
</tr>
</tbody>
</table>

Notes:

i) The above values are valid for altitudes not exceeding 1000 Meters. A correction factor of 1.25 percent per 100 Meters is to be applied for increasing the clearance for altitudes more than 1000 Meters and up to 3000 Meters.

ii) The above safety working clearances are based on an insulator height of 2440 mm, which is the height from the lowest point on the insulator (where it meets the earthed metals) from the ground.

iii) “Safety Working Clearance” is the minimum clearance to be maintained in air between the live part of the equipment on one hand and earth or another piece of equipment or conductor (on which it is necessary to carry out the work) on the other.
EARTHMAT DESIGN:

1.0 BASIC REQUIREMENT:

1.1 Provision of an adequate earthings system in a Sub Station is extremely important for the safety of the operating personnel as well as for proper system operation and performance of the protective devices. The primary requirements of a good earthings system in a Sub Station are:

a) The impedance to ground should be as low as possible but it should not exceed 1.0 (ONE) Ohm.

b) The Step Potential, which is the maximum value of the potential difference possible of being shunted by a human body between two accessible points on the ground separated by the distance of one pace (which may be assumed to be one metre), should be within safe limits.

c) Touch Potential, which is the maximum value of the potential difference between a point on the ground and a point on an object likely to carry fault currents such that the points can be touched by a person, should also be within safe limits.

1.2 To meet these requirements, an earthed system comprising of an earthings mat buried at a suitable depth below ground and supplemented with ground rods at suitable points is provided in the Sub Stations.

1.3 All the structures & equipments in the Sub Station are connected to the earthings mat so as to ensure that under fault conditions, none of these parts is at a potential higher than that of the earthings mat.

1.4 The neutral points of different voltage levels of transformers & reactors are separately earthed at two different points. Each of these earthed points should be interconnected with the station earthings mat.

2.0 MEASUREMENT OF EARTH RESISTIVITY:

2.1 Weather Conditions:
The resistivity of earth varies over a widerange depending on its moisture content. It is, therefore, advisable to conduct earth resistivity tests during the dry season in order to get conservative results.

2.2 Test Procedure:
Four electrodes are driven into the earth at equal intervals along a straight line in the chosen direction. The depth of the electrodes in the ground shall be of the order of 30 to 50 cm. The earth resistance Megger is placed on a steady and approximately level base, the link between terminals P and C is opened and the four electrodes are connected to the instrument terminals as shown in the figure. An appropriate range on the instrument,
avoiding the two ends of the scale as far as possible, is then selected to obtain clear readings.
Theresistivityiscalculated fromtheequationgivenbelow:

where
\[ \rho = 2 \pi s R \]
\( \rho \) = resistivityofsoilinohm–metre,
\( s \) = distancebetweentwosuccessiveelectrodesin metres,and
\( R \) = Meggerreadinginohms.

2.3 TestingSoilUniformity.
2.3.1 It isdesirableto get informationaboutthe horizontalandvertical variationsin earth resistivityoverthesiteunderconsideration. Thehorizontalandverticalvariationmaybe detectedbyrepeatingthe tests atleast6(Six) differentlocationwithanumberofdifferent electrode spacings, increasing from 1metre to 50metres in the steps of 1, 5, 10, 15, 25 and 50metres. A diagram showing the typical layout for earth resistivity measurement in 6 directions is enclosed.

2.3.2 Thesereadings, along with a sketch showing the directions in which earth resistivity readings have been taken, shall besubmittedtolotheSuperintending Engineer(400KV Design) for designing the earthmat.
2.3.3 An example of the format in which the earth resistivity readings are to be recorded is given below.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Electrode Spacing</th>
<th>Megger Reading in Ohms</th>
<th>Earth Resistivity in Ohm–m</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direction1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>1 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>5 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>10 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>15 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>25 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>50 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Direction2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>1 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>5 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>10 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>15 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>25 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>50 M</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Similarly for Direction 3 to Direction 6.
CHAPTER – 5

SUBSTATION

PROJECT MANAGEMENT
a. Concept of Project Management

The project is a combination of activities and resources to be utilized in a way that project is completed in time schedule without cost overrun. Following are the key resources/ components which need to be managed in the project management:

i. Project Organization and Responsibilities
ii. Manpower/ Labour Resource
iii. Material and Machine Resource
iv. Financial Expenditures/ Bookings
v. Physical Progress
vi. Time-Lines for various activities and Completion Schedule.
vii. Documentation such as drawings, approvals, Technical Documentation etc.

b. The responsibilities and action plans for the various activities for the substation construction to be executed departmentally is as under:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Activity under the Project</th>
<th>Office/ Officers Responsible for the activity</th>
<th>No. of days required for the Activity (Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Planning of Substation as per Requirement of System send by respective Discom’s after carrying out the detailed System Studies</td>
<td>SE (P&amp;P), RVPN, Jaipur under PPM wing</td>
<td>30</td>
</tr>
<tr>
<td>2.</td>
<td>Preparation of Project Report with Estimation of Cost (Typical BOQ for 132 kV and 220 kV AIS Substations are enclosed at RVPN/CM/Drg.- ___ and RVPN/CM/Drg.- ___ for reference which should be modified as per project specific requirements. The Standard Issue Rate of Material and overheads as prescribed by RVPN be used for preparation of various type of Estimates)</td>
<td>SE (P&amp;P), RVPN, Jaipur under PPM wing Cost Estimates to be updated from the latest purchases from SE (400 kV Design/ Purchase) and CE (MM) Standard Issue Rate. SE (P&amp;P) can take the tentative estimations for special projects from respective wings which are not standard in nature.</td>
<td>15</td>
</tr>
<tr>
<td>3.</td>
<td>To obtain the approval of</td>
<td>CE (PPM)</td>
<td>15</td>
</tr>
<tr>
<td>Whole Time Directors/Board of Directors as per the Delegation of Powers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Conveying of administrative approval to Concerned CE and Concerned CE (Civil)</td>
<td>CE (PPM)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5. Technical Sanction of the Estimate of Work</td>
<td>ZCE (T&amp;C)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>6. Approval and Opening of WiM</td>
<td>Circle SE and Circle Accounts officer</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>7. Approval of Project Team</td>
<td>ZCE (T&amp;C) shall issue order for project execution team i.e. Circle SE, XEn, AEn&amp;JEn responsible for project execution and supervision. ZCE (T&amp;C) shall issue order for project execution team i.e. Circle SE, XEn, AEn&amp;JEn responsible for project execution and supervision.</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8. Identification of Land for the Substation</td>
<td>Respective Circle SE shall identify the suitable land for the substation and submit the various alternatives for the approval of concerned Zonal Chief Engineer</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>9. Allotment of the Land from the Administration</td>
<td>Respective Circle SE shall identify the suitable land for the substation and submit the various alternatives for the approval of concerned Zonal Chief Engineer</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>10. Land Acquisition, Lease Deed Matters</td>
<td>Respective SE in consultation with the Land Acquisition Officer</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>11. Physical Possession of Land after allotment</td>
<td>Concerned XEN/ AEN</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>12. Boundary Wall of the Substation Land</td>
<td>Concerned SE shall intimate to concerned SE (Civil) for initiating action for Boundary wall of the substation land.</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>13. Survey Details of Land with Land Plan with</td>
<td>Concerned AEN/XEN will submit the same to SE</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Activity Description</td>
<td>Responsible Authority</td>
<td>Remarks</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>14.</td>
<td>Development of Tentative Single Line Diagram and Electrical Layout Plan</td>
<td>SE (400 kV Design)</td>
<td>15</td>
</tr>
<tr>
<td>15.</td>
<td>Final Single Line Diagram and Electrical Layout Plan</td>
<td>SE (400 kV Design)</td>
<td>7</td>
</tr>
<tr>
<td>16.</td>
<td>Earth-mat Design and Layout</td>
<td>SE (400 kV Design)</td>
<td>30</td>
</tr>
<tr>
<td>17.</td>
<td>Execution of Civil Works such as Civil Foundation for structures, Transformers</td>
<td>Concerned SE (Civil)</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Control Room Building, Pathways, Trenches, Jelly spreading, Internal Road, Drainage</td>
<td>Residential Quarters requirements shall be got approved from the concerned ZCE (T&amp;C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>System, Water Supply System, Colony Area etc. as per approved Electrical Layout plan.</td>
<td>before civil execution.</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Purchase and Availability of Required Material in the Stores/ Site</td>
<td>CE (MM)</td>
<td>240</td>
</tr>
<tr>
<td>20.</td>
<td>Allotment of Material for the Project</td>
<td>ZCE (T&amp;C), Jaipur / Concerned ZCE</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>kV and 220 kV AIS Substations are enclosed at RVPN/CM/Drg- ___ and RVPN/CM/Drg.- ___</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>for reference which should be modified as per</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>project specific requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Award of Work on Labour Rate Contract</td>
<td>Concerned SE/ XEn as per delegation of Power</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Execution of Electrical work (s) awarded on labour rate including Structure Erection, Erection of Busbars &amp; Interconnections, Equipment Erection, Transformer Erection, Cable Laying, Earthing System, Lighting System etc.</td>
<td>Contractor to be supervised by Concerned Project Team</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Preparation of Cable Schedule for the termination in Switchyard and Control Room</td>
<td>Concerned JEN/AEN to be checked by XEn</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Functional and Operational testing of Switchyard Equipments/ Switchgears</td>
<td>Concerned JEN/AEN to be checked by XEn</td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>Testing of Switchgears, Transformers and other equipments with Control and Protection System under the project</td>
<td>Concerned XEn (Protection) in coordination with concerned Project team.</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Deposition of Electrical Inspector Fees for clearance of charging</td>
<td>Concerned XEn/ AEn</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>Commissioning of Substation Project</td>
<td>Concerned Project Team with XEn (Protection)</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>Documentation of Project i.e. Technical Literature, Brochures, Cable Schedule, and Commissioning Test Results</td>
<td>Concerned Project Team shall handover to Substation-In-charge</td>
<td></td>
</tr>
</tbody>
</table>

Some activities in the construction of a substation can happen simultaneously. The overlapping of the activities should be planned to minimize the time needed to construct the substation.

c. **Project Monitoring and Review Technique (PERT)**

All the substation projects need to be monitored for the progress against the decided time schedule. Various softwares are available for preparation of PERT chart is available. A typical PERT chart is developed in MS- Project software for EHV substation projects and enclosed at RVPN/CM/Drg- _____ for reference. For all the projects, specific PERT chart shall be issued with the time schedule for each activity after the administrative and financial approval of the project.
Master PERT chart of the Project shall be prepared by CE (PPM) in consultation with the ZCE / CE (Civil) concerned and CE (MM) which shall be got approved from the WTD of RVPN.

Based on this master PERT Chart, each concerned wing such as T&C, MM and Civil shall prepare the sub PERT charts to match with the Master PERT chart schedule. Sub PERT chart shall have detailed break-up of the activities with the time schedules and responsible office/ officer.

Monitoring and the Sub-PERT chart shall be monitored at the level of concerned wing to complete the activity on or before the schedule of the Master PERT chart. Concerned CE shall ensure the weekly/ fortnightly/ monthly progress recording/ updating and review of activities. The delay/ lagging in any activity shall be documentarily recorded with reasons and signed by the project team/ Responsible officers.

Monitoring of the Master PERT chart shall be done at the level of CE (PPM) and shall be periodically apprised to WTD of RVPN regarding progress, slippage of schedule and identifying the activity lagging behind the schedule.

The other important aspect of the project is financial booking in line with the physical progress. The Quarterly financial booking of the project shall be submitted by T&C, Civil and Accounts wings, proper re-conciliation of Accounts and concerned wing shall be done. Quarterly financial booking shall be submitted by concerned CE to CE (PPM) for incorporation in PERT report showing financial and physical progress.
CHAPTER – 6

SUBSTATION SUB-SYSTEMS
3.5 ILLUMINATION SYSTEM:
3.5.1 Good lighting in a substation is necessary to facilitate normal operation and maintenance activities and at the same time to ensure safety of the working personnel. As per latest IS:3646 (Pt.II) “Schedule for values of illumination and Glare Index” recommends values of intensity of illumination. Table 3.1 contains the recommended values for different parts of substation.

Table 3.1: Recommended Illuminator Values

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Particulars</th>
<th>Average Illumination level ‘Lux’</th>
<th>Limiting Glare Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><strong>Control rooms:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical contro panels</td>
<td>200 to 300</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Rear of control panels</td>
<td>150</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Control desks</td>
<td>300</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Switch houses</td>
<td>150</td>
<td>25</td>
</tr>
<tr>
<td>2.</td>
<td>Battery room</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>Carrier room</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Offices and reception</td>
<td>300</td>
<td>19</td>
</tr>
<tr>
<td>5.</td>
<td>Cloak rooms</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>6.</td>
<td>Workshop/Repair bay</td>
<td>300</td>
<td>25</td>
</tr>
<tr>
<td>7.</td>
<td>Test room</td>
<td>450</td>
<td>19</td>
</tr>
<tr>
<td>8.</td>
<td>Outdoor switchyard</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>9.</td>
<td>Stairs</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>10.</td>
<td>Corridors</td>
<td>70</td>
<td>16</td>
</tr>
<tr>
<td>11.</td>
<td>Approach roads</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>12.</td>
<td>Pathways</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>13.</td>
<td>Car parks</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>14.</td>
<td>Conference room</td>
<td>300</td>
<td>19</td>
</tr>
<tr>
<td>15.</td>
<td>Store room</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>16.</td>
<td>Cable gallery/floor</td>
<td>70</td>
<td>-</td>
</tr>
<tr>
<td>17.</td>
<td>AC plant/DG set room</td>
<td>150</td>
<td>-</td>
</tr>
</tbody>
</table>
Out door switchyard average illumination level shall be 50 lux on main equipment and 20 lux on balance area of switchyard. In the out door switchyard, the area covered by transformer/reactor should have 50 lux.

3.5.2 The lighting system of a particular area whether outdoor or indoor should be designed in such a way that uniform illumination is achieved. As far as possible any dark spots should be avoided. This requires careful placing of the luminaries, selection of proper mounting heights and provision of sockets in the marshalling kiosks and mechanism boxes of circuit breakers/disconnect switches for providing supplementary lighting wherever required. In outdoor switchyards, only the equipment/bus bar areas are illuminated. In outdoor area, luminaries should be directed as far as possible towards transformers, circuit breakers/disconnect switches, their mechanism boxes etc., where some operations may be necessary during emergency at night.

3.5.3 There are several classifications of the types of lighting such as direct, indirect, semi-indirect, diffusion, etc., The types of lighting or the combinations should be so chosen as would provide adequate level of glare-free illumination without creating undesirable shadows.

3.5.4 Direct lighting system is the most commonly used and it employs open dispersive reflectors, silver glass reflectors and angle reflectors. The simplest form of general diffusion fitting is the plain sphere of opal glass. The spherical form be modified and any form, which the designer can think of may be used. The efficiency of the general diffusion fitting depends partly on shape but much more on the properties of the diffusing material used.

3.5.5 The typical indirect fitting is and opaque bowl with lamp suspended in it at such a depth that all the direct light from the lamp as well as form the bowl is emitted in the upper hemisphere. The semi direct fittings lie in between the indirect and the general diffusion fittings.

3.5.6 Flood light fittings are in essence, projectors with parabolic reflectors. There are two types of floodlights: the wide beam type and the narrow beam type. Wide beam type is suitable where accurate control is not necessary and the light is projected only over a short distance. The narrow beam type is used where light is required to be projected over longer distances.

3.5.7 The choice of lamps, i.e. incandescent, fluorescent, mercury vapour, sodium vapour halogen etc., depends mainly on the nature of work, the number of hour of utilization annually, the cost of energy and the power available for illumination. Table 3.2 gives different types of lamps and fittings that may be used in different area of a substation.

3.5.8 The foremost criterion in the design of illumination system of indoor area such as control room, workshop, repair bay, offices, etc., is that illumination at the working height throughout the area should be as uniform as possible so as to avoid eye fatigue. In practice, complete uniformity of illumination is difficult to achieve and a ratio of the minimum intensity to the maximum equal to about 70 percent is usually considered acceptable.

3.5.9 Energy conservation requirement has to be kept in view while selecting type of lamp and type of fitting. While designing the lux level requirement Utilization coefficient factor may be considered to take care effect of dust, pollution etc. on reflectors used in the lighting fixtures.
The night time lighting of exterior areas is necessitated by operational requirement, security or decorative purposes or a combination of these. It is used for illuminating outdoor switchyards transformer yards, approach roads to substations, etc., Use of flood lights has been in practice for illumination of switchyards. However, floor lights generally cause glare, if not properly positioned and mounted at proper heights. As the lumen output of mercury/dodium vapour lamps is quite appreciable as compared to incandescent lamps, flood light units having mercury/sodium vapour lamps with medium and wide angle coverage, mounted at suitable heights are preferred. If the floor light is mounted at a height of 6 to 10m it would be away from the normal vision angle (8) of a man approaching it and therefore, there would be no problem of glare. If the design of the flood lighting is followed in an orderly fashion, it is easy to obtain uniform illumination in the outdoor switchyard. The spillover light from flood lights provided in the switchyard is generally sufficient for fence lighting. Separate fence lighting is provided only in exceptional cases. Light fittings in the switchyards are mounted on substation structure/lighting masts. Typical lamps and fittings generally provided in some identified areas are given in Table 3.2

Table 3.2. Typical Lamps & Fittings in Some identified Areas.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Particulars of area</th>
<th>Type of lamps</th>
<th>Type of fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Unloading-cum-repair bay</td>
<td>Mercury vapour sodium</td>
<td>High bay</td>
</tr>
<tr>
<td>2.</td>
<td>Store rooms, workshops</td>
<td>Fluorescent</td>
<td>Industrial</td>
</tr>
<tr>
<td>3.</td>
<td>Control room, offices carrier room</td>
<td>Fluorescent</td>
<td>Decorative</td>
</tr>
<tr>
<td>4.</td>
<td>Battery room</td>
<td>Fluorescent</td>
<td>Acid proof, Industrial</td>
</tr>
<tr>
<td>5.</td>
<td>Compressor room etc.,</td>
<td>Fluorescent</td>
<td>Industrial</td>
</tr>
<tr>
<td>6.</td>
<td>External lighting on building</td>
<td>Mercury vapour sodium vapour</td>
<td>Water tight flood light</td>
</tr>
<tr>
<td>7.</td>
<td>Outdoor switchyard</td>
<td>Mercury vapour sodium vapour</td>
<td>Water tight flood light</td>
</tr>
<tr>
<td>8.</td>
<td>Fence lighting</td>
<td>Mercury vapour sodium vapour</td>
<td>Post type water tight, flood light</td>
</tr>
<tr>
<td>9.</td>
<td>Roads</td>
<td>Mercury vapour sodium vapour</td>
<td>Post type water tight, flood light</td>
</tr>
</tbody>
</table>

3.5.10 The purpose of street lighting in substations is to promote safety and convenience on the approach roads, service roads and side walls inside switchyard, etc. The aim should be to provide conditions of visibility adequate for accurate, certain and comfortable seeing.

3.5.11 Emergency lighting is called for in case of AC supply failure in substations. In indoor installations such as a control room, switchgear rooms, etc., DC lamps
connected to the DC supply system should be provided at suitable locations. These are brought into service in case of AC supply failure. These are normally ired through automatic changeover contractor at the DC distribution board. In workshops/repair shops and machine hall, where mercury/dodiumvavour lamps are employed, provision should be made for one incandescent lamp fitting of suitable power for a group of 4 to 6 mercury/dodium vapour lamps. This would avoid an extended total blackout in the event of a voltage dip or momentary interruption of AC supply, as the discharge lamps take a few minutes to give full light output again.

3.8 FIRE PROTECTION FACILITIES

3.8.1 In view of a large number of oil-filled equipments in a substation, it is very important that proper attention is given to isolation, limitation and extinguishing of fire so as to avoid damage to costly equipment, reduce chances of serious dislocation of power supply and ensure safety of personnel. The first step in this direction is inherent in the design and loayout of the substation itself, which should be such that if fire occurs in any equipment it should be limited and isolated so that it does not spread to other equipments. For this purpose the following are the general guidelines:

(i) The spacing of the equipment should be considered. Extra space is not usually provided for fire isolation, but the space available is taken into account in deciding the isolation measures.

(ii) Fire isolation walls should be provided between large oil-filled equipments such as two or more transformers placed adjacent to each other. These should be of adequate strength and of such size that the adjacent equipment is reasonable safe from fire risk due to burning oil flying from the equipment on fire.

(iii) In indoor areas automatic fireproof doors should be provided for rooms which house major oil-filled equipment. The rooms should also be constructed with a view to isolating the fire.

(iv) Soak pits or drain pits should be provided below large oil-filled equipment to drain off the burning oil falling below the equipment.

(v) Minor items of oil-filled equipment should be placed in beds of gravel or pebbles which will quench and prevent the spread of burning oil.

(vi) Care should be exercised that any prospective fire can be easily approached for quenching. In closed spaces and buildings attention should also be given to evacuation of personnel (Refer IS: 1646).

(vii) All oil pipes and cable trenches should be sectionalized by means of cross walls.


3.8.4 Fire Fighting System

3.8.4.1 All substations should be equipped with fire fighting systems conforming to the requirements given in latest IS:1646 and Fire Protection Manual Part-I issued by Tariff Advisory Committee of Insurance Companies.
3.8.4.2 Trailer pumps where provided should draw their water supply from ground tanks of suitable sizes, the location and distribution of which shall be such that no item to be protected is more than about 90m away from any ground tank.

3.8.4.3 The more valuable equipment or areas forming concentrated fire risk should be covered by special fire protective systems. In this class are:

(a) Transformers, both indoor and outdoor:
(b) Oil filled reactors:
(c) Oil-filled switchgear:
(d) Oil tanks and oil pumps:
(e) Oil, grease and paint stores: and
(f) Synchronous condensers.

3.8.4.4 Although the substitution of bulk-oil and minimum oil circuit breakers by SF6 gas circuit breakers has reduced the risk of fires in electrical installations, considerable risk still exists on account of transformers, reactors, cables etc., which contain combustible insulating materials. Fires in live electrical equipment, motors, machinery etc. fall in class C according to the Tariff Advisory Committee Classification of Fires. It is necessary to provide efficient Fire Protection Systems in the Electrical installations. Fire Protection System consists of the following:

(i) Fire Prevention
(ii) Fire Detection and annunciation
(iii) Fire Extinguishing

3.8.5 Fire Prevention:

3.8.5.1 Fire prevention is of utmost importance and should be given its due if risk of occurrence of fires has to be eliminated/minimized. The safety and preventive measures applicable for substations as recommended by the relevant authorities must be strictly followed while planning the substations.

3.8.5.2 All fire fighting equipment and systems should be properly maintained Regular mock drills should be conducted and substation staff made aware of importance of fire prevention and imparted training in proper use of the fire fighting equipment provided in various parts of the substation, control room building etc.

3.8.6 Fire Detection and Annunciation

3.8.6.1 Fire detection if carried out at the incipient stage can help in timely containment and extinguishing of fire speedily. Detection can either be done visually by the personnel present in vicinity of the site of occurrence or automatically with the use of detectors operating on the principles of fixed temperature, resistance variation, differential thermal expansion, rate of rise of temperature, presence of smoke, gas, flame etc. Fire detectors of the following types are usually used:

(i) Ionisation type
(ii) Smoke type
(iii) Photoelectric type
(iv) Bimetal type
(v) Linear heat detection type

3.8.6.2 Ionisation type detectors are used more commonly. However in areas like cable vaults, ionisation smoke and linear heat detection type detectors are used. Smoke type detector is effective for invisible smoke, and photoelectric type for visible smoke. Smoke type detectors incorporate LEDs, which start glowing in the event of fire.

3.8.6.3 Detectors are located at strategic positions and arranged in zones to facilitate proper indication of fire location, transmission of Audio-visual signals to Fire control panels and actuation of the appropriate Fire Fighting Systems. In the rooms with false ceilings, these are provided above the ceiling as well as below it. For the detectors located above the false ceilings, remote response indicators should also be provided.

3.8.6.4 Detectors are provided at the rate of one for a maximum area of 80m in the zones to be covered by the Fire Protection System.

3.8.7 The Fire Extinguishing Systems used for fire protection of the various equipments/building in substations are the following:

(i) Hydrant system
(ii) High velocity water spray system
(iii) Portable fire extinguishers
(iv) Nitrogen injection fire prevention method for transformer only

These are described below briefly.

3.8.8 Hydrant System

3.8.8.1 Hydrant System is installed for the protection of the following areas from fire:

(i) Control room building
(ii) L.T. transformer area
(iii) Diesel generator set building
(iv) Fire water pump house
(v) Suitable location in the switchyard.

3.8.8.2 Hydrants are the backbone of Fire Fighting System as these can help fighting fires of all intensities in all classes of fires and continue to be in service even if the affected buildings/structures have collapsed. These keep the adjoining properties/buildings cool and thereby save them from the serious effects of fire and minimize the risk of explosions.
3.8.8.3 The Hydrant system is supplied water from Fire Water Pump House. Fire Water Pump House is located by the side of Fire Water Storage Tanks constructed within the substation boundary limits. These tanks are made of RCC above ground such that these are easily accessible. Water from these tanks is pumped into the Fire Hydrant System with horizontal centrifugal pumps.

3.8.8.4 The Hydrant System essentially consists of a network of pipes, laid both above ground and underground, which feed water under pressure to a number of hydrant valves located at strategic locations throughout the substation. Pressure in the piping is maintained with the help of hydro-pneumatic tanks and jockey pumps. Jockey pumps compensate for minor leakages also. The hydro-pneumatic tanks are pressurized with compressed air supplied by two air-compressors of which one is working at a time and other acts as standby.

Adjacent to the Hydrants, hosepipes, branch pipes and nozzles are kept in Hose Boxes. In case of fire, the houses with nozzies are coupled to the respective hydrants and water jet is directed towards the seat of fire.

3.8.8.5 On drop of pressure in the piping network below a preset value, the Hydrant Pump starts automatically and continues to run till it is stopped manually after fire has been extinguished.

3.8.8.6 The quantity of water to be available for fire protection and the number of fire water pumps depend on the total number of hydrants which are provided as per guidelines of Tariff Advisory Committee Manual, according to which substations fall in “Light Fire Hazard” category. The parameters of the Fire Water Pumps as per TAC guidelines are given below.

(a) For the total number of hydrants up to twenty, one no. pump of 96 m/hr capacity with a pressure of 5.6 kg/cm (gauge)

(b) For the total number of hydrants exceeding twenty up to fifty five, one no. pump of 137 m/hr capacity with a pressure of 7.0 kg/cm (gauge)

(c) For the total number of hydrants exceeding fifty five, up to hundred, one no. pump of 171 m/hr with a pressure of 7.0 kg/cm (gauge)

3.8.8.7 As per TAC guidelines, the jockey pump should have a capacity of 10.8 m/hr. and the hydro-pneumatic tank should have a capacity of 18 m. The effective capacity of the Fire Water Tank should be not less than one hour of aggregate pumping capacity, with a minimum of 135 m.

3.8.8.8 All components of the Hydrant System such as piping, valves, fittings, hoses, branch pipes, nozzies etc. should be of approved make acceptable to TAC.

3.8.9 High Velocity Water (HVW) Spray System

3.8.9 This type of Fire Protection System is provided for the following types of equipment:

(i) Power Transformer, both auto and multi-winding

(ii) Shunt Reactors
This system is designed on the assumption that one reactor/transformer is on fire at a time. For this assumption, the largest piece of equipment forms the basis.

3.8.9.2 High Velocity Water Spray System consists of a network of projectors arranged around the equipment to be protected. Water under pressure is directed into the projector network through a deluge valve from a piping network exclusively laid for the Spray System. Water leaves the projectors in the form of conical spray of water droplets travelling at high velocity.

3.8.9.3 The high velocity droplets bombard the surface of oil and form an emulsion of oil and water which does not support combustion. This emulsion converts a flammable liquid into a non-inflammable one. However, this emulsion is not of a stable character and therefore shortly after the water is shut off, oil starts to separate out from water which can be drained away, leaving the oil behind unimpaired.

3.8.9.4 The rate of burning of a flammable liquid depends upon the rate at which it vaporizes and the supply of oxygen to support combustion. It is the maximum when the rate of burning of the flammable liquid is the maximum and the surface of the liquid is near boiling point. The high velocity water spray system while forming an emulsion, intersperses cold water with the liquid, cools it and lowers down the rate of vapourisation which prevents further escape of flammable vapours. During passage of water droplets through flames, some of the water gets converted into steam, which dilutes oxygen in the air supporting the fire and creates a smothering effect, which aids in extinguishing the fire.

3.8.9.5 An automatic deluge valve triggered by a separate system of quartzoid bulb detector heads mounted on a pipe work array charged with water, at HVW spray mains pressure, initiates the HVW Spray System operation. When a fire causes one or more of the quartzoid bulbs to operate, pressure in the detector pipe work falls and this allow the deluge valve to open thereby permitting water to flow to all the projectors in the open pipe array covering the risk.

3.8.9.6 Water Supply to HVW Spray System

(a) Two pumps are provided for HVW Spray System. Of these, one is electric motor driven and the other diesel engine driven. The capacity and head of the pumps is selected to protect the biggest risk. It has been experienced that each pump having a capacity of 410 m/hr is usually adequate for the biggest risk in substations.

(b) These pumps are located in Fire Water Pump House. Suitable connection with the Hydrant System is provided so as to allow flow of water from Hydrant System to HVW Spray System but not in the reverse direction.

(c) Standby diesel engine driven pump is a common standby facility for HVW spray as well as Hydrant System.

(d) These pumps are automatically started through pressure switches located sequentially in headers. However, stopping of the pumps is done manually after the fire gets extinguished.

(e) The values of pressure of running water and discharge density given below are recommended for HVW Spray System:

(i) Minimum pressure of running water = 3.5 Bar
(ii) Maximum pressure of running water = 5.0 Bar
   At any projector at any instance
(iii) Discharge density on ground surface = 6.1 lpm/m
iv) Discharge density on other surface = Not less than 10.2 lpm/m

3.8.10 Water Supplies

Water for fire fighting purposes should be supplied from the water storage tanks meant exclusively for the purpose. The aggregate storage capacity of these tanks should be equal to the sum of the following:

(i) One-hour pumping capacity of Hydrant System or 135 m which over is more.
(ii) Half-an-hour water requirement for single largest risk covered by HVW Spray System.

The water storage tank made of RCC construction over ground should be in two parts.

3.8.10.2 Fire Water pumps located in the Fire Water Pump House should have pumping head suitable to cover the facilities for future stages also. The piping system should be designed to permit extensions without disruption in the existing system. The material of piping is mild steel as per IS: 1239/IS:3589 medium grade system. The pipe laid underground is coated and wrapped against corrosion as per IS:10221 and the piping laid over ground consists of galvanised mild steel.

3.8.10.3 All equipment and accessories, constituting the HVW Spray System, such as flow control valve, heat detectors, projector nozzles, piping, valves, fittings instrumentation etc., should be of approved makes acceptable to TAC.

3.8.11 Portable and Mobile Fire Extinguishers

3.8.11.1 Portable and Mobile Fire Extinguishers are provided at suitable locations for indoor/outdoor applications. These extinguishers are used during early stages of localised fires to prevent them from spreading. Following types of these extinguishers are usually provided.

(i) Pressurised Water Type in 9.01 kg size
(ii) Carbon Dioxide Type in 4.5 kg size
(iii) Dry Chemical Type in 5.0 kg size
(iv) Halon Type in 5.0 kg size
(v) Mechanical foam Type in 50 ltrs. 90ltrs.

For the quantities of these types and their applications, the norms given in TAC manual should be followed.

* The make of these extinguishers should also be acceptable to TAC
* Halon type fire extinguishers are now getting phased out on account of their negative effect on the atmosphere.
* The transformers shall be protected by automatic high velocity water spray system or by carbon dioxide or BCF (Bromochloro-difluromethane) or BTM (Bromotrifluromethane) fixed installation system or Nitrogen injection and drain method.

* Nitrogen injection fire prevention method is being used by a few utilities at present.

3.8.12 Instrumentation and Control

3.8.12.1 Fire Protection System should include suitable instrumentation and necessary controls to render the system efficient and reliable. There should be local control panels for each of the pumps individually as also for the operation of deluge valve of the HVW Spray System. There should be a common control panel for the Jockey Pump and Air Compressors. Main annunciation panel should be provided in the control room for the facilities provided in the control room and for repeating some annunciation from pump house.

3.8.12.2 The following Annunciation is usually provided in the Fire Water Pump House.

(i) Electric motor driven HVW spray pump running/falls to start
(ii) Diesel engine driven HVW spray pump running/falls to start
(iii) Hydrant pump running/falls to start
(iv) Jockey pump running/falls to start
(v) Air compressor falls to start
(vi) Hydro-pneumatic tank pressure low
(vii) Hydro-pneumatic tank pressure high
(viii) System header pressure low
(ix) Fire in transformer/reactor
(x) Fire in smoke detection system
(xi) Water storage tank water level low
(xii) High speed diesel oil tank level low

3.8.12.3 The following Annunciations should be available in the control room also:

(i) Fire in transformer/reactor
(ii) Hydrant pump/diesel engine operated HVW Spray pump in operation
(iii) Motor operated HVW spray pump in operation
(iv) Fire/Fault in Zone 1
(v) Fire/Fault in Zone 2
(vi) Fire/Fault in Zone 3
(vii) Fire/Fault in Zone 4 (depending on the number of zones)

3.8.12.4 All fire protection equipment should be covered by a regular and strict maintenance and test routine. The hydrant systems should be checked every week which may be possible during night shifts. Sprinkler systems should be checked at regular intervals. Portable equipment should be charged at specified intervals and checked regularly for loss of charge, damage, etc. Records of all tests and checks must be maintained.

3.8.12.5 Provision should be made to switch off the air conditioning equipment in case of fire.

3.8.12.6 Cable entry openings shall be sealed to prevent the spreading of fire.

3.8.13 Diagram of Fire Fighting System

A flow diagram of a typical HVW Spray and Hydrant System is enclosed as Flg.5.

3.9 DC SYSTEM

3.9.1 DC Auxiliary supply is required for relays, instrumentation, closing and tripping of circuit breakers, emergency lighting, control board indications, etc. During normal operation, battery charger (rectifier bridge with Silicon diodes and Silicon control rectifiers) provides the required DC supply. However, to take care of failure of the AC supply (rectifier), a storage battery of adequate capacity is provided to meet the DC requirement. Normally, the storage battery merely keeps floating on the direct current system and supplies current in case of failure of the rectifier in substation. It is desirable to provide duplicate rectifiers to meet the contingency of rectifier failure. An arrangement shall be made to supply an uninterrupted DC supply to load wherever the battery charger is facilitated with float/trickle/boost charging.

3.9.2 The voltage commonly used for the DC auxiliary supply is 110 to 220 volts batteries for substations and 48 volts for PLCC, Generally lead acid batteries are used.

3.9.3 Capacity of the battery should be adequate to supply.

(a) Momentary current required for the operation of switchgear

(b) The continuous load of indicating lamps, holding coils for relays contractors, etc.,

(c) Emergency lighting load.

3.9.4 Complete DC equipment for a substation may be divided into three parts i.e., storage battery and accessories, charging equipment and distribution board.

3.9.5 The charging equipment generally consists of float charger and boost charger in major substations, twin float chargers and twin boost chargers or with float cum boost charges with a suitable switching cubicle are generally used for reliability.

3.9.6 The distribution board has an incoming circuit from the DC battery and a number of outgoing circuits for closing and tripping, alarm and indication for control and relay panels. A separate circuit is provided for the emergency load normally fed from AC supply but is automatically switched on to DC supply in the event of AC power failure.
3.10 AC AUXILIARY SUPPLY

3.10.1 AC supply both single and three-phase, are needed in a substation for internal use for several functions such as:

(a) Illumination
(b) Battery charging
(c) Transformer cooling system
(d) Oil filtration plant
(e) Transformer tap-changer drives
(f) Air compressors
(g) Power supplies for communication equipment
(h) Crane
(i) Breakers/disconnect switch motors
(j) Fire protection system
(k) Space heaters in cubicles and marshalling kiosks
(l) Air-conditioning/ventilation equipment

3.10.2 Auxiliary Transformer

The design of AC auxiliary supply system must be such that it ensures continuity of supply under all conditions, as far as practicable, reliability being the basic requirement. In a substation, it is normally provided from a station transformer connected to the 11KV or 33KV station bus. Its capacity should be adequate to meet the demands of all the essential connected loads. Generally, two such transformers are provided in all major substations.

3.10.3 In case of transformers where tertiary winding is available one auxiliary transformer can be connected to tertiary of transformer for station power supply with adequate insulation margin and protection to save the damage to main transformers from the Secondary system faults.

3.10.4 The station transformer is connected to the indoor AC distribution panel through duplicate cables. Duplicate feeds to important loads are made from the AC distribution panels through outlets, which are controlled, by switch fuses or circuit breakers.

In the event of shutdown of the entire station, ensure availability of AC auxiliary supply for charging of protective equipments, DG set shall preferably be provided in major substations with Auto Main Fail (AMF) panel preferably. Change over scheme shall be provided in AC distribution panel, to feed important loads by DG set.

3.10.5 Incomer of AC distribution panel shall be provided with 4-pole breaker either it may be from auxiliary transformer or from DG set.
3.11 VENTILATION

3.11.1 Battery Room Ventilation

Exhaust fans should be provided. Further it is necessary to ensure sufficient air inlet to the battery room by providing blowers, if necessary. Exhaust alone without air inlet a negative pressure will be created in the battery room which will cause.

(a) Evaporation of electrolyte even at the normal room temperature and the fine spray of electrolyte will settle on cells, stands etc., reducing the electrical insulation of the battery from the ground.
(b) The hydrogen evolved from the battery may form an explosive mixture if the room pressure has reduced.
CHAPTER – 7

SUBSTATION ERECTION, TESTING AND COMMISSIONING
GENERAL INSTRUCTIONS

1.0 Transportation and unloading of the substation material and equipment at the location shall be done in a safe manner so that they are not damaged or misplaced.

2.0 All the material and equipment shall be checked as per Bill of Material (BOM).

3.0 All support insulators, circuit breaker poles, Transformer bushings and other fragile equipment shall preferably be handled carefully with cranes having suitable boom length and handling capacity.

4.0 Sling ropes, etc. should have sufficient strength to take the load of the equipment to be erected. They should be checked for breakages of strands before being used for the erection of equipments.

5.0 The slings should be of sufficient length to avoid any damage to insulator or other fragile equipment due to excessive swing, scratching by sling ropes, etc.

6.0 Mulmul cloth shall be used for cleaning the inside and outside of hollow insulators.

7.0 Erection of equipment shall be carried out as per and in the manner prescribed in the erection, testing and commissioning manual/instructions/procedures of the manufacturer.

8.0 The services of the manufacturer’s Engineer, where necessary, maybe utilized for erection, testing and commissioning of substation equipment.

9.0 Whenever work is required to be got done at the existing GSS, where the adjacent portions may be charged, effective earthing must be ensured for safety against induced voltages so that work can be carried out without any danger/hazard to the workmen.

10.0 Wherever it is necessary to avail of a shutdown of energized circuits for carrying out any work, the Work-in-Charge shall submit a requisition to the Engineer-in-charge of the GSS stating the date, time and duration of the shutdown and the section/portion which is to be kept out of circuit during the shutdown.

11.0 The Work-in-Charge shall ensure that the portion of the switchyard under shutdown has been isolated and that effective earthing of the equipment/busbar, on which work is to be carried out, has been done.

12.0 The Work-in-Charge shall ensure that the work is completed within the requisitioned time.

13.0 After completion of the erection work, all surplus material including bolts and nuts, templates, etc. shall be returned to the store. All unusable cut lengths of materials such as conductor, earth wire, aluminium pipes, etc. shall not be treated as waste and shall also be deposited in the store.
STRUCTURES

1.0 GENERAL INSTRUCTIONS:
1.1 The structure material shall be stacked member/item wise.

1.2 The following are required to be made available to the workers for erection of substation structures/beams and equipment structures:

   i) Drawings and bill of material of structures/beams/equipment structures.
   ii) Templates of structures.
   iii) Tools such as levelling instruments, tackles, spanners, jacks, winches, ropes, derrick, etc.

2.0 TYPE OF STRUCTURES:
2.1 The types of structures generally used at substations are given below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Structure</th>
<th>Type of Structure</th>
<th>Height of Column/Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 400kVStruc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>EHT1</td>
<td>Column with Peak</td>
<td>27.0/20.5</td>
</tr>
<tr>
<td>2.</td>
<td>EHB</td>
<td>Beam</td>
<td>25.3 (Width)</td>
</tr>
<tr>
<td>B. 220kVStruc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>AT1</td>
<td>Column with Peak</td>
<td>20.0/14.5</td>
</tr>
<tr>
<td>2.</td>
<td>AT3</td>
<td>Column without Peak</td>
<td>15.0/14.5</td>
</tr>
<tr>
<td>3.</td>
<td>AT4</td>
<td>Column with Peak and Beams at two levels for Bus Barstringing</td>
<td>20.0/14.5 and 9.5</td>
</tr>
<tr>
<td>4.</td>
<td>AT6</td>
<td>Column without Peak</td>
<td>10.0/9.5</td>
</tr>
<tr>
<td>5.</td>
<td>AT8</td>
<td>Column with Peak</td>
<td>15.0/9.5</td>
</tr>
<tr>
<td>6.</td>
<td>AB</td>
<td>Beam</td>
<td>16.6 (Width)</td>
</tr>
<tr>
<td>C. 132kVStruc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>BT1</td>
<td>Column with Peak</td>
<td>16.0/11.5</td>
</tr>
<tr>
<td>2.</td>
<td>BT3</td>
<td>Column without Peak</td>
<td>12.0/11.5</td>
</tr>
<tr>
<td>3.</td>
<td>BT4</td>
<td>Column with Peak and Beams at two levels for Bus Barstringing</td>
<td>16.0/11.5 and 7.5</td>
</tr>
<tr>
<td>4.</td>
<td>BT6</td>
<td>Column without Peak</td>
<td>8.0/7.5</td>
</tr>
<tr>
<td>5.</td>
<td>BT7</td>
<td>Column with Peak</td>
<td>12.0/7.5</td>
</tr>
<tr>
<td>6.</td>
<td>BB</td>
<td>Beam</td>
<td>12.2 (Width)</td>
</tr>
<tr>
<td>7.</td>
<td>P</td>
<td>Peak</td>
<td>2.5</td>
</tr>
<tr>
<td>8.</td>
<td>Q</td>
<td>Column</td>
<td>7.5/7.5</td>
</tr>
<tr>
<td>9.</td>
<td>R</td>
<td>Extension</td>
<td>3.0</td>
</tr>
<tr>
<td>10.</td>
<td>GD</td>
<td>Beam</td>
<td>10.0 (Width)</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Name of Structure</td>
<td>Type of Structure</td>
<td>Height of Column/Height of Conductor (Meters)</td>
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<tr>
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<tr>
<td><strong>D.</strong></td>
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<tr>
<td></td>
<td><strong>33kV and 11kV Structures:</strong></td>
<td></td>
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</tr>
<tr>
<td>1.</td>
<td>X</td>
<td>Peak</td>
<td>1.5</td>
</tr>
<tr>
<td>2.</td>
<td>Y</td>
<td>Column</td>
<td>5.5/5.5</td>
</tr>
<tr>
<td>3.</td>
<td>Z</td>
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</tr>
<tr>
<td>4.</td>
<td>GF – 5.4</td>
<td>Beam for 33kV</td>
<td>5.4 (Width)</td>
</tr>
<tr>
<td>5.</td>
<td>GF – 4.6</td>
<td>Beam for 11kV</td>
<td>4.6 (Width)</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td><strong>E.</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Equipment Structures:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>AO1</td>
<td>220 kV Isolators</td>
<td>--</td>
</tr>
<tr>
<td>2.</td>
<td>AO1 (T)</td>
<td>220 kV Tandem Isolators</td>
<td>--</td>
</tr>
<tr>
<td>3.</td>
<td>AO3</td>
<td>220 kV C.T.</td>
<td>--</td>
</tr>
<tr>
<td>4.</td>
<td>AO4</td>
<td>220 kV C.V.T.</td>
<td>--</td>
</tr>
<tr>
<td>6.</td>
<td>BO1</td>
<td>132 kV Isolator</td>
<td>--</td>
</tr>
<tr>
<td>7.</td>
<td>BO1 (T)</td>
<td>132 kV Tandem Isolator</td>
<td>--</td>
</tr>
<tr>
<td>8.</td>
<td>X – 15</td>
<td>33kV &amp; 11kV Isolators</td>
<td>--</td>
</tr>
<tr>
<td>9.</td>
<td>X – 15 (T)</td>
<td>33kV &amp; 11kV Tandem Isolators</td>
<td>--</td>
</tr>
<tr>
<td>10.</td>
<td>C.T. Structure</td>
<td>33kV &amp; 11kV C.T., P.T.</td>
<td>--</td>
</tr>
<tr>
<td>11.</td>
<td>P.I. Structure</td>
<td>220 kV, 132 kV, 33kV &amp; 11kV P.I.</td>
<td>--</td>
</tr>
</tbody>
</table>

3.0 **SETTING OF STUB/FOUNDATION BOLTS, LEVELLING AND GROUTING:**

3.1 In case of structures with foundation bolts, the template, along with the foundation bolts tightened on both sides, shall be placed on the foundation. The length of the foundation bolts above the template shall be sufficient so that all parts of the baseplate assembly of the structure, washers, nuts, and locknut can be tightened fully and 2–3 threads are left above the locknut.

3.2 The template is levelled and centered with reference to its location on the foundation. The foundation bolt shall thereafter be grouted ensuring that there is no displacement during the placing of the concrete and use of vibrator.

3.3 In case of structures with stubs, the template with stub shall be placed on the foundation. In case of structures in which the lowest member is used as a stub, the assembled lower part of the structure is placed on the foundation. This is levelled and centered with reference to its location on the foundation. The stubs/lowest members shall thereafter be grouted ensuring that there is no displacement during the placing of the concrete and use of vibrator.
3.4 While levelling and centering the structure/template, the following points should be checked:
   
   a) Level of structure/template with reference to the finished foundation level or the ground level.
   
   b) The level of the structure/template with reference to the level of other similar structures.
   
   c) Distance of centre line of the structure from the centre line of other structures or from a reference point.
   
   d) Centretocentredistancebetweenstructures, particularly structures which are to be connected together, for example, by a common beam.

4.0 ERECTION OF STRUCTURES:
4.1 Method of Erection:
There are mainly three methods of erection of structures, which are as below:

i) Ground assembly method.

ii) Section method.

iii) Built up method or Piecemeal method.

4.2 Ground Assembly Method:
4.2.1 This method is used for erection of equipment structures and is the preferred method for erection of substation structures when crane facility is available.

4.2.2 This method consists of assembling the structure on the ground and erecting it as a complete unit.

4.2.3 The complete structure is assembled in a horizontal position near its location. On sloping or uneven ground, suitable packing is provided in the lower level area before or during assembly, as required, to eliminate/minimize stress on the structure members.

4.2.4 After the assembly is complete, the structure is picked up from the ground with the help of a crane and set on its foundation.

4.3 Section Method:
4.3.1 This method is used for large and heavy structures when crane facility is available.

4.3.2 A mobile crane is used for erecting the structures.

4.3.3 The two faces/sides of the complete structure are assembled on the ground and then erected. Alternatively, the two faces/sides of the major sections of the structure are assembled on the ground and then are erected as units.

4.3.4 Each assembled side is then lifted clear of the ground with the crane and is lowered into position on its foundation or fitted onto the sub foundation bolts which are already grouted. One side is held in place with props or rope guys while the otherside is being erected. The two opposite sides are then connected together with cross members.
4.3.5 Incase where the major sections of the structure have been assembled, the first face of the second section is erected. After the two opposite faces have been erected, the bracings on the other two sides are bolted up. The last lift raises to the top of the structure. After the structure top is erected and all side bracings have been bolted up, all the guys are thrown off.

4.4 Built up method or Piecemeal method:
4.4.1 This method is used for large and heavy structures when crane facility is not available.

4.4.2 This method consists of erecting the structure member by member. The structure members are kept on ground serially according to erection sequences so that they can be set up conveniently.

4.4.3 The erection progresses from the bottom upwards. The four main corner leg members of the first section of the structure are first erected.

4.4.4 The cross bracings of the first section are raised one by one and bolted to the already erected corner leg angles. If these have been assembled on the ground, then they are lifted up as a unit.

4.4.5 For assembling the second section of the structure, a derrick is placed on one of the corner legs. This derrick is used for raising parts of second section. The leg members and bracings of this section are then hoisted and assembled.

4.4.6 The derrick is then shifted to the corner leg members on the top of the second section to raise the part of the third section of the structure in position for assembly. The derrick is thus moved up as the structure grows. This process is continued till the complete structure is erected.

5.0 ERECTION OF BEAMS:
5.1 The two faces of the beam are assembled on the ground.

5.2 Each face of the beam is raised with the help of crane or using derricks which are placed on the top of already erected structures on both the sides of the beam. Single or multi-way pulleys with polypropylene/steel ropes are used as per load requirement. The end of the beam are connected to the column as per fixing arrangement provided on the columns.

5.3 The bracings of the upper and lower faces of the beam are then raised up and fitted.

6.0 The columns shall be truly vertical and the beam struly horizontal after erection. Measures taken to bring the column to verticality and beam to horizontal should not result in strain on the structure members so as to cause distortion/bending of the members.

7.0 The work of erection of beams on erected columns and erection of equipment on erected structures shall not be taken up until these have been checked for tightening of the bolts & nuts.
8.0 All bolted connections shall be well tightened using spring washers & then punched at three points on the circumference of the bolt.
BUSBAR & EARTH WIRE

1.0 GENERAL INSTRUCTIONS:
1.1 Care shall be taken during sagging operations so that no damage or deformation is caused to the structures.

1.2 The ends of the cut piece of conductor or earth wire shall be tied with at least two rounds of binding wire so that the strands do not open out. The tying of the binding wire shall be done such that the binding wire does not get tightened in the groove of the T-Clamp or the PG (Parallel Groove) - Clamp or the terminal connector of the equipment.

1.3 Cut lengths of conductor and earth wire which are available as surplus/leftover material from line works should preferably be used for stringing of busbars & earth wire. Cut lengths of conductor and earth wire left after stringing of busbars and earth wire can be used for jumpering work.

1.4 If possible, the stringing of Earth Wire should be done before the stringing of conductor of Bus Bar and the erection of equipments.

1.5 The stringing of conductor of Bus Bar should be done before the erection of equipments if allowed by the site conditions. While erecting Bus Bars, the higher Bus Bars must be erected first and then the lower Bus Bars.

2.0 BUSBARMATERIAL:
2.1 The bus bar material generally used in 400kV, 220kV & 132kV substations is given below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Bus Bar and Jumper Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>400kV Main Bus</td>
<td>114.2 mm dia. Aluminum pipe</td>
</tr>
<tr>
<td>2.</td>
<td>400kV Equipment Interconnection</td>
<td>114.2 mm dia. Aluminum pipe</td>
</tr>
<tr>
<td>3.</td>
<td>400kV Overhead Bus &amp; Droppers in all bays</td>
<td>Twin ACSR Moose</td>
</tr>
<tr>
<td>4.</td>
<td>220kV Main Bus</td>
<td>Quadruple/Twin ACSR Zebra/ Twin AACTarantulla</td>
</tr>
<tr>
<td>5.</td>
<td>220kV Auxiliary Bus</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td>6.</td>
<td>220kV Equipment Interconnection</td>
<td>Twin ACSR Zebra/ Single ACSR Zebra</td>
</tr>
<tr>
<td>7.</td>
<td>220kV Overhead Bus &amp; Droppers in all bays</td>
<td>Twin ACSR Zebra/ Single ACSR Zebra</td>
</tr>
<tr>
<td>8.</td>
<td>132kV Main Bus</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td>9.</td>
<td>132kV Auxiliary Bus</td>
<td>ACSR Panther</td>
</tr>
<tr>
<td>10.</td>
<td>132kV Equipment Interconnection</td>
<td>ACSR Zebra/ ACSR Panther</td>
</tr>
<tr>
<td>11.</td>
<td>132kV Overhead Bus &amp; Droppers in all bays</td>
<td>ACSR Panther</td>
</tr>
<tr>
<td>12.</td>
<td>33kV Main Bus</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td>13.</td>
<td>33kV Auxiliary Bus</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td>14.</td>
<td>33kV Equipment Interconnection, overhead bus and droppers:</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td></td>
<td>(i) Bus coupler &amp; transformer bay</td>
<td>ACSR Zebra</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>(i) Feederbay.</td>
<td>ACSRPanther</td>
<td></td>
</tr>
<tr>
<td>15. 11kVMainBus</td>
<td>TwinACSRZebra</td>
<td></td>
</tr>
<tr>
<td>16. 11kVAuxiliaryBus</td>
<td>ACSRZebra</td>
<td></td>
</tr>
<tr>
<td>17. 11kVequipmentinterconnection, overheadbusanddroppers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Transformerbay</td>
<td>TwinACSRZebra/ SingleACSRZebra</td>
<td></td>
</tr>
<tr>
<td>(ii) Buscoupler</td>
<td>ACSRZebra</td>
<td></td>
</tr>
<tr>
<td>(iii) Feederbay.</td>
<td>ACSRPanther</td>
<td></td>
</tr>
</tbody>
</table>
3.0 **STRINGING OF CONDUCTOR BUSBARS:**

3.1 The conductors shall be handled with care to prevent scratches on the conductor. When the conductor is to be taken from drums, small lengths can be unwound from the drum. For longer lengths, the conductor drum shall be placed on a turntable or jacked up on a suitable size of steel shaft. The conductor shall be paid out in a manner so that there are no scratches or damages caused to the conductor due to rubbing on the sides of the drum.

3.2 Disc insulators shall be cleaned and examined for any cracks/chipping, etc. Disc insulators having any hair cracks or chipping or defective glazing or any other defect shall not be used. The limits of the area of defective glazing are given by the following formulas.

\[
a) \text{Single Glaze Defect} = \frac{D \times F}{20000} \text{ Sq.cm.}
\]

\[
b) \text{Total Glaze Defect} = \frac{D \times F}{2000} \text{ Sq.cm.}
\]

where,

\[D = \text{Diameter of the disc in cm.}\]
\[F = \text{Creepage distance in cm.}\]

3.3 The disc insulators shall be assembled on the ground to form the suspension and tension strings as given below.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>System Voltage</th>
<th>Suspension String</th>
<th>Tension String</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>E&amp;M Strength (kN)</td>
<td>Nos.</td>
</tr>
<tr>
<td>1.</td>
<td>400kV (Anti-fog type)</td>
<td>120</td>
<td>25</td>
</tr>
<tr>
<td>2.</td>
<td>220kV</td>
<td>70</td>
<td>15</td>
</tr>
<tr>
<td>3.</td>
<td>220kV</td>
<td>70</td>
<td>13</td>
</tr>
<tr>
<td>4.</td>
<td>132kV</td>
<td>45</td>
<td>9</td>
</tr>
<tr>
<td>5.</td>
<td>33kV</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>11kV</td>
<td>45</td>
<td>3</td>
</tr>
</tbody>
</table>

3.4 After assembly of the strings, the mouth of the W-clips/R-clips shall be widened to prevent any inadvertent removal during service.

3.5 The suspension and tension hardware shall be assembled as per the respective drawings and the disc insulator strings shall be fitted in the requisite portion of the hardware assembly.

3.6 For stringing of busbars, the conductor shall be fixed and tightened in the clamp of the tension hardware on one side of the bus. Thereafter, the complete hardware assembly with the conductor...
shall be hoisted up and fixed on the beam at this end. Sagging arrangement shall be made on the other end of the bus and the conductors shall be tensioned.

3.7 Measurement of length of conductor required for the bus shall be made thereafter and the conductor shall be released so that it returns to the ground. The conductor shall be cut to the marked length after deducting the length of the tension hardware with insulators and fixed on the clamp of the tension hardware. The conductor along with tension hardware set shall then be again pulled up and connected to the beam. If the bus bar has two or more sections, then at the common beam of two sections, the conductor of one bus may be allowed to go beyond the tension hardware to be used as jumper to connect it to the next section. This will avoid one joint and save PG and T-Clamps.

3.8 Equalizing of tension in the different sub-conductors of the same phase and in the different phases shall be done, if required, to ensure equal sag of all the sub-conductors or between phases of the bus sections as well as that of adjacent or parallel sections.

3.9 The spacers shall be fitted on the twin and quadruple conductor bus bars at the spacing shown in the drawing. The spacers shall also be provided at points where jumpers are taken from the bus bar using T-clamps and/or P.G. clamps. Spacers are not used at jumper points in case T-spacers are used for taking jumpers from multiconductor bus bars.

4.0 JUMPERING OF CONDUCTORS:
4.1.1 The jumpers connecting different sections of the bus bars as well as those connecting equipment to bus bars shall be of Y-type.

4.1.2 A typical diagram of Y-type jumpering is given below.
4.1.3 Formaking Y-type jumpers, the jumper conductor(s) shall be first connected to the bus bar conductor(s) using T-Clamp/Spacer T-Clamp which is suitable for clamping the respective conductors, i.e., busbar conductor(s) and the jumper conductor(s). Thereafter, the busbar conductor(s) shall be again connected with the jumper conductor(s) using properly curved & shaped Y-conductor(s) and 2 nos. PG-clamps as shown in the diagram above.

4.2 The jumpering between equipment shall be done with single/twin/quadruple conductors as per the terminal connectors provided on the equipment.

4.3 Incase of jumpers for twin and quadruple conductors, the spacers shall also be fitted at a suitable spacing on the jumpers in order to maintain their shape.

4.4 JUMPERING OF BUSBARS:
4.4.1 For jumpering of different sections of busbar on the beam, the suspension hardware set along with disc insulators shall first be hoisted and fitted on the beam.

4.4.2 Conductor of approximately the length required for the jumper shall be cut and straightened so that kinks are removed. This shall be connected to the busbar conductor on one side of the beam after taking into consideration the natural curve of the conductor.

4.4.3 This shall then be passed through the clamp on the suspension hardware so that the proper curve is obtained. The other end of the conductor shall then be taken up to the busbar conductor on the other side and measurement of the length shall be taken. The conductor shall be cut to the appropriate length and then connected to the busbar conductor on the other side. The length of the conductor used and its natural curve should ensure a neat and proper curve is obtained in the jumper without any kinks or bends. The clamp of the suspension hardware shall then be tightened after ensuring proportional length of the conductor on both the sides of the beam.

4.5 JUMPERING FROM BUSBAR TO EQUIPMENT/PIPEBUS:
4.5.1 Approximate length of the conductor required for the jumper shall be cut and then connected to the busbar conductor.

4.5.2 Incase the jumper is to be connected to equipment/pipebus near or under a beam, the suspension hardware along with disc insulators is first fitted on the beam. The conductor shall be passed through the clamp of the suspension hardware.

4.5.3 The end of the conductor shall be taken up to the terminal connector of the equipment/connector fitted on the pipebus. The measurement of length of the conductor up to the equipment/pipebus shall be made.

4.5.4 After cutting the conductor to the required length, it shall be connected to the equipment/pipebus.

4.5.5 The clamp of the suspension hardware shall be tightened thereafter.
4.5.6 As far as possible, jumpers from Bus Bar to Circuit Breaker should be such that if the Circuit Breaker is tripped, the lower terminal of it’s pole should be dead.

4.5.7 Jumpers from Bus Bar to any equipment should be such that they do not cause excessive uplift / tension to the equipment terminal.

4.6 JUMPERING BETWEEN EQUIPMENTS:

4.6.1 The distance between terminal connector of one equipment and terminal connector of other equipment is first measured. The appropriate length of the conductor shall be cut and then straightened so that curves and kinks are removed.

4.6.2 The jumper conductor shall then be connected to the terminal connector of both the equipments and straightened to shaped as per site condition to give a neat and proper look.

4.6.3 Vertically supported insulators of equipments and Post Insulators should be checked for verticality again after jumpering on both sides, and corrected if required.

4.6.4 Jumpering to a circuit breaker should be such that when it is tripped, the lower terminal of it’s pole should become dead.

4.6.5 Jumpering of equipments should be such that it does not cause excessive stress on equipment terminals / clamps, e.g., a horizontal jumper on a vertically fixed clamp causes more stress.

5.0 STRINGING OF SHIELD/ EARTH WIRE:

5.1 SubStation is shielded against direct lightning strokes by overhead shield wire/ earth wire. The methodology followed for system up to 400kV is by suitable placement of earth wire so as to provide coverage to all the station equipment. Generally, an angle of shield of 60° for zones covered by two or more wires and 45° for single wire is considered adequate.

5.2 The shield/ earth wire shall be handled with care to prevent scratches on it or damage to the strands of the wire. When the shield/ earth wire is taken from drums, small lengths can be unwound from the drum. For longer lengths, the wiredrum shall be placed on a turntable or jacked upon a suitable size of steel shaft. The shield/ earth wire shall be paid out in a manner so that there are no scratches or damages caused to the shield/ earth wire due to rubbing on the sides of the drum.

5.3 The earth wires shall be strung from one peak to another peak of the structure as per layout of the GSS.

5.4 The tension hardware shall be assembled as per relevant drawings.

5.5 The shield/ earth wire shall be fitted and tightened in the clamp of the tension hardware on one side. Thereafter, the complete hardware assembly along with the shield/ earth wire shall be hoisted up and fixed on the peak of the structure at one end.
5.6 Sagging arrangements shall be made on the other end and the shield/earth wire shall be tensioned. Measurement of length of shield/earth wire required shall be made thereafter and the shield/earth wire shall again be released so that it is returned to the ground. The shield/earth wire shall be cut to the marked length after adding the length of wire required for jumpering and fitted in the clamp of the tension hardware at the marked point. The shield/earth wire along with tension hardware shall then be pulled up again and connected to the peak of the structure.

5.7 Adjustment of tension in the earth wire may be done, if required, to ensure equal sag of all the earth wires in adjacent or parallel sections.

5.8 As far as possible, rather than cutting the earth wire, it should be allowed to pass through the tension hardware clamp to go to the next terminating point and so on. It will avoid joints in the earth wire and save earth wire clamps.

6.0 JUMPERING OF SHIELD/EARTH WIRE:

6.1 The lengths of the earth wire which remain outside the tension hardware on the peak of the structure shall be cut, if required, so that these lengths when joined together form a smooth and proper curve. These shall be connected together using a PG-Clamp.

6.2 The earth bond provided with the earth wire tension clamp shall be connected to the specified point on the peak of the structure and to the earthing riser, which is used as a down conductor from the peak, for the purpose of connecting the shield/earth wire to the earth mesh of the substation.
1.0 ERECTION OF ALUMINIUM PIPE BUSBAR:

1.1 Aluminium pipes are used for 400kV and 33kV busbar jumpers and interconnections at 400kV GSS. The diameter of the pipes is 114.30mm and 73.03mm for 400kV and 33kV respectively.

1.2 The height of the 400kV main bus is 8 meters & 10 meters and that of jumpers is generally 8 meters, 10 meters & 13 meters.

1.3 Fixed, sliding and expansion type clamps are fitted on the already erected post insulators as per the drawing.

1.4 The standard length of aluminium pipes is generally 6.0 to 7.0 meters. To reduce welding work at the bus height in case longer length is required, a maximum of 4 to 5 lengths of aluminium pipes may be welded together on the ground using straight truncouplers. The pipe length is then lifted and erected on the post insulators.

1.5 If required for the bus length, the already erected pipe lengths are welded together at the bus height.

1.6 If the bus height changes, then the pipes at the different levels are welded together with a piece of pipe using appropriate angular couplers (90° or 110° or 135°) as per the drawing.

2.0 JUMPERING OF ALUMINIUM PIPES:

2.1 Jumpers between equipment to equipment and equipment to bus may either be directly supported on post insulators.

2.2 In cases where the length required for jumpers is more than one pipe length and where angles are required to be given in the jumpers, welding of aluminium pipe to pipe or pipe to angular connectors is got done. Such welding may also be required to be got done after erection/fitting of pipes on clamps/ connectors.

2.3 For jumpering between equipments, the pipes are erected between the equipments, supported & fitted on the clamp on post insulators where provided, and fitted on the terminal connectors of the equipments.

2.4 For jumpering between equipment and bus, the pipes are erected between the equipment and the bus, supported & fitted on the clamp on post insulators where provided. One end is fitted on the terminal connectors of the equipment. The other end is then welded to aluminium pipe using appropriate angular connector(s) (20° or 80° or 90°) as per the drawing.

2.5 All the open ends of pipes are closed with corona end shields.

3.0 JOINTING OF ALUMINIUM PIPES/COUPLERS/CONNECTORS:

3.1 The joints/couplers shall be got machined in order to perfectly match the inner/outer diameter with the aluminium pipe.
3.2 All the surfaces to be welded must be thoroughly cleaned with Acetone or Alcohol to remove any oxide layer and foreign contaminants present on it to attain a fast joint and avoid porosity. In addition, a stainless steel wire brush shall be used for cleaning the surfaces.

3.3 **Straight Run Coupler:**
3.3.1 Before fitting the straight run coupler, the edges of the pipes to be welded for straight joints are to be beveled at an angle of 45° with a flat file to make a V-groove at the end of the joint. In cases where the outer diameter of the sleeve does not match the inner diameter of the pipe, the sleeve shall be cut to match the inner diameter of the pipe.

3.3.2 The straight run coupler is then to be pressed down and both the pipes are pushed onto it till their ends come near the centre of the coupler. The centering pin of the coupler is fitted in the hole provided for it and the pipe ends are brought together until they touch the centering pin.

3.3.3 The straight run coupler is then split open so that it fits tightly on the inner surface of the pipe. It is held in this position till at least 25% of the welding of the coupler has been done.

3.3.4 The welding of the joint is then done till the V-groove between the pipes is filled with the fused metal.

3.4 **Angular Coupler:**
3.4.1 For jointing of pipes with angular coupler, the ends of both the pipes are fitted into the coupler.

3.4.2 The pipes are then welded on the coupler.

3.5 **Angular Connector:**
3.5.1 For jointing of pipes with angular connector, the end of the pipe is first fitted into the connector and welded.

3.5.2 The connector with the pipe is then fixed on the pipe bus and the connector is welded to the pipe bus.

4.0 **ALUMINIUM WELDING:**
4.1 The following material/T&P/consumables are required for carrying out the work of welding of aluminium pipes/ couplers/ connectors.
   c) Oxy-acetylene torch with accessories or blow lamp. d) Filler wire.
   e) Water tank for welding.
   f) Tool such as chipping hammer, file, sandpaper, steel wire brush, windscreen, blue glass slits, hacksaw frame, blades, powersaw, etc.
g) Cleaner, dye and developer.
h) All safety equipments.

4.2 T.I.G (TUNGSTEN INERT GAS) welding utilizes high frequency A.C. generating set and welding torch having tungsten wire without flow of inert gas like Argon, etc. M.I.G. (METAL INERT GAS) welding process is used as an alternative when T.I.G. welding is not available.

4.3 To avoid cracks in the joints after welding, the surfaces should be preheated uniformly with oxy-acetylene torch or blow lamp.

4.4 During welding, continuous flow of inert gas shall be maintained over the joint as well as inside the pipe to avoid oxidation on the inside surface. This flow of inert gas on joint should continue for at least 15 seconds after the welding of joint is completed.

4.5 All the welding at a joint must be in one layer. If more layers are required at the joint, every bottom layer shall be cleaned with wire brush and checked for cracks before starting welding of the second layer. If any crack is observed, the whole layer shall be chipped off and refilled.

4.6 The joint, when completed, must be filed smooth with a wood file and fine sand paper.

4.7 Windshield shall be used, if required, for protecting the joints from the blowing wind which may take away heat and inert gas flow at the surface of joints.

4.8 Every care shall be taken for preventing the scratches and roughness on the aluminum surface.

4.9 The welding should be done so that molten mass is filled in gaps and no crack or imperfections are present in joints. Unacceptable joints shall be chipped off for re-welding.

4.10 Each and every joint shall be subjected to:
   a) Physical examination.
   b) Liquid penetration test.

4.11 For liquid penetration test, the following three items are required:
   a) Cleaner for cleaning the joint.
   b) Reddy for spraying on the cleaned joint which will penetrate into the cracks, if any.
   c) White developer to be sprayed on the joint that will draw the reddy from the cracks and make them visible, if present.

5.0 Depending upon the site conditions, some welding can be done at ground level and the rest is done at a height from 8.0 to 13.0 meters from the ground level as per requirement. The necessary arrangements for welding of joints at such heights shall be made.
POWERTRANSFORMERS

1.0 GENERALINSTRUCTIONS:
1.1 The erection work shall be done generally as per instructions/procedures prescribed in the following documents:

   b) Manufacturer’s Erection Drawings.
   d) Transformer Manual (Technical Report No. 1) issued by the Central Board of Irrigation & Power.

1.2 The work shall be carried out under the supervision of Work-In-Charge/Manufacturer’s Engineer and as per instructions given by him/them.

1.3 Transformer oil drums should not be stored in low-lying areas. They should be stored so that the air release hole (smaller hole) is on the upper side and at an angle of 45° to the vertical as shown in the diagram below.

![Air Release Hole](image)

1.4 All the accessories should generally be stored in a closed room. However, accessories such as condenser bushings, radiators, conservator, headers, pipework and A-frame can be stored under covered sheds.

1.5 The gas pressure in transformers received gas-filled should be checked periodically. A positive pressure (generally 0.15 kg/cm² at 30°C) should always be maintained. In case of reduction in pressure, it should be maintained by filling in gas from the cylinder on the transformer.

Measure IR values with 2 KV Megger in between Core to Tank, Core to Frame and Tank to Frame prior to erection of Transformer.

1.6 The core and windings should be exposed to the atmospheric air for the minimum possible time period and for not more than 8 hours at a time. The weather conditions during transformer erection should be dry. The transformer tank should not be opened when it is raining.

1.7 The Bushing CT’s fitted in the turrets should be got tested by the protection wing before erection of turrets.
1.8 Check the open and closed conditions of contacts provided in equipment such as M.O., L.G., Oil surge relays, Buchholz relays, oil flow indicators, etc. before they are installed.

1.9 The top oil temperature should invariably be noted during measurement of IR values of the transformer.

1.10 IR values should not be measured when the transformer tank is under vacuum.

2.0 Initial oil filling in Transformers received gas filled:

2.1 Oil Preparation:
2.1.1 The oil supplied in oil drums (for first filling, topping up & OLTC) is first filled into oil storage tank(s) through filter machine. This oil is then filtered in the tank(s).

2.1.2 The following oil values shall be attained so as to facilitate early and effective dehydration of the transformer:
   a) Breakdown Voltage: 70kV (Minimum)
   b) Moisture Content: 10 ppm (Maximum)

   The oil temperature in the filter machines should be set at 60°C.

2.2 Vacuuming of the Transformer:
2.2.1 Provide equalizing connections between main tank and OLTC Diverter Switch chamber(s) and isolate those parts of the transformer which are not designed for vacuum.

2.2.2 Erection of the part of the pipeline between the tank and the conservator up to the Buchholz relay.

2.2.3 Connect a breatheto any valve above the tank oil level through a suitable pipe.

2.2.4 Connect a transparent plastic pipe (either reinforced having wall thickness of 5 to 8 mm suitable for withstanding vacuum) between the top and bottom valves of the transformer to check the oil level.

2.2.5 Apply vacuum to the transformer. The vacuum pipe is generally connected to the pipeline between transformer tank and conservator. The extent of vacuum and the duration of its application shall be as per manufacturer's recommendations. In case this is not specified by the manufacturer, then vacuum of 1.00 torr (maximum) is to be applied for at least 12 hours for transformers of up to 145 kV class and 24 hours for transformers of high voltage class.

2.3 Oil Filling:
2.3.1 The treated oil shall then be filled into the transformer tank under vacuum until the oil level reaches 250 mm below the top cover level. The oil level can be seen in the transparent plastic pipe provided.
2.3.2 The vacuum in the tank is then slowly released by slightly opening the valve on which the breather is connected so that only moisture-free air goes inside the tank. The rate of release of vacuum should be very slow so that the silicagel in the breather does not get sucked into the tank.

2.4 Internal Inspection:
2.4.1 Internal inspection of transformers up to 145 kV class may be carried out if recommended by the manufacturer and as per procedure prescribed by him.

2.4.2 The oil is drained from the tank for internal inspection, and for erection if required. Where connections are required to be made inside the tank and when the erection work is to be continued on the next day, the oil is refilled after the day's erection activities are completed. Additional precautions prescribed by the manufacturer for dry air and humansafety during such erection activities should be followed.

3.0 The oil received in drums (for topping up & OLTC) for transformers received oil filled is filled into a storage tank through filter machine. This oil is filtered in the tank until the values given at para 2.1.2 are attained.

4.0 Transformers with separately mounted cooler banks:
4.1 Large size EHV Transformer (generally 245 kV class and above) are provided with separately mounted cooler banks.

4.2 Placing on foundation, levelling and centering of cooler banks supports (A-frame).
4.3 Erection of lower and upper headers on the A-frame.
4.4 Assembly and fitting of upper and lower cooler pipe line from transformer tank to respective headers including fixing of Valves, Pumps, NonReturn Valves, expansion joints, oil flow indicators, etc., as per General Arrangement (GA) drawing. The arrow mark on the oil pumps and oil flow indicators should point towards the transformer tank.
4.5 Grouting of cooler banks supports (A-frame).
4.6 Erection of Radiator on the headers.

5.0 Transformers with tank mounted cooler bank/ radiators:
5.1 Erection of headers, if provided.
5.2 Erection of radiator on headers/ tank.

6.0 Erection of Accessories:
6.1 Erection of main conservator & OnLoad Tap Changer (OLTC) conservator along with their supports.
6.2 Erection of HV, LV and TV turrets, when supplied separately.
6.3 Erection of HV, LV, TV & neutral bushing(s) and making their connections inside the tank, as required.

6.4 Fitting of Pressure Relief Devices along with pipes, if provided.

6.5 Erection of Explosion Vent, if provided. Ensure that diaphragms are fitted on both ends of the event pipe.

6.6 Assembly and fitting of equalizing pipeline between tank cover, turrets, inspection covers, etc. as provided.

6.7 Assembly and fitting of Buchholz pipeline, fitting of valves, expansion joints as provided and Buchholz relays, and connecting it to the equalizing pipeline and the main conservator. The arrow marks on the Buchholz relays should point towards the conservator. Where two Buchholz relays are provided, the relay near the tank is designated as Buchholz Relay–I and the relay near the conservator as Buchholz Relay–II.

6.8 Assembly and fitting of pipelines for breathers of main and OLTC conservators and fixing of breathers after checking the silicagel (to be replaced/regenerated, if not of blue colour), and also of filling of oil in the oil cup. Ensure that the sealing provided on the air passage of the breathers has been removed.

6.9 Assembly and fitting of cooler fans, including fitting of supports, if provided. The levelling, centering and grouting of ground mounted supports is to be got done before erection.

6.10 Erection/placing of control cubicle/marshalling box & OLTC drive mechanism. In case these are ground mounted, then these are to be placed on the foundation, levelled, centered and then grouted.

7.0 Filling of topping up oil in the transformer tank and conservator. During this process, the air release valves/plugs provided on the top of the conservator should be kept open. The oil shall be filled up to $1/3$rd level in the conservator.

8.0 Dehydration of Transformer by Hot Oil Circulation:

8.1 When starting the dehydration, oil is drawn from the bottom of the transformer into the filteration plant and let into transformer against the top for removing any settled moisture/impurities. The readings of IR values shall not be taken during this process as these will be misleading due to erroneous indication of winding temperature. After about 8–12 hours of circulation in this manner, the cycle is reversed, i.e., oil is drawn from the top and fed at the bottom.
8.2 During dehydration, measure insulation resistance values of the transformer every 2 hours. The test voltage of 5kV is applied for one minute. The winding temperature is assumed to be the same as the oil temperature under steady state conditions.

8.3 In the beginning, the IR values drop down as the temperature increases. If there is moisture in the windings, then the IR values at constant temperature will drop down as the moisture is removed from the insulation and gets dissolved in the oil. The moisture in the oil is continuously removed by the filtration plant. After the moisture has been removed from the winding, the IR values will start rising as the dissolved moisture in the oil is removed. These reach a constant value after the drying out is complete. The dehydration process is thereafter continued for a minimum of another 24 hours or until the oil values given at para 8.7 are attained.

8.4 If there is no moisture in the windings, then the IR values at constant temperature will remain the same. In such a case, the dehydration is stopped after the time prescribed by the manufacturer. If no such time is prescribed, then the dehydration at constant temperature is carried out for a minimum of 72 hours or until the oil values given at para 8.7 are attained.

8.5 Allow the transformer to cool down to atmospheric temperature. Measure the IR values at 2-hour intervals during the cooling period.

8.6 IR values can be plotted against time. A typical indicative drying out curve is shown below:

8.7 The following oil values shall be attained in order to increase the time interval before re-filteration of oil is required when the transformer is in service:
a) BreakDownVoltage: 80kV(Minimum)
b) MoistureContent: 10ppm(Maximum)

8.8 Comparetheinsulationresistancevalueswiththefollowingreferencevalues:

i) Newtransformers: FactoryTestResults.
ii) Oldtransformers: PreviousTestResults

Insulation resistance varies inversely with the temperature. For a 10°C change of
temperature, the insulation resistance changes by a ratio generally in the range of 2:1 to 1.4: 1.

If the specified IR values are achieved, the transformer can be charged.

8.9 If the specified IR values are not attained, then carry out further drying out by adopting any
of the following processes, as convenient. However, in case of transformers within
guarantee period, the manufacturer is to be contacted.

a) Hot air circulation.
b) Hot oil circulation and short circuit heating.
c) Heating, vacuum pulling and Nitrogen filling.
d) Hot oil circulation and vacuum pulling.

The processes at (a), (b) and (c) are described in the CIIP Manual on Transformers
(Publication no. 295) and in the IS: 10028 (Part – II) – 1981. The process at (d) is mostly
adopted and is described at para 8.9 below.

8.10 Drying by Hot oil circulation and vacuum pulling:

8.10.1 Carryouthotoilcirculationonthetransformer.Aftermaximumtopoiltemperatureis
attained, the hot oil circulation is continued for 2–3 volumes of the transformer oil. The
IR values and the temperature are noted.

8.10.2 Drain the oil from the tank and apply vacuum immediately and maintain for 12 hours. The
precautions, as given earlier, for application of vacuum (para 2.2.1) as well as for allowing
dry air into the transformer while draining oil (para 2.2.5) are to be followed.

8.10.3 Fill the oil again into the transformer. Start hot oil circulation and continue for 2–3
volumes of the transformer oil after maximum top oil temperature is attained. The IR
values and the temperature are noted.

8.10.4 The IR values as measured above at para 8.10.1 & para 8.10.3 are compared. If there is
improvement in the IR values, then the above process as given at para 8.10.2 & para 8.10.3
is continued till two consecutive readings are same.

8.10.5 If there is no change in the IR values as measured above at para 8.10.1 & para 8.10.3, then
another cycle of the above process as given at para 8.10.2 & para 8.10.3 is carried out. If
still there is no change, then the drying out process is stopped, otherwise it is continued till
two consecutive readings are same.
8.10.6 After constant IR values are achieved, the drying out process is stopped and the transformer is allowed to cool down to atmospheric temperature.

8.11 The IR values are then measured and the temperature is noted. These are compared with the reference values. If the previous IR values are achieved, the transformer can be charged.

9.0 Pressurizing of aircell in the main conservator:

9.1 Method recommended by the manufacturer:
9.1.1 Open the air release plugs/valves provided on the top of the conservator.
9.1.2 Drain the oil from the transformer through the bottom filter valve till the conservator is empty. This can be checked by ensuring that there is no oil in the Buchholz relay(s).

9.1.3 Remove the breather. Connect the air filling device, which is provided with a pressure gauge and a filling pipe in which an on return valve is fitted, to the breather pipe. Any valves in the breather pipes should be kept open.

9.1.4 Inject air into the Air Bag/PRONAL through the air filling device to a maximum pressure of 0.1 kg/cm².

9.1.5 Slowly pump the oil through the bottom filter valve. Temporarily stop the oil filling operation when oil along with air bubbles starts coming out of the air release plugs/valves. Close the air release valves such that the flow of oil will be very slow. Where air release plugs are provided, they should be fitted but not fully tightened.

9.1.6 Continue the oil filling. Oil mixed with air bubbles will start coming out. When all the air has been expelled, only oil will come out through the air release plugs/valves. The prismatic oil level gauge, if provided on the conservator, will indicate full oil level.

9.1.7 Stop the oil filling after ensuring that no air bubbles come out with the oil. Close the air release plugs/valves while still maintaining the air pressure.
9.1.8 Releasetheairpressurethereafter.

9.1.9 Refit thebreatheronthepipeline.

9.1.10 Continueth eofillingin thetransformer till thelevelshown on the Magnetic Oil Level Gauge (MOLG)correspondsto theoil temperature as per thereference mark given on the MOLG.

9.2 AlternateMethod/FieldPractice:

9.2.1 Keep theoil level in the conservator at approximately 1/3rd level.

9.2.2 Open theair releaseplugs/valves provided on the top of the conservator.

9.2.3 Remove the breather. Connect the air filling device, which is provided with a pressure gauge and a filling pipe in which an onreturn valve is fitted, to the breather pipe. Any valves in the breather pipes should be kept open.

9.2.4 Inject air into the Air Bag/PRONAL through the air filling device to a maximum pressure of 0.1 kg/cm².

9.2.5 The air in the conservator out sidethe Air Bag/PRONAL is pushed out through the air releaseplugs/valves. When all the air has been expelled, oil along with air bubbles starts coming out of the air releaseplugs/valves. The oil is allowed to come out until there are no air bubbles in the oil.

9.2.6 The prismatic oil level gauge provided on the conservator will indicate the oil level. The air releaseplugs/valves are then closed while still maintaining the air pressure.

9.2.7 Releasetheairpressurethereafter.

9.2.8 Refit thebreatheronthepipeline.

9.2.9 The level of oil shown on the Magnetic Oil Level Gauge (MOLG) is checked with respect to the oil temperature and the reference mark given on the MOLG.

9.2.10 While injecting air into the air cell, the abrupt and excessive increase of pressure should be avoided since it may cause the PRV to operate causing wastage of oil and even an accident.

10.0 Filling of oil in OLTC and its Dehydration:

10.1 Fill filtered oil (as per para 2.1.1/para 3.0) in the OLTC diverterswitchchamber(s) and the OLTC conservator.

10.2 Carry out dehydration of the oil. This oil is filtered in the OLTC diverterswitchchamber(s) until the values given at para 8.7 are attained.

11.0 Air Release from the Transformer:
11.1 Releaseairfromthefollowingairreleasepointstilltherearenoairbubblesintheoil comingoutfromthesearlreasepoints.
   a) AirreleaseplugsprovidedontheMaintankcoverandbushingturrets.
   b) AirreleaseplugsprovidedontheRadiators,HeadersandCoolerBankpipelines.
   c) BuchholzRelays.
   d) FloattypeOilSurgeRelays(OSR).
   e) Pressurereliefdevice(PRandinExplosionVent(ifprovided).
   f) Airreleasescrews/throughoiltypeBushings(up to 33kV).
   g) Airreleasescrews/plugsofdontheheadingflangeofO.I.P.Condenser typeBushings.
   h) Upperterminalofo.I.P.CondensertypeBushings
   i) OnLoadTapChanger/DiverterSwitchChamber.

12.0 AssemblyofOLTC DriveMechanism&OperatingSystem:
12.1 Fixthebrackets,gearboxesandoperatingshaftsbetweenOLTC drivemechanismand OLTC diverter switches. When connectingthe operating shaft(s), ensure that the tap position indicated in the OLTC drive mechanismand at the head of OLTC diverter switch(es)arethesame. Lockthebolts&nutssofthecoupling bracketsoftheoperating shaft(s),if provided.

12.2 ChecktheoperationoftheOLTC manuallyandmakeadjustmentssothatthereareequal numbersoffreeturnsoftheoperating handleafterachangepinchainthediverter switch bothduringRaise&Loweroperations.

12.3 Synchronize theoperationofall thethreeOLTCdiverterswitchessothatall thethree phasesoperatealmostsimultaneously.

13.0 CablingontheTransformer:
13.1 Carryoutlayingofcontrolcablesfromfans,protectiverelays,bushing/WTICT’s,etc.to thefancontrolcubicle/marshallingbox/Temperaturemeterbox.

13.2 Preparethecablesat boththeendsandfitintocable glands.

13.3 Drill holes in the cable gland plates of the fan control cubicle/marshalling box/ Temperaturemeterboxasperrequirement.

13.4 Fitthecablesonthese cable gland platesandconnectthewiresasoperschematicdrawing.

14.0 Fix/fit minoraccessoriesasbelow:
   a) Clamps/Bracketsfordabesandfixingofpipesonthem.
   b) ProtectivecoversforOLTCoperatingshaft(s).
   c) Fixingofcabletrays/bracketsonthetankcoverandclampingofcables onthem.
   d) Fixingof sensors/probesforoil&windingtemperatureindicatorsofterfillingoil in thepocketsprovidedforthem.
   e) Fixingofterminal connectersonthe bushings.
   f) Anyotheraccessories,etc.as provided.

15.0 Afterinstallationworkisover, the transformeristobemade readyforcommissioning. Prior
toputtingthetransformerintoservice,attentionsshouldbepaidtothechecksandtests
giveninthefollowingparas. Thechecks/testsgivenhereafter aregenerally applicable.
Specificchecks/testsprescribedbythemanufacturer arealsotobecarriedout. Problems
arisingoutofpeculiarsituationssaretobeassessedandsolvedoncasetocasebasis.

16.0 **PRE–COMMISSIONINGCHECKS:**

16.1 All equipmentsare mounted in position as per General Arrangement drawing of the
manufacturer.

16.2 MinimumclearancesbetweenlivepartsandbetweenlivepartstoearthareasperGeneral
Arrangement drawing.

16.3 ArrowontheBuchholzRelays&OilSurgeRelays pointingtowardstheConservator.

16.4 Arrowontheoilflowindicatorsandtheoil
pumpsispoinctowardsthetransformertank.

16.5 Inspectthetransformeralloverandcheckallflangedjointsandfittingsforoilleakages. If
foundnecessary, re–tightenthethebolts.

16.6 IsolatingvalvesinBuchholzpipelineandalltheradiatorsandanyvalveifprovidedinthe
breatherpipelinemarefullyopenedandlockedintheopenposition.

16.7 Releaseairfromtheinsideofthetransformertankbyopeningallplugs/ventingscrews/
valvesonradiators, bushings, Buchholzrelay,OLTCoilsurgerelay(floattype)andgas
collection pipe, if provided, andtankcoveruntiloilappears. Closetheseaftertheabove
checkhasbeencarriedout.

16.8 Oillevel inthe mainconservatorandOLTConservatorisaspertheoil
temperature.

16.9 Oillevel inthecondenserbushings.

16.10 Thethermometerpocketsprovidedforoilandwindingtemperatureindicatorsarefilled
withoil.

16.11 Thecolourofsilicagelinthebreathersisblueandthatoilisfilleduptocorrectoillevel
markintheoilcup.

16.12 Buchholzrelaycontactsarenotlockedandthesearein‘SERVICE’position.

16.13 ThetransportlocksprovidedinequipmentsuchastheMOLG, oilflowindicators, OTI,
WTI, etc. havebeenremoved.

16.14 SettingofallthemercurswitchesforAlarm, TripandCoolercontrolintheOil and
WindingTemperatureIndicators. Aspergeneralprevailingpractice, thesettingsare mad
e asgivenbelow:
a) Oil Temperature Indicator (OTI):  
   Alarm: Trip  
   ON: 70°C  
   OFF: 60°C  
   ON: 80°C  
   OFF: 70°C

b) Winding Temperature Indicator (WTI):  
   Fan/ Fan  
   Group – I:  
   Start: 55°C  
   Stop: 50°C  
   Oil Pump/ Fan  
   Group – II:  
   Start: 65°C  
   Stop: 60°C  
   Alarm:  
   ON: 80°C  
   OFF: 70°C  
   Trip:  
   ON: 90°C

If the site and load conditions warrant, higher settings of the winding temperature alarm & trip contacts may be adopted for which the manufacturer’s recommendations are to be followed.

16.15 The Transformer neutral is connected to earth at two separate earth pits/electrodes which in turn are connected to the earthmat.

16.16 The Transformer tank, OLTC drive mechanism, cooler bank, marshalling box, cooler control cabinet, temperature meter box, etc. as provided are earthed.

16.17 Proper connections and tightness of terminal connectors provided on Bushings.

16.18 Bolts & nuts of the coupling bracket of the operating shaft(s) of the OLTC have been locked.

16.19 No oil is visible in Explosion Vents sight glass, if provided.

16.20 Jumpering arrangement to achieve phase matching, if the transformer is to run in parallel with another transformer.

16.21 Setting of overload/protection relays/MCBs for fans & pumps and for OLTC motors per their rating.

17.0 PRE–COMMISSIONING TESTS:

For DGA oil sample shall be taken after 24 hours of stopping filtration.

17.1 Non-Trip Alarms:  
   Operation of the corresponding auxiliary relays if provided and alarm annunciation on actual operation of the transformer mounted protective relays and supervisory equipments.

   i)  Main Conservator Low oil level alarm.  
   ii) OLTC Conservator Low oil level alarm.  
   iii) Oil temperature high alarm.  
   iv) Winding temperature high alarm (HV).  
   iv) Winding temperature high alarm (LV).
v) Winding temperature high alarm (TV).
vi) Air cell fail alarm.

17.2 Trip Alarms:
Operation of the corresponding auxiliary relays, Master Trip relays and alarm annunciator on actual operation of the transformer mounted protective relays and supervisory equipments.

i) Buchholz Alarm (I & II) by draining oil from the relay.
ii) Buchholz Trip (I & II) by draining oil from the relay.
iii) Oil Temperature Trip.
iv) Winding Temperature Trip (HV).
v) Winding Temperature Trip (LV).
vii) OLTC Surge Relay (U, V, W/ common, as provided).

17.3 Testing by the Protection Wing of Over current, Earth fault, Over flux, Neutral Displacement alarm, Restricted Earth Fault (REF), Circulating Current Differential protection, Transformer Differential protection relays, associated Master Trip relays, alarm annunciations, etc., as provided.

17.4 Tripping of HV circuit breaker & inter tripping of LV circuit breaker on operation of Master Trip Relays. This may be checked for operation of each Master Trip Relay for 2 or 3 protective relays.

17.5 Phase sequence of the A.C. supply to the Cooler Control Cubicle (CCC)/ Fan Control Cubicle (FCC)/ Marshalling Box.

17.6 Direction of rotation of fans and pumps.

17.7 Operation of fans/oil pumps as per settings made in the winding temperature indicators as per para 16.14.

17.8 Operation of standby fans/ pump on failure of each fan/ pump.

17.9 Lamp indications on RTCC Panel for fans and pumps.

17.10 Testing of alarm annunciations, such as “Fan Fail: Group – 1&2”, “Pump Fail: Group – 1&2”, “Cooler Control Supply Fail”, “Standby Fan Fail: Group – 1&2”, “Standby Pump Fail: Group – 1&2”, etc., as provided in the RTCC Panel.

17.11 Manual operation of OLTC:

a) Operate by handle from tap no. 1 to the maximum tap position & back to tap no. 1.

b) Verify the reading of Tap Position Indicator (TPI) on Remote Tap Changer Control (RTCC) panel on all the tap positions.
c) Observe any abnormal sounds during this operation.
d) Confirm functioning of mechanical locking at extremetapositions.
e) Check functioning of operation counter.

17.12 Electrical operation of OLTC:

a) Operation of handle interlock. There should be no electrical operation of the OLTC with handle inserted.
b) Check phasesequence of the A.C. supply to the OLTC drivemechanism.
c) Operate OnLoad Tap Changer (OLTC) from tap no. 1 to the maximum tapposition & back to tap no. 1 from local and from remote, i.e., RTCC Panel. Never start this OLTC operation from extremetapositions.
d) Confirm functioning of electrical limitswitches at extremetapositions.
e) StepbystepoperationoftheOLTC (onlyonetapshould change inonepulseorwith continuouspulse).
f) Check tripping of MCB in OLTC drivemechanism by pressing “Emergency Push Button” from local and from RTCC Panel.
g) Checking of Lamp Indications provided in the RTCC Panel.
h) If the transformer is to be run in parallel with another transformer, operation of OLTC Drive mechanism by making one transformer as ‘Master’ and another one as ‘Follower’ & vice versa, i.e., “Master–Follower Operation of Transformer”.
i) Testing of alarm annunciations, such as “Tap Changer Stuck/Tap Change Delayed”, “OLTC Motor MCB Trip”, “OLTC Control Supply Fail”, “OLTC out of Step”, etc., provided in the RTCC Panel.

17.13 Reading of Oil & Winding temperatures on Remote Temperature indicators provided in the RTCC Panel with reference to the OTI & WT if fitted on the transformer.

17.14 Testing of Transformer:
a) Magnetizing current measurement of all three phases of LV winding with single phasesupply applied between phase and neutral alone by one keeping HV & TV windings open.
b) Magnetizing current measurement of all three phases of HV winding at Tap no. 1 with single phasesupply applied between phase and neutral alone by one keeping LV & TV windings open.
c) Magnetizing current measurement of all three phases of the TV winding in case all the three phases have been brought out. For star connected TV winding, single phase supply is applied between phase and neutral of TV winding one by one keeping HV & LV windings open. Incase of delta connected TV winding, the voltage is applied one by one between phases of the TV winding keeping HV & LV windings open.

d) Magnetic balance test on all three phases of LV winding by applying single phase voltage one by one between phase and neutral of one phase and measuring the induced voltage on the other two phases.

e) Magnetic balance test on all three phases of TV winding, incase all the three phases of the TV winding have been brought out, by applying single phase voltage one by one between phase and neutral one by one for star connected winding or between phases for delta connected winding and measuring the induced voltage on the other two phases.

f) Short circuit current measurement of all three phases of HV winding at Tap no. 1 with single phase supply applied between phase and neutral one by one with LV winding short–circuited and TV winding open–circuited.

g) Short circuit current measurement of all three phases of HV winding at Tap no. 1 with single phase supply applied between phase and neutral one by one with TV winding short–circuited in case all the three phases of the TV winding have been brought out. LV winding is kept open–circuited.

h) HV, LV and TV WTI CT testing by measuring the current in the leads from the WTI CT terminal to the winding temperature indicator(s) during the above short circuit current measurement tests.

i) Checking of continuity of contacts in diverters switch: During short circuit current measurement test above, connect an analog type AVO/multi–meter on the HV winding and operate the OLTC from tap no. 1 to the maximum tap. There should not be any break in the current during tap change which is indicated by the sudden deflection in the multi–meter reading.

j) Incase of tertiary winding where two terminals have been brought out, testing of TV winding by giving 3–phase supply to HV, then shorting each LV phase with neutral one by one and measuring open delta voltage and closed delta current.

k) Transformer Turns ratio measurement between HV–LV, HV–TV & LV–TV using turns ratio measuring instrument.

l) Insulation resistance measurement (meggering) and recording the readings for 15 sec. and 60 sec. between HV–Earth, LV–Earth, TV–Earth, HV–LV, HV–TV & LV–TV using 5kV megger. The 60 second values shall be taken as the reference value for future comparison. The top oil temperature is to be recorded.
m) Winding resistance measurement of all three phases of HV (at Tap no. 1), LV and TV windings. The top oil temperature is to be recorded.

n) Subject to availability of testing instrument, measurement of capacitance and Tan δ of condenser bushings and transformer windings for reference. The top oil temperature is to be recorded. It is not advisable to carry out this test when the relative humidity is above 75%.

o) Checking of Vector Group of the transformer. Check earth resistance of transformer neutrals. Check SFRA.

p) Testing of transformer oil. (Take oil sample after 24 hours of stopping filtration). The following tests are generally desired to be carried out on transformer oil as per IS 1866:2000–Code of Practice for Electrical Maintenance and Supervision of Mineral Insulating Oil in Equipment. The limits for unused mineral oil filled in New Power Transformers as recommended in Table 1 of the above Indian Standard are given below.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Property of Oil</th>
<th>Highest Voltage of Equipment (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt; 72.5</td>
</tr>
<tr>
<td>1.</td>
<td>Appearance</td>
<td>Clear; free from sediments and suspended matter</td>
</tr>
<tr>
<td>2.</td>
<td>Density at 29.5°C (g/cm³), Max.</td>
<td>0.89</td>
</tr>
<tr>
<td>3.</td>
<td>Neutralization value (mg KOH/g), Max.</td>
<td>0.03</td>
</tr>
<tr>
<td>4.</td>
<td>Water Content (ppm), Max.</td>
<td>10</td>
</tr>
<tr>
<td>5.</td>
<td>Dielectric dissipation factor at 90°C and 40 Hz to 60 Hz, Max.</td>
<td>0.015</td>
</tr>
<tr>
<td>6.</td>
<td>Resistivity (90°C) × 10^12 (ohm·cm), Min.</td>
<td>6</td>
</tr>
<tr>
<td>7.</td>
<td>Breakdown Voltage (kV), Min.</td>
<td>80</td>
</tr>
<tr>
<td>8.</td>
<td>Dissolved Gas Analysis</td>
<td>For Reference</td>
</tr>
<tr>
<td>9.</td>
<td>Viscosity at 27°C (cSt), Max.</td>
<td>27</td>
</tr>
<tr>
<td>10.</td>
<td>Flash Point (ºC), Min.</td>
<td>140</td>
</tr>
<tr>
<td>11.</td>
<td>Pour point (ºC), Max.</td>
<td>-6</td>
</tr>
<tr>
<td>12.</td>
<td>Interfacial Tension (mN/m), Min.</td>
<td>35</td>
</tr>
<tr>
<td>13.</td>
<td>Oxidation Stability of uninhibited oil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(i) Neutralization Value (mg KOH/g), Max.</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(ii) Sludge (percent by mass), Max.</td>
<td>0.1</td>
</tr>
<tr>
<td>14.</td>
<td>Oxidation Stability of inhibited oil</td>
<td>Similar values as before filling</td>
</tr>
<tr>
<td></td>
<td>(i) Induction Period (hours)</td>
<td></td>
</tr>
</tbody>
</table>
q) The following tests as recommended in IS:1866 are the minimum tests which should be conducted on the transformer oil. The limits as recommended in Table 1 of IS 1866:2000 are also given below.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Property of Oil</th>
<th>Highest Voltage of Equipment (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt; 72.5</td>
</tr>
<tr>
<td>1.</td>
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<td>2.</td>
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<td>0.89</td>
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<td>3.</td>
<td>Neutralization value (mg KOH/g), Max.</td>
<td>0.03</td>
</tr>
<tr>
<td>4.</td>
<td>Water content (ppm), Max.</td>
<td>10</td>
</tr>
<tr>
<td>5.</td>
<td>Dielectric dissipation factor at 90°C and 40 Hz to 60 Hz, Max.</td>
<td>0.015</td>
</tr>
<tr>
<td>6.</td>
<td>Resistivity (90°C) × 10¹² (ohm·cm), Min.</td>
<td>6</td>
</tr>
<tr>
<td>7.</td>
<td>Breakdown Voltage (kV), Min.</td>
<td>80</td>
</tr>
<tr>
<td>8.</td>
<td>Dissolved Gas Analysis</td>
<td>For Reference</td>
</tr>
</tbody>
</table>

r) Other tests as prescribed in the Operation and Maintenance Manual of the Manufacturer.

17.15 The results of all the above tests are to be recorded for future reference.

18.0 CHARGING OF TRANSFORMER:
18.1 Check the tripping of HV circuit breaker & intertripping of LV circuit breaker on operation of Master Trip Relays. This may be checked for operation of each Master Trip Relay for 2 or 3 protective relays.

18.2 Transformer is to be charged at tap no. 2. Otherwise, transformer may trip on differential protection due to high magnetizing inrush current.

18.3 After charging, the operation of the OLTC is to be checked by increasing the tap position up to the tap corresponding to the system voltage.

18.4 Manufacturers recommend that transformer be kept on load for 24 hours. During this period, observe the temperature rise of the oil & winding.

18.5 De-energize the transformer and check the Buchholz relay for any collection of air / gas.

18.6 Recharge the transformer at Tap no. 2.

18.7 After re-charging, the tap position of the transformer is to be fixed according to the HV side voltage available. The tap position (same voltage ratio) should also match with the transformer already in service in case of parallel operation.

18.8 Then take load on the transformer.
For operation and maintenance of Power Transformers, the “MAINTENANCE ANNUAL FOR POWER TRANSFORMERS” of VPN (erstwhile RSEB) should be followed.
CIRCUITBREAKERS

1.0 GENERALINSTRUCTIONS:
1.1 The circuit breakers are to be erected, tested and commissioned as per the instructions given in the Erection, Installation & Commissioning Manual of the Manufacturer.

1.2 The services of the Manufacturer’s Erection & Commissioning Engineer may be utilized wherever required.

1.3 Bending of compressed air piping, if required, shall be done in a manner such that the inner diameter of the pipe is not reduced. This should be done through cold bending using a bending machine only.

1.4 Cutting of the pipes, wherever required, shall be done such that there is no flaring of the end of the pipe. Only a proper pipe – cutting tool shall be used.

1.5 The SF6 gas should be filled in one pole at a time to ensure that gas is filled in all the three poles.

1.6 The procedure/stepsbased generally followed for erection of Circuit Breakers are given below.

2.0 Erection of Supporting Structures:
2.1 Assemble the supporting structure(s) if the members are received in loose condition.

2.2 Erect the supporting structure(s) on the foundation and carry out their levelling, centering and grouting.

2.3 Level the top of the already erected supporting structure(s) and check their verticality.

3.0 Preparation & Checking of the Circuit Breakers Poles:
3.1 Clean the insulators of the breaker poles and check for cracks in the insulators.

3.2 In case of SF6 Circuit Breakers, check that there is positive pressure of the SF6 gas in the breaker poles, and the support columns if provided, by opening the cover of the pipe connection and pressing the non-return valve.

3.3 In case of Vacuum Circuit Breakers, check the vacuum in the individual poles as follows:
   a) Remove the linkage of the individual pole from the operating lever.
   b) Pull the linkage of each interrupter manually towards the ‘OPEN’ position during which operation, appreciable forces should be countered. Release the moving contactrod suddenly. It should return automatically to the ‘CLOSED’ position with a loud metallic noise.
   c) Reconnect the linkage of the individual pole to the operating lever.

4.0 Erection of Circuit Breaker Poles:
4.1 In case of CBs received with poles already fitted on a common base channel, erect the base channel along with breaker poles on the supporting structures.
4.2 In case of CBs with common base channel but in which the poles are received separately, first erect the base channel on the supporting structure(s) and carry out levelling. Thereafter, erect the poles on the base channel. Erect the middle pole first followed by the side poles.

4.3 In case of CBs in which the poles are to be erected on the operating mechanism, first erect the operating mechanisms on the supporting structures and carry out levelling. Thereafter, erect the CB poles on the operating mechanisms.

4.4 In case of other types of CBs, erect the CB poles on the supporting structures.

4.5.1 In case of CBs with horizontal arc chambers, first erect the support columns on the supporting structures.

4.5.2 Fit the pre-insertion resistors and voltage grading capacitors, if provided, on the arc chambers.

4.5.3 Thereafter erect the arc chamber assemblies on the supporting columns of individual phases.

4.6 Check the verticality of the erected poles of the CBs and correct them wherever required.

4.7 Erect the operating mechanism / operating drive on the supporting structure of the designated phase, or on all the three individual phases/ poles, or on the common structure, or on the common base channel, as applicable.

4.8 Fit the terminal connectors on the three poles of the breaker.

5.0 Erection of Operating Mechanism, Accessories & Associated Equipment:

5.1 In case of ground mounted control cubicle, erect it on its foundation and carry out its centering, levelling and grouting. In other cases, erect the control cubicle on the supporting structure/ base channel as provided.

5.2 Place the air compressor, if provided separately, on its foundation and carry out its centering, levelling and grouting.

5.3 In case of ground mounted operating mechanism, erect it on its foundation and carry out its centering, levelling and grouting. In other cases, erect the operating mechanism on the supporting structure/ base channel as provided.

5.4 In case of circuit breakers up to 33 kV, the operating mechanism is generally received mounted on the assembled structure.

6.0 For Gang Operated Circuit Breaker:

6.1 Connect the operating shaft/ rod between the poles and between the first pole and the mechanism, or as applicable.
6.2 IMPORTANT: DONOT CHANGE OR ADJUST THE LENGTH OF THE OPERATING SHAFT/ROD.

6.3 Fit the protective covers for operating shaft/rod, if provided.

7.0 Gas Filling in SF6 Gas Circuit Breakers:
7.1 CBs with Common SF6 Gas Pipeline:
7.1.1 Fit the SF6 gas density monitor on the support structure/base channel as provided and connect to the SF6 gas pipeline.

7.1.2 Connect the SF6 gas pipeline to one pole & fill SF6 gas in the pole up to about 2 kg/cm². Check for leakage of SF6 gas in the pole and in the SF6 gas pipeline. Attend to the leakages, if any.

7.1.3 Fill SF6 gas in the pole up to the prescribed rated/filling pressure. The filling pressure should correspond to the ambient temperature at the time of filling as per the chart given in the manufacturer’s manual. The setting and operation of the lockout contacts (closing) and the alarm contact (opening) provided in the density monitor, are checked during SF6 gas filling.

7.1.4 Connect the SF6 gas pipeline to the second pole. The gas pressure in the first pole will fall.

7.1.5 Check for leakage of SF6 gas in the second pole. Attend to the leakages, if any.

7.1.6 Fill the SF6 gas in the two poles simultaneously up to the prescribed rated/filling pressure.

7.1.7 Connect the SF6 gas pipeline to the third pole.

7.1.8 Check for leakage of SF6 gas in the third pole. Attend to the leakages, if any.

7.1.9 Finally fill SF6 gas in all the three interconnected poles up to the prescribed rated/filling pressure.

7.1.10 The procedure from para 7.1.4 to para 7.1.9 ensures that SF6 gas is filled in all the three poles.

7.1.11 Ensure that the alarm and lockout contacts are in normal condition after SF6 gas filling.

7.2 CBs with SF6 Gas Density Monitor on Individual Poles:
7.2.1 Fit the SF6 gas density monitor on each pole along with pipeline if provided.

7.2.2 Fill SF6 gas in each pole one by one up to about 2 kg/cm². Check for leakage of SF6 gas in the poles and in the SF6 gas pipeline. Attend to the leakages, if any.
7.2.3 Fill SF₆ gas up to prescribed filling pressures in each pole one by one. The filling pressures should correspond to the ambient temperature at the time of filling as per the chart given in the manufacturer’s manual. Check operation of the alarm and lockout contacts provided in the density monitor during SF₆ gas filling.

7.2.4 Check for leakage of SF₆ gas from all points (e.g., joints, couplings, cementing on insulator & metallic joints, brazing, etc.) and attending to any leakage if detected.

7.2.5 Ensure that the alarm and lockout contacts are in normal condition after SF₆ gas filling.

8.0 Circuit Breakers having Pneumatic Operated Mechanism:

8.1 Fabricate the compressed air pipeline as per pipeline drawing & clean it. The pipeline is first cleaned by passing a mulmul cloth through it with the help of a wire. Thereafter, one end of the pipeline is connected to the air compressor and the other end is plugged. A small air pressure is injected in the pipeline and then suddenly released by removing the plug so that the pipeline is flushed.

8.2 Fit the pipeline as per drawing.

8.3 Check phase sequence of the A.C. supply to the air compressor and check direction of rotation of air compressor motor. Check and top up oil in the air compressor. Also check that the V-belt is at the correct tension.

8.4 Pressurize the compressed air pipeline and air storage tank(s) to about 5 kg/cm² and check for air leakage from all possible points (e.g., control blocks, joints, couplings, brazing, etc.) and attending to any leakage if detected.

8.5 Pressurize the compressed air pipeline to the rated pressure. During the rising pressure, check the operation of the pressure switches and verify their settings, as per the manufacturer’s recommendations, for “Low Air Pressure Lockout”, “Auto Reclose Blocking”, “Low Air Pressure Alarm”, & “Compressor Stop”.

8.6 Switch off the A.C. supply to the compressor. Open the drain valve on the air storage tank such that air is released slowly. During the falling pressure, check the operation of the pressure switches and verify their operating and differential settings, as per the manufacturer’s recommendations, for “Compressor Start”, “Low Air Pressure Alarm”, “Auto Reclose Blocking” & “Low Air Pressure Lockout”. Adjust the pressure settings if required.

8.7 Check the auto/ manual operation of the air compressor.

8.8 Start the compressor in the manual mode and build up pressure. Check operation of safety valve and verify its setting. If the safety valve does not operate even when the prescribed pressure is exceeded, stop the air compressor and adjust the setting to the required value and re-verify this setting. Drain air so as to maintain normal pressure in the storage tank(s).
9.0 CircuitBreakershavingHydraulicOilOperatedMechanism:

9.1 Clean all the prefabricated hydraulic oil pipes bypassing a mulmul cloth through them with the help of a wire.

9.2 Fit the prefabricated hydraulic coil pipeline as per drawing.

9.3 Fill hydraulic oil, of the designated grade as supplied with the Circuit Breaker, in the storage tank(s) up to the fill mark.

9.4 Check phase sequence of the A.C. supply to the oil pump motor and check its direction of rotation.

9.5 Start the oil pump motor and release air from the venting screw(s) provided. Buildup pressure in the hydraulic coil pipeline. Topup oil, as and when required, to maintain oil level in the storage tank.

9.6 During increasing pressure, check operation of pressure switches and verify their settings for “Low Oil Pressure Lockout”, “Auto Reclose Lockout”, “Low Oil Pressure Alarm” & “Oil Pump Stop”.

9.7 Check for oil leakage from all the points (e.g., joints, couplings, brazing, etc.) and attend to the leakages if detected.

9.8 Open bypass valve to reduce oil pressure. During falling pressure, check operation of pressure switches and verify their settings for “Oil Pump Start”, “Low Oil Pressure Alarm”, “Auto Reclose Lockout”, and “Low Oil Pressure Lockout”.

9.9 Check the auto/manual operation of the oil pump.

9.10 Start the oil pump in the manual mode and build up pressure. Check operation of safety valve and verify its setting. If the safety valve does not operate even when the prescribed pressure is exceeded, stop the oil pump motor and adjust the setting to the required value and re-verify this setting. Open bypass valve to reduce the oil pressure to normal.
10.0 **CircuitBreakershavingSpringOperatedMechanism:**

10.1 ENSURE THAT THE CLOSING SPRING IS FULLY DISCHARGED. If it is not fully discharged, then discharge the spring as per instructions given in the manufacturer’s manual.

10.2 Carry out slow mechanical operation (closing and tripping) of Circuit Breaker as per procedure prescribed by the manufacturer. Take all the precautions mentioned in the manufacturer’s manual.

10.3 Manually charge the closing spring and check electrical limitswitch, mechanical latches and stopper(s) as provided.

10.4 Discharge the spring as per directions in the manufacturer’s manual.

10.5 Charge the spring electrically and verify the operation of the limitswitch. Adjust the setting of the limit switch if required.

11.0 **Cabling&Wiring:**

11.1 Carry out laying of cables between the following:

i) Operating mechanism of individual phases (R, Y & B) and control cubicle, if applicable.

ii) Compressor and control cubicle.

iii) Density Monitor and control cubicle.

iv) Control cubicle and Control & Relay Panel.

v) Control cubicle and bay marshalling kiosk.

11.2 Fix the cables in cable glands and then fix the cable glands on cable gland plates in the respective equipment.

11.3 Connect the cables as per schematic diagram of the circuit breaker. The following typical connections are made at the circuit breaker end.

a) DC positive & DC negative for local operation.

b) DC positive for remote closing.

c) DC positive for remote tripping.

d) Remote closing signal.

e) Remote tripping signal.

f) Protection trip signal.

g) Trip circuit supervision.

h) ON/OFF indications (Lamp & Semaphore).

i) Auto Trip/ Spring Charged Lamp indication.

j) Air pressure/Oil pressure/Spring charging limit switch contacts for autoreclose blocking.

k) Contacts of pressure switches for annunciation of low SF6 gas/air/oil pressure alarms & lockout conditions and for loss of N2 pressure.

l) Contact for annunciation of pole discrepancy trip alarm. 

m) Auxiliary contacts as required for various control circuits.

11.4 Dress and fix the cables in cable trays/ trenches/ supports/ brackets.
12.0 **PRE–COMMISSIONING CHECKS:**

12.1 Check the following in the Air Compressor:

i) Oil level is up to the mark.

ii) Oil colour is not black.

iii) Air filter is clean.

iv) V–belt is properly tensioned.

12.2 Check SF₆ gas/ hydraulic oil/ air leakages, as applicable, and attend if required.

12.3 Check the pressure of SF₆ gas/ hydraulic oil/ air in the circuit breaker, as applicable.

12.4 Check clamping of the pipeline for SF₆ gas/ hydraulic oil/ air, as applicable.

12.5 Check the oil level in the oil storage tank(s) of all the three poles of CB with hydraulic oil operated mechanism. The oil level should be between the maximum & minimum level marks, otherwise, top up with oil.

12.6 Check the contact wear indication mark or the specified gap as given in the instruction manual in case of Vacuum Circuit Breakers with the circuit breaker in the closed position.

12.7 Lubricate all the moving parts and the pins in the operating mechanism.

12.8 Check settings of air/ oil pressure switches.

12.9 Check resistance of closing and tripping circuits.

12.10 Check and adjust the resistance in the closing/ tripping coil circuits, if required.

12.11 Check alarm annunciations in the C&R Panel for low SF₆ gas/ hydraulic oil/ air pressure alarm, SF₆ gas/ hydraulic oil/ air pressure lockout and loss of N₂, as applicable.

12.12 Check closing and opening operation of circuit breaker from local, remote and protection. Check closing of Circuit Breaker through auto–reclose scheme, if provided. Confirm that the correct pole of the Circuit Breaker has operated.

12.13 Check operation of dashpot/damper. It should damp the speed of the Circuit Breaker at the end of both closing and tripping operations.

12.14 Check functioning of operation counter.

12.15 Check operation of anti–pumping/ hunting relay by giving continuous closing and tripping signals simultaneously. The breakers should close and then trip and should not close again.

12.16 Check operation of pole discrepancy relay, if provided, and its alarm annunciation in the C&R Panel.
12.17  Check lamp and semaphore indications, as applicable, in the C&R Panel for CB OPEN, CLOSED, AUTOTRIP and SPRING CHARGED conditions.

12.18  Check the Trip Circuit Supervision circuits in both CB open and closed conditions by removing the wires of the tripping circuit.

12.19  Check functioning of space heater and internal illumination circuits.

12.20  Check earthing of the poles, base channel, control cubicle, operating mechanism, compressor and structure(s), as applicable.

13.0  PRE-COMMISSIONING TESTS:

13.1  Measure insulation resistance with 5kV megger of all three phases between lower terminal to earth and between upper and lower terminals with the breaker in the open position.

13.2  Measure Closing (C), Opening (O) and Close–Open (CO) operation timings of the breaker with CB Timer or CB Analyser.

13.3  Test the operation of the CB with the emergency tripping arrangement, if provided.

13.4  Manufacturers of Vacuum Circuit Breakers recommend the following method for testing the vacuum in the interrupters with the circuit breaker in 'OPEN' condition: Using high voltage testing equipment, apply the voltage as given below across the upper and lower terminals of the VCB for 60 seconds.

(a)  33kV VCB - 70kV
(b)  11kV VCB - 28kV

The vacuum interrupters should withstand the applied voltage.

Since the above facility is not available, check the vacuum as given at para 3.3 above.
ISOLATORS

1.0 ERECTION OF ISOLATORS:
1.1 Level the already erected structure(s) and carry out minor fabrication works, if required, for erection of the Isolator and operating mechanism(s).

1.2 Erect the 3 nos. base frames of individual phases on the structure(s).

1.3 Carry out levelling and centering of the base frames.

1.4 Fix the link pipes on the rotating part of the base frames of the individual phases.

1.5 Clean and assemble the polycone insulator/insulator stack, as applicable. For single break isolators, there will be six polycone insulators/insulator stacks whereas for double break Isolators, the quantity will be nine.

1.6 Fit the male and female contact arms on the polycone insulators/insulator stacks in case of single break Insulator. In case of double break Isolator, 6 nos. fixed contacts and 3 nos. moving contacts are fitted on the polycone insulators/insulator stacks.

1.7 Fix the fixed contacts of earth blades in case of Isolator with Earth Switch.

1.8 Fix the arcing horns (make before & open after the main contacts) or coronarings, as applicable.

1.9 Erect the above assemblies on the rotating part of the base frames.

1.10 Carry out adjustment/alignment of individual phases for smooth opening and closing and proper making of contacts.

1.11 Fit the inter-phase connecting pipes between the rotating part of the base frames of the individual phases, including fixing of hardware for interlocking with earth switch wherever provided.

1.12 Fit the operating mechanism box for the Isolator.

1.13 Fit the main operating down pipe to operating mechanism for the Isolator.

1.14 Check the operation and final adjustment/alignment of all the three phases of main Isolator for smooth, synchronized and complete operation as one unit.

1.15 Adjust the mechanical end stops on the base channel for both the closed and open positions.

1.16 Fit the terminal connectors on the Isolator.

2.0 ERECTION OF EARTH SWITCHES:
2.1 Fix the earth blade mounting arrangements on the base frames of all three phases.
2.2 Fit the moving contact (earth blade) of the earth switches and counterweights, wherever provided.

2.3 Carry out the operation and adjustment/alignment of earth switch of each phase for smooth opening and closing and proper making of contacts.

2.4 Fit the inter-phase connecting pipes between the earth switches of the individual phases, including fixing of hardware for interlocking with main isolator.

2.5 Fit the operating mechanism box for the earth switches.

2.6 Fit the main operating down pipe to operating mechanism for the earth switch.

2.7 Check the operation and final adjustment/alignment of all the three phases of the earth switch for smooth, synchronized and complete operation as one unit.

2.8 Carry out the adjustment and setting of mechanical interlock between main isolator and earth switch to ensure that earth switch does not operate if the main isolator is closed, and that main isolator does not operate if the earth switch is closed.

2.9 Carry out the adjustment of mechanical end stoppers for the OPEN position of earth switch.

2.10 Fit the earth bonds and other accessories as provided.

3.0 OPERATING MECHANISM:

3.1 Carry out the adjustment and setting of auxiliary switches.

3.2 Carry out the adjustment of limits switches in CLOSED and OPEN positions of isolator in case of motor operated mechanism.

3.3 Carry out the adjustment of mechanical end stoppers for both the CLOSED and OPEN positions.

3.4 Carry out the adjustment of interlocking coil and plunger in CLOSED and OPEN positions.

4.0 Cabling & Wiring:

4.1 Carry out laying of cables between the following:

i) Operating mechanisms of individual phases (R, Y & B) in case of individual phase operating mechanism.

ii) Operating mechanism and Control & Relay Panel.

iii) Operating mechanism and bay marshalling kiosk.

4.2 Fix the cables in cable glands and then fix the cable glands on cable gland plates in the respective equipment.

4.3 Connect the cables as per schematic diagram of the isolator and earth switch. The following typical connections, as applicable, are made at the isolator and earth switch end:

a) DC positive & DC negative for local operation.
b) Interlockingsupply.
c) DCpositiveforremoteclosing.
d) DCpositiveforremoteopening.
e) Remoteclosingsignal.
f) Remoteopeningsignal.
g) OPEN/ CLOSEindications(Lamp/ Semaphore).
h) Contactforannunciationofpolediscrepancytrip alarm.
i) Auxiliarycontactasrequiredforvariouscontrolcircuits.

4.4 Dressandfixthecablesincable trays/ trenches/ supports/ brackets.

5.0 PRE-COMMISSIONINGCHECKS:
5.1 LubricateallthemovingpartsandthepinsoftheIsolator&earthswitchandinthe operatingmechanism.

5.2 CheckphasesequenceoftheA.C.supplytothemotorandcheckdirectionofrotationof isolator,ifapplicable. Keeptheisolatorinhalfclosedpositionbeforecheckingthephase sequence.

5.3 CheckoperationofIsolatorandearthswitchforfollowing:
   i) Smoothoperation.
   ii) Completeinsertionandmakingofcontactsincloseposition.
   iii) Completeopeningofcontactsincloseposition.
   iv) Functioningofmechanicalinterlockbetweenmainisolatorandearthswitch.
   v) Settingofendstoppersincloseandopenconditions.
   vi) Operationofauxiliaryswitches.

5.4 Checklamp/semaphoreindications,asapplicable,intheC&RPanelforIsolatorandearth switchOPENandCLOSEDconditions. Alsocheckoperationofvoltageelectionrelay,if provided,forBusIsolators.

5.5 CheckoperationofinterlockingcoilintheIsolatorandearthswitches.

5.6 Checkoperation&verifysettingofoverloadrelay/MCBsformotor,asprovided.

5.7 Checkoperation&verifysettingoftimerforIsolatoroperationandpolediscrepancy,if provided.

5.8 Checkoperationofelectricallimitswitchesinmotoroperatedmechanism.

5.9 Checklocalandremoteelectricaloperationoftheisolator,includinginterlockingbetwee n mainisolatorandearthswitches,ifapplicable.

5.10 Checkoperationoftheelectricalemergencyopeningarrangement,ifprovided.

5.11 Checkfunctioningofspaceheaterandinternalilluminationcircuitsinthemotoroperated mechanism.

6.0 GENERALCHECKS:
6.1 Re-check the adjustment/alignment of the Isolator main contacts for smooth opening and closing and proper making of contacts after jumpering on both sides.

6.2 Check earthing of the main Isolator and earth switch.

6.3 Check earthing of the operating mechanism.

6.4 Check earthing of moving parts such as operating handles of isolators, which should be earthed through flexible earthing connectors.

7.0 PRE-COMMISSIONING TESTS:

7.1 Measure the insulation resistance with 5kV megger of each phase to earth in the Isolator CLOSED position.

7.2 Measure the Contact Resistance of 400kV Isolators in the CLOSED position.
**CURRENT TRANSFORMERS**

1.0 **GENERAL INSTRUCTIONS:**

1.1 While erecting the Current Transformers, it must be ensured that the P1 terminal is towards the Main Bus side.

1.2 The different cores of the secondary winding of the Current Transformers are used for the following purposes. The secondary windings are rated for 1 Amp or 5 Amp.

<table>
<thead>
<tr>
<th>No.</th>
<th>Core Number</th>
<th>Accuracy Class</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11kV Feeders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 400.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>0.2s</td>
<td>Metering</td>
</tr>
<tr>
<td><strong>33kV Feeders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 500.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>0.2s</td>
<td>Metering</td>
</tr>
<tr>
<td><strong>11kV side of 132kV Class Transformers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 800.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Differential Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3.</td>
<td>Core 3</td>
<td>0.2s</td>
<td>Metering: Indication &amp; Energy Meter</td>
</tr>
<tr>
<td><strong>33kV side of 132kV Class Transformers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 500.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Differential Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3.</td>
<td>Core 3</td>
<td>0.2s</td>
<td>Metering: Indication</td>
</tr>
<tr>
<td><strong>132kV Feeders at 132kV GSS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 500.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Distance Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3.</td>
<td>Core 3</td>
<td>0.2s</td>
<td>Metering: Indication &amp; Energy Meter</td>
</tr>
<tr>
<td><strong>132kV Feeders at 220kV GSS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 500.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Distance Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3.</td>
<td>Core 3</td>
<td>0.2s</td>
<td>Metering: Indication &amp; Energy Meter</td>
</tr>
<tr>
<td><strong>132kV side of 132kV class Transformers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTRatio: 500.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Core 1</td>
<td>PS</td>
<td>Differential Protection</td>
</tr>
<tr>
<td>2.</td>
<td>Core 2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3.</td>
<td>Core 3</td>
<td>0.2s</td>
<td>Metering: Indication &amp; Energy Meter</td>
</tr>
<tr>
<td>No.</td>
<td>Core Number</td>
<td>Accuracy Class</td>
<td>Purpose</td>
</tr>
<tr>
<td>-----</td>
<td>-------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>1</td>
<td>Core1</td>
<td>PS</td>
<td>Differential Protection</td>
</tr>
<tr>
<td>2</td>
<td>Core2</td>
<td>PS</td>
<td>Overcurrent &amp; Earth fault Protection</td>
</tr>
<tr>
<td>3</td>
<td>Core3</td>
<td>0.2s</td>
<td>Metering: Indication &amp; Energy Meter</td>
</tr>
</tbody>
</table>

### 220kV Transformers

CT Ratio: 1000

<table>
<thead>
<tr>
<th>No.</th>
<th>Core Number</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core1</td>
<td>PS Distance Protection Main–1</td>
</tr>
<tr>
<td>2</td>
<td>Core2</td>
<td>PS Distance Protection Main – 2</td>
</tr>
<tr>
<td>3</td>
<td>Core3</td>
<td>0.2s Metering</td>
</tr>
<tr>
<td>4</td>
<td>Core4</td>
<td>PS Over Current, Earth Fault and LBB</td>
</tr>
<tr>
<td>5</td>
<td>Core5</td>
<td>PS Bus Bar Protection</td>
</tr>
</tbody>
</table>

### 220kV Transformers

CT Ratio: 1000

<table>
<thead>
<tr>
<th>No.</th>
<th>Core Number</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core1</td>
<td>PS Distance Protection Main–1</td>
</tr>
<tr>
<td>2</td>
<td>Core2</td>
<td>PS Differential Protection</td>
</tr>
<tr>
<td>3</td>
<td>Core3</td>
<td>0.2s Metering</td>
</tr>
<tr>
<td>4</td>
<td>Core4</td>
<td>PS Over Current, Earth Fault and LBB</td>
</tr>
<tr>
<td>5</td>
<td>Core5</td>
<td>PS Bus Bar Protection</td>
</tr>
</tbody>
</table>

### 400kV Transformers

CT Ratio: 2000

<table>
<thead>
<tr>
<th>No.</th>
<th>Core Number</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core1</td>
<td>PS Differential Protection Main – 1 / Distance Protection Main–1</td>
</tr>
<tr>
<td>2</td>
<td>Core2</td>
<td>PS Differential Protection Main – 2 / Distance Protection Main–2</td>
</tr>
<tr>
<td>3</td>
<td>Core3</td>
<td>0.2s Metering</td>
</tr>
<tr>
<td>4</td>
<td>Core4</td>
<td>PS Over Current, Earth Fault and LBB protections</td>
</tr>
<tr>
<td>5</td>
<td>Core5</td>
<td>PS Bus Bar Protection</td>
</tr>
</tbody>
</table>

1.3 Ferrule markings as mentioned below are generally used as prefix for indicating the wires of different cores of the Current Transformers:

S.No. CT CORE USED FOR PREFIX FERRULE
1. Differential/Distance Protection
2. BusBar Protection
3. Overcurrent & Earth fault (Backup Protection)
4. Metering

<table>
<thead>
<tr>
<th>2.0</th>
<th>ERECTION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Carryout levelling of already erected structure(s) and minor fabrication work, if required, for reerection of the Current Transformer.</td>
</tr>
<tr>
<td>2.2</td>
<td>Clean the insulator of the Current Transformer.</td>
</tr>
<tr>
<td>2.3</td>
<td>Measure the IR values of primary terminal to earth with 5kV Megger.</td>
</tr>
<tr>
<td>2.4</td>
<td>Erect the Current Transformer on the structure.</td>
</tr>
<tr>
<td>2.5</td>
<td>Fit the terminal connectors on the Current Transformer.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.0</th>
<th>Cabling &amp; Wiring:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Carryout laying of cables from secondary terminal box of the Current Transformer to the bay Marshalling Kiosk (MK)/ Junction Box.</td>
</tr>
<tr>
<td>3.2</td>
<td>Fix the cables in cable glands and then fix the cable glands on cable gland plates in the respective equipment.</td>
</tr>
<tr>
<td>3.3</td>
<td>Connect all the cores of the secondary winding from the secondary terminal box of Current Transformers (R, Y &amp; B phases) to the Marshalling Kiosk/ Junction Box.</td>
</tr>
<tr>
<td>3.4</td>
<td>All the cores of Current Transformer which are not used must be shorted and earthed in the Marshalling Kiosk/ Junction Box.</td>
</tr>
<tr>
<td>3.5</td>
<td>Dress and fix the cables in cable trays/ trenches/ supports/ brackets.</td>
</tr>
<tr>
<td>3.6</td>
<td>These secondary windings of different phases of Current Transformers are generally star connected. A typical wiring connection for Core–1 of Current Transformers in the Bay Marshalling Kiosk/ Junction Box is shown below:</td>
</tr>
</tbody>
</table>
4.0 PRE–COMMISSIONING CHECKS:

4.1 Check tightening of connections of wiring of the secondary windings in the secondary terminal box of the Current Transformer and also in the Marshalling Kiosk/Junction Box.

4.2 Check that the star/neutral formation of the secondary windings of the three phases of the Current Transformer has been made correctly.

4.3 Check that the neutral point of the secondary windings has been earthed in the Marshalling Kiosk/Junction Box.

4.4 Check that all the spare cores of the secondary winding of the Current Transformer have been shorted and earthed.

4.5 Check the earthing of the Current Transformers and Marshalling Kiosk/Junction Box.

4.6 Check the oil level in the Current Transformer.

5.0 PRE–COMMISSIONING TESTS (By Protection Wing):

5.1 Measurement of insulation resistance between primary winding to earth, primary winding to all the secondary windings with 5kV Megger and all secondary winding to earth with 500 V Megger.

5.2 Verification of all the current ratios between the primary winding and all the secondary windings.

5.3 Verification of polarity between the primary winding and all the secondary windings.

5.4 Testing of knee point voltage of all the protection cores.
5.5 Checking of fuse of the secondary windings as per their accuracy class / knee point voltage/burden for protection/metering.

5.6 Checking of continuity of the current circuit of these secondary windings and the verification of phases (R, Y, B) by applying current through primary injection in each Current Transformer and measuring the current in the respective equipment in the control room, such as meters and relays, etc., for each core at a time while shorting all the other cores in the Current Transformer.

5.7 Check capacitance and Tan Delta values

6.0 For operation and maintenance of Current Transformers, the "MAINTENANCE MANUAL FOR 132KV, 33KV AND 11KV INSTRUMENT TRANSFORMERS (CT’s, ELECTROMAGNETIC PT’s AND CVT’s)" of VPN (erstwhile RSEB) should be followed.
CAPACITORVOLTAGETRANSFORMERS(CVT)/
POTENTIALTRANSFORMERS(PT)

1.0 GENERALINSTRUCTIONS:
1.1 Electromagnetic Voltage Transformers, generally referred to as Potential Transformers (PT), and Capacitor Voltage Transformers (CVT) are used for protection and metering. The term Voltage Transformer (VT) is used to cover both PT and CVT.

1.2 The different cores of the secondary windings of the VT are used for the following purposes. The secondary windings are rated for 110/√3 Volts.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Core Number</th>
<th>Accuracy Class</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>11kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Winding1</td>
<td>0.2s</td>
<td>Metering</td>
</tr>
<tr>
<td>33kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Winding1</td>
<td>0.2s</td>
<td>Metering</td>
</tr>
<tr>
<td>2.</td>
<td>Winding2</td>
<td>0.2s</td>
<td>Metering</td>
</tr>
<tr>
<td>132kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Winding1</td>
<td>3P</td>
<td>Protection &amp; Metering (connected in star)</td>
</tr>
<tr>
<td>2.</td>
<td>Winding2</td>
<td>0.2</td>
<td>Directional Earth Fault Protection (connected in open delta)</td>
</tr>
<tr>
<td>220kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Winding1</td>
<td>3P</td>
<td>Protection &amp; Metering (connected in star)</td>
</tr>
<tr>
<td>2.</td>
<td>Winding2</td>
<td>0.2</td>
<td>Directional Earth Fault Protection (connected in open delta)</td>
</tr>
<tr>
<td>400kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Winding1</td>
<td>3P</td>
<td>Protection (connected in star)</td>
</tr>
<tr>
<td>2.</td>
<td>Winding2</td>
<td>3P</td>
<td>Directional Earth Fault Protection (connected in open delta)</td>
</tr>
<tr>
<td>3.</td>
<td>Winding3</td>
<td>0.2</td>
<td>Protection &amp; Metering (connected in star)</td>
</tr>
</tbody>
</table>

1.3 A ferrule ‘E’ is generally used as a prefix of the ferrule markings for indicating the wires of different cores of the VTs.

1.4 The CVT or its individual units should be kept shorted and earthed to prevent shock from accumulated charge. This shorting may be temporarily removed for testing. The shorting should be finally removed before energizing the CVT.

2.0 ERECTION:
2.1 Carry out leveling of already erected structure(s) and minor fabrication work, if required, for erection of the Capacitor Voltage Transformers/Potential Transformers.

2.2 Clean the insulators of the VTs.

2.3 Assemble the different units of the same serial number of the CVT, if applicable.

2.4 Measure the IR values of primary terminal to earth with 5kV Megger.

2.5 Erect the Capacitor Voltage Transformer/ Potential Transformer on the structure.
2.6 Fit the covers on the joints between different units of the CVT, if applicable.

2.7 Fit the terminal connectors on the VT’s.

3.0 **Cabling & Wiring:**

3.1 Carry out laying of cables from secondary terminal box of the VT to the bay Marshalling Kiosk / Junction Box.

3.2 Fix the cables in cable glands and then fix the cable glands on cable gland plates in the respective equipment.

3.3 Connect all the cores of the secondary winding from the secondary terminal box of VTs (R, Y & B phases) to the Marshalling Kiosk / Junction Box.

3.4 The cores of VTs which are not used should be left open. One end of these windings must be earthed in the Marshalling Kiosk / Junction Box.

3.5 Dress and fix the cables in cable trays / trenches / supports / brackets.

3.6 The secondary windings of different phases of VTs are connected either in either star or open delta. Typical wiring connections of 2 core CVTs and PTs in the Bay Marshalling Kiosk / Junction Box are shown below:

---

4.0 **PRE-COMMISSIONING CHECKS:**
4.1 Earththe HTerminalofCVT, ifitisnotusedforPLCCsystem.

4.2 Checkthatthe formationof the star/ neutral point oropendelta connectionsofthe secondary windings of the three phases of the VT has been made correctly and that the neutral end of the star connected winding and one end of the opendelta connected winding have been earthedin the Marshalling Kiosk/Junction Box.

4.3 Checkthattheconnectionsofthewiringofthesecondarywindingsinthe secondary terminal box andin the Marshalling Kiosk/Junction Box.

4.4 Checkthe earthing of the VTs.

4.5 Checkthatthefuses provided in the VT secondary circuits are of correct rating and that there is proper grading of the fuses.

4.6 Checkthatthereisnoshorting inthewiring of thesecondarycircuitofthe VTs.

4.7 Checkthatthetemporary shorting and earthing of the CVT or its unit has been removed.

5.0 PRE-COMMISSIONING TESTS (By Protection Wing):

5.1 Measurement of insulation resistance between primary windingto earth, primary winding to all thesecondary windings, and all secondary windings to earth.

5.2 Verificationofall thevoltage ratios between theprimary winding and all thesecondary windings.

5.3 Verificationofpolarity between theprimary winding andall thesecondary windings.

5.4 Verificationof fuse of thesecondary windingsas per their accuracy class/burden for protection/metering.

5.5 Verificationoftheconnectionsofthevoltage circuit of the VT secondary windings and verification of the phases (R, Y, B) by applying voltage through variacineachwire of the control cable from the VTto the control room, and measuring the voltage at all points in the respective equipment in the control room, such as meters and relays, etc., for each core at a time while keeping all the other cores in the VT disconnected.

6.0 For operation and maintenance of Capacitor Voltage Transformers/Potential Transformers (CVTs/PTs), the “MAINTENANCE MANUAL FOR 132KV, 33KV AND 11KV INSTRUMENT TRANSFORMERS (CT’s, ELECTROMAGNETIC PT’s AND CVT’s)” of VPN (erstwhile RSEB) should be followed.
LIGHTNING ARRESTERS

1.0 GENERAL INSTRUCTIONS:
1.1 The serial number of all the units of a multi–unit Lightning Arrester (LA) should be the same.

1.2 The units of a multi–unit Lightning Arresters should be assembled in the sequence shown on the rating plate of the LA or in the catalogue of the manufacturer.

1.3 The insulated base unit should be erected in cases of Lightning Arresters provided with surge monitors.

1.4 The installation of the Lightning Arresters should be such that the direction of the open end of the explosion release event (at top & bottom) is away from adjacent expensive equipment such as transformers.

2.0 Erection of LA of 132kV Class & Above:
2.1 Level the already erected supporting structure(s) and carry out minor fabrication work thereon for erection of the Lightning Arresters and surge monitors, as required.

2.3 Clean the insulators of the Lightning Arresters.

2.4 Assemble the different units of the same serial number of the Lightning Arresters, if applicable. Also, carry out fitting of the coronarings between different units, if provided.

2.5 Erect the Lightning Arresters on the already erected and levelled supporting structure(s).

2.6 Fit the Surge Monitor on the structure and connect it to the lowest unit of the Lightning Arrester above the base insulator.

2.7 Fit the corona/grading ring on the top of the Lightning Arrester, if provided.

2.8 Fit the terminal connectors on the Lightning Arresters.

3.0 Erection of 33kV & 11kV LA:
3.1 Make mounting arrangements on the beam of the already erected sub–station structures.

3.2 Clean the insulators of the Lightning Arresters.

3.3 Erect the Lightning Arresters on the already prepared arrangement on the beam of the sub–station structures.

3.4 Fit the terminal connectors on the Lightning Arresters.

4.0 PRE–COMMISSIONING CHECKS:
4.1 Ensure that there is appropriate clearance (Min. 25mm) between the structure and the connection from the bottommost unit of the Lightning Arrester to the Surge Monitor as shown in the drawing below:

![Diagram of Lightning Arrester and Surge Monitor]

4.2 For LA sof 132kV class & above, check the tightness of the connection between the Lightning Arrester and the Surge Monitor, and between the Surge Monitor and earth.

4.3 Check the tightness of the earthing connection of the Lightning Arrester for 33kV & 11kV LAs.

4.4 Note down the initial readings of the surge counters in the Surge Monitors.

5.0 PRE-COMMISSIONING TESTS:
5.1 Measure the insulation resistance of individual units of the Lightning Arrester, if applicable, with 5kV Megger.

5.2 Measure the insulation resistance between line end of LA to earth with 5kV Megger.

5.3 Check operation of surge monitor.

6.0 Check the leakage current meters in the Surge Monitor after the Lightning Arresters are energized. The readings should be well within the “green zone” marked on the scale of the leakage current meters.
POST/ POLYCONENEINSULATORS

1.0 **ERECITION:**

1.1 Level the top plate of the already erected structure for Post/ Polycone Insulators.

1.2 Clean the Post/ Polycone Insulators.

1.3 Assemble the parts of Post/ Polycone Insulators if required.

1.4 Erect the Post/ Polycone Insulators on the already erected supporting structure.

1.5 Fit the corona ring on the Post/ Polycone Insulators if provided.

1.6 Fit the clamp on the Post/ Polycone Insulators.

2.0 **PRE-COMMISSIONING CHECKS:**

2.1 Check the tightness of the earthing connection of the base of the Post/ Polycone Insulators.

3.0 **PRE-COMMISSIONING TESTS:**

3.1 Measure the insulation resistance between top and bottom part of the Post/Polycone Insulators with 5kV Megger.
WAVETRAPS

1.0 GENERAL INSTRUCTIONS:

1.1 The Wave Traps are erected as below.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Line Type</th>
<th>Type of Coupling</th>
<th>Phases on which Wave Traps are erected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Single Circuit</td>
<td>PhasetoPhase</td>
<td>Two phases of the line</td>
</tr>
<tr>
<td>2.</td>
<td>Double Circuit</td>
<td>Inter-circuit</td>
<td>Same phase of both the circuits</td>
</tr>
</tbody>
</table>

1.2 For single circuit lines, the Wave Traps are generally erected on R&B phases.

1.3 For double circuit lines, the Wave Traps are generally erected on the Y phase of both the circuits.

1.4 The Wave Traps may be required to be erected on phases different from those mentioned at para 1.2 and para 1.3 above in case the end to end return loss is not found satisfactory during testing of the PLCC Carrier Sets.

2.0 ASSEMBLY:

2.1 Clean the Wave Trap and its associated equipment.

2.2 Fit the tuning pot and associated equipment in the Wave Trap.

2.3 Fit the end covers on the wave traps and position them correctly.

2.4 Fit the terminal connectors on the Wave Traps.

3.0 ERECTION OF SUSPENSION TYPE WAVE TRAPS:

3.1 Fit the hardware for fixing the Wave Trap to the suspension string assemblies of the designated phases.

3.2 Hoist the Wave Trap through lifting arrangement on the beam of the sub-station structure.

3.3 Fit the Wave Trap on the already erected suspension string assemblies through suitable attachment.

4.0 ERECTION OF PEDESTAL TYPE WAVE TRAPS:

4.1 Level the top plate of the already erected structure for wave trap.

4.2 Assemble the parts of the Poly cone Insulators, if applicable.

4.3 Erect the poly cone insulator(s) on the supporting structure.

4.4 In case three Poly cone Insulators are provided for each Wave Trap and these are in parts, then the connecting plate between the joint of the parts of the Poly cone Insulators is also fitted.

4.5 Erect the Wave Trap on the poly cone insulators.
LINEMATCHINGUNIT(LMU)/LINEMATCHINGDISTRIBUTIONUNIT(LMDU)

1.0 GENERAL INSTRUCTIONS:
1.1 Open the earthing of the HF terminal of the CVTs and the LMU / LMDU before testing the system.

2.0 ERECTION:
2.1 Make arrangements/carry out minor fabrication work (if required) on the supporting structure of the 2 nos. designated Capacitor Voltage Transformers (as per coupling requirement) for fixing of Line Matching Unit (LMU)/Line Matching Distribution Unit (LMDU). These CVTs shall be of the same phase on which the wavetrap have been/are to be erected.

2.2 Fit the LMU/ LMDU on the already erected structure.

2.3 Earth the LMU/ LMDU by connecting the earthing terminal to the earth mat.

2.4 Connect the HF terminal of the Capacitor Voltage Transformer to the HF terminal of the LMU/ LMDU.

2.5 Lay the coaxial cable between LMU and LMDU.

2.6 Prepare the end of the coaxial cable and fix the connectors at the ends.

2.7 Fit the coaxial cable on the LMU and LMDU.

3.0 PRE-COMMISSIONING CHECKS:
3.1 Check the tightness of the connection of the HF terminal of the CVT and the connections in the LMU/ LMDU.

3.2 Visual check for any dry solder in the circuit of the LMU/ LMDU.

3.3 Check the tightness of connections in the LMU/ LMDU.

3.4 Check that the strappings inside the LMU/ LMDU are connected in the required manner so as to match with the impedance of the coaxial cable (75 ohms/125 ohms as the case may be).

3.5 Check earthing of the LMU/ LMDU.
CAPACITOR BANKS

1.0 GENERAL INSTRUCTIONS:

1.1 DURING ERECTION WORK ON CAPACITOR BANKS, THE CAPACITORS SHOULD BE KEPT SHORTED AND EARTHED TO PREVENT ELECTRIC SHOCK DUE TO ACCUMULATED CHARGE.

1.2 CAUTION: CAPACITOR BANKS SHOULD NOT BE SWITCHED ‘ON’ WITHIN 5 MINUTES OF SWITCHING OFF TO ALLOW THE CAPACITOR UNITS TO GET DISCHARGED.

2.0 ERECTION OF STRUCTURES:

2.1 Assemble the structures for the Capacitor Banks, Series Reactors and Residual Voltage Transformers / Neutral Current Transformers, if the members are received in loose condition.

2.2 Erect the supporting structures on the foundation, carry out their levelling, centering and grouting.

2.3 Level the top of the already erected supporting structures and check their verticality.

3.0 ERECTION OF CAPACITOR BANKS:

3.1 Erect the post insulators on the already erected structure(s). Refer to instructions in Clause 11 for erection of post/ polycone insulators.

3.2 In case individual structures are provided for each phase, erect the frame of each phase of the Capacitor Banks on the post insulators.

3.3 In case only one structure is provided for all the three phases, erect the frame of the first phase on the post insulators. Erect the frame of the second phase after erecting post insulators on the frame of the first phase. Similarly, erect the frame of the third phase after erecting post insulators on the frame of the second phase.

3.4 Erect the capacitor units on the already erected frames as per the erection plan of the manufacturers so that the capacitances of all the phases are balanced. If no erection plan is provided, measure the capacitance of all the units and make phase wise combinations so that the capacitances of all the phases are balanced.

3.5 Interconnect the capacitor units and phases as per manufacturer’s general arrangement drawing, including fitting of external fuses if provided.

3.6 Fit the post insulators and connecting strips for jumpering as per manufacturer’s general arrangement drawing.

4.0 ERECTION OF ASSOCIATED EQUIPMENT:
4.1 Clean the insulators of the Series Reactors and Residual Voltage Transformers/Neutral Current Transformers.

4.2 Measure the IR values to earth of Series Reactors with 5 kV Megger.

4.3 Measure the IR values between primary terminal to earth and primary terminal to secondary terminal of Residual Voltage Transformers/Neutral Current Transformers with 5 kV Megger.

4.4 Erect the associated equipment, viz., Series Reactors and Residual Voltage Transformers.

4.5 Erect the circuit breaker with supporting structure, current transformers and isolators as per instructions in Clause 6 for erection of CB, Clause 7 for erection of isolators and Clause 8 for erection of CTs.

5.0 Cabling & Wiring:
5.1 Carry out laying of cables between the following:

   i) Residual Voltage Transformers/Neutral Current Transformers and the Marshalling Kiosk/ Junction Box.
   ii) Marshalling Kiosk/ Junction Box and Control & Relay Panel.

5.2 Fix the cables in cable glands and then fix the cable glands on cable gland plates in the respective equipment.

5.3 Connect the cables as per schematic diagram of the Control & Relay Panel.

5.4 Dress and fix the cables in cable trays/ trenches/ supports/ brackets.

6.0 PRE-COMMISSIONING CHECKS:
6.1 Check for proper connection of Capacitor Bank units as per manufacturer’s drawings.

6.2 Check setting of timer (5 minutes) fore closing interlock for Circuit Breaker (Timers should permit closing of CB only after passage of 5 minutes after tripping of CB).

6.4 Check healthiness and rating of fuses of units of the Capacitor bank.

6.5 Check the earthing of the structures and the equipment.

6.6 Check that there is no shorting and earthing of the Capacitor Units/ Banks.

6.7 Check oil level in the Residual Voltage Transformers/Neutral Current Transformers and Series Reactors (if oil filled).
6.8 Carry out pre-commissioning checks on circuit breaker, current transformers and isolators as per instructions in Clause–6 for erection of CB, Clause–7 for erection of isolators and Clause–8 for erection of CTs.

7.0 PRE-COMMISSIONING TESTS:
(By Protection Wing/Capacitor Division)

7.1 Measurement of capacitance of the three phases of the Capacitor Banks for verifying balancing.

7.2 Measurement of IR values to earth of Capacitor Banks & Series Reactors with 5kV Megger.

7.3 Measurement of IR values between primary terminal to earth and primary terminal to secondary terminal of Residual Voltage Transformers/Neutral Current Transformers with 5kV Megger.

7.4 Checking of polarity between primary & secondary windings of the Residual Voltage Transformers/Neutral Current Transformers.

7.5 Verification of ratio between primary & secondary windings of the Residual Voltage Transformers/Neutral Current Transformers.

7.6 Carry out pre-commissioning tests on circuit breaker, current transformers and isolators as per instructions in Clause–6 for erection of CB, Clause–7 for erection of isolators and Clause–8 for erection of CTs.
EARTHING

1.0 GENERAL INSTRUCTIONS:

1.1 Earthing of the SubStations shall be done as per the earthmat design provided by the Design Wing and in accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards & Codes of Practice and Regulations except where specifically increased in the design.

   b) Indian Electricity Rules, 1956 with latest amendments.

1.2 A typical earthmat design of a SubStation is enclosed as Annexure–A.

1.3 The details of the earthing material generally used in a substation are given below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Purpose</th>
<th>Description &amp; Size of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>132kV Substations</td>
</tr>
<tr>
<td>1.</td>
<td>Main Earthing Conductor for Earth Mat.</td>
<td>25mm dia. M.S. Rod</td>
</tr>
<tr>
<td>2.</td>
<td>Earthing Conductor for Risers (for equipments &amp; structures).</td>
<td>50×10mm M.S. Flat</td>
</tr>
<tr>
<td>3.</td>
<td>Earthing of LT panels, DC panels, C &amp; R Panels, marshalling boxes, Compressors, MOM boxes, junction boxes, lighting panels, etc.</td>
<td>50×6mm M.S. Flat</td>
</tr>
<tr>
<td>4.</td>
<td>Earth Electrodes</td>
<td>25mm dia. M.S. Rod, 3250mm long</td>
</tr>
<tr>
<td>5.</td>
<td>Earthing conductor along rack of cable trenches</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

1.4 All equipments and structures are required to be earthed by two separate and distinct connections with earth as per Rule 61 of the Indian Electricity Rules, 1956.

1.5 The neutrals of all voltage levels of transformers/ reactors shall be earthed through independent earthing. All these earthing points should be interconnected with the substation earth mat. Each earthing lead from the neutral of the power transformer/reactor shall be directly connected to two earth electrodes separately which, in turn, shall be
connected to the earth mesh. The transformer / reactor tanks as well as associated accessories like separate cooler banks shall also be connected to the earth mat at two points.

1.6 Capacitor Voltage Transformers & Lightning Arresters shall be earthed through two independent risers directly connected to the earthelectrodes which should in turn be connected to the substations earthmat. The distance between the electrodes should not be less than 4.0 metres.

1.7 All other equipment such as Circuit Breakers, CTs, Isolators, Post Insulators, etc. shall also be earthed at two points.

1.8 Bus Bar structures and equipment structures shall be earthed at two points.

1.9 Marshalling boxes, cubicles, C&R Panels and all other metal enclosures, which are normally not carrying any current, shall also be earthed.

1.10 All the earthing connections to the earthmat shall be by 2 nos. direct earthing risers free from kinks and of the shortest length. The two earthing connections / risers should be connected to the different sides of the earthmat enclosing the structure/equipment to be earthed.

1.11 For equipment earthing (including isolators), the earthing risers should be connected to the earthing terminal/pad of equipment and brought down along the leg/main member of the structure and connected to the earthmat. The structures shall not be used as a part of the earthing.

1.12 Burial of Earthing Conductor:
1.12.1 The alignment of the earthmat conductor can be changed by forming U–loops in case it fouls with equipment/structure foundations. The average spacing for East-West rows and for North-South rows of the earthmat shall, however, be kept as near as possible to the spacing indicated in the earthmat design.

1.12.2 Earthing conductors in the switchyard area shall be buried at least 600mm below finished ground level unless stated otherwise.

1.12.3 Earthing conductor around any building shall be buried at a minimum distance of 1500mm from the outer boundary of the building.

1.12.4 In case high temperature is encountered at any location, the earthing conductors shall be laid at a minimum distance of 1500mm away from such location.

1.12.5 Earthing conductors, if embedded in the concrete, shall have approximately 50mm concrete cover.
1.13 Earthing conductors laid in cable trenches, ladders, columns, beams, walls, etc. shall be supported by suitable welding/cleating at intervals of 750 mm.

1.14 Wherever earthing conductors pass through walls, floors, etc., galvanized iron sleeves shall be provided for the passage of the conductor and both ends of the sleeves shall be sealed to prevent the passage of water through the sleeves.

1.15 The earthing conductors shall be clamped with the equipment support structures at 1000 mm interval.

1.16 Transformer/Railway track within the switchyard area shall be earthed at a spacing of 30 meters and also at both ends.

1.17 Flexible earthing connectors shall be provided for the moving parts of equipment such as earthing switches and operating handles of isolators, etc.

1.18 All lighting panels, lighting fixtures, junction boxes, receptacles, conduits, etc. shall be earthed.

1.19 Earthing risers shall be run from the peaks of structures to the main earth mesh. The earthing bonds of the earth wire tension hardware shall be connected at the top of this earthing riser with bolts and nuts.

1.20 Bending of earthing rod and flat shall preferably be done by gas heating.

1.21 Fencing should be separately earthed. Independent earthing conductor for earthing of fencing, buried to a depth of 600 mm, shall be provided 2 meters outside the switchyard fence. All the gates and every alternate post of the fences shall be connected to the earth at the corners and at every 20 meters.

1.22 EARTHELECTRODES:
1.22.1 The length of earth electrodes shall not be less than 3250 mm and shall be one piece.

1.22.2 Except where rock is encountered, rods shall be driven to a depth of at least 3000 mm.

1.22.3 Where rock is encountered, the depth of the electrodes should be 3600 mm. The electrodes can be buried inclined to the vertical at a tangent not more than 30° from the vertical. In all other cases, drilling shall be done for providing the pit for the electrode.

1.22.4 To reduce the depth of burial of an electrode in case of rocky soil without increasing the resistance, a number of rods can be connected together in parallel. The resistance in this case is practically proportional to the reciprocal of the number of electrodes used. In case of insituating outside the resistance area of the other, the distance between two electrodes in such cases shall preferably be not less than twice the length of the electrode.

1.23 JOINTS:
1.23.1 Minimum joint shall be made in the earth mat conductor as well as in preparing the risers.
1.23.2 All joints in the steel earthing system, except those where earth mat may have to be separated from equipment, etc. for testing, shall be made by electric arc welding. Welded surfaces should be painted with bitumen compound and afterwards coated with bitumen tape to protect them from rusting and corrosion.

1.23.3 Joints in the earthing conductor between the switchgear units and such other points which may be required to be subsequently opened for testing should be bolted type. The bolted connections, after being checked and tested, shall be painted with anticorrosive paint/compound. These joints should be accessible and frequently supervised.

1.23.4 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt.

1.23.5 Steel to copper connections shall be first bolted, then brazed and shall be coated with bitumen tape to moisture ingress.

1.23.6 All welded joints shall be allowed to cool down gradually to atmospheric temperature. Artificial coolings should not be used.

1.24 The entire surface of the earth mat is to be covered with 100 mm layer gravel extended one meter beyond the periphery of earth mat. The layer of gravel may be protected by providing suitable brick/stonelining, wherever required.

2.0 PLACING OF EARTH ELECTRODES:
(See Annexure–B: (l) EARTH ELECTRODE)

2.1 Cut M.S. Rod of the applicable diameter to approximate lengths of 3.25 meters (or more if full length of rod is more) and, if required, prepare one end as spike for placing/driving into the ground.

2.2 Earth Electrode in Loose/Sandy Soil:
2.2.1 Excavate a pit approximately 1 M. x 1 M. up to 0.6 metre depth.

2.2.2 Place the earth electrode in the excavated pit and drive it in the ground with a sledgehammer such that the top of the electrode is 0.55 metre below the foundation top level. This will leave 0.25 metre of the electrode above the ground for connecting it to the earth mat rods.

2.3 Earth Electrode in Hard Soil:
2.3.1 Excavate a pit approximately 1 M. x 1 M. up to 0.6 metre depth.

2.3.2 Augur a hole in the ground to a depth of 3 metres.

2.3.3 Place the electrode in the augured hole such that the top of the electrode is 0.55 metre below the foundation top level.

2.3.4 Backfill the excavation and compact the soil after completion of the work.
2.4 **Earth Electrode in Rocky Soil:**

2.4.1 Where rock is encountered at a depth of less than 3.6 m below the foundation level, excavate a trench which is inclined to the vertical at an angle not more than 30° from the vertical.

2.4.2 In all other cases, carry out drilling of the rocky soil for providing the pit for the electrode.

2.4.3 To reduce the depth of excavation and burial of the electrode in case of rocky soil without increasing the resistance, a number of rods are connected together in parallel. The resistance in this case is practically proportional to the reciprocal of the number of electrodes used. Hence, the total length of such electrodes should be equal to 3.0 m plus 0.25 m for each length. For example, if the depth of excavation is reduced to 1.35 m (600 mm below ground level + 750 mm electrode depth), then 4 nos. electrodes, each of length 1000 mm (3000 ÷ 4 = 750 mm + 250 mm), shall be welded together. The distance between two electrodes in such a case shall preferably be not less than twice the length of the electrode. The distance between any two electrodes in the example above shall not be less than 2 m. A sketch showing this type of arrangement is given below.

2.5 For connecting the electrode to the earthmat, clamp/hold the M.S. Rod of the electrode and the earthmat together. First weld these together at the crossing point.

2.6 Fabricate four cleats in the shape of M.S. Angles from M.S. Flat of size to be used for earthing risers and length equal to 10 times the diameter of the M.S. Rod. Weld these at all the corners of the joint. A typical joint is shown in Annexure – B (II): JOINT OF M.S. ROD TO M.S. ROD AT ELECTRODE AND AT MESH CROSSINGS.

2.7 After welding, apply bituminous compound to the hot joints, and cover the joints with bitumen impregnated tape.

2.8 Backfill the excavation and compact the soil after completion of the work.

2.9 In case of rocky soil, the backfilling can also be done with Bentonite, or a combination of bentonite and black cotton soil, in the ratio of 1:6, to reduce the resistances to earth.

3.0 **Laying of Earth Mat:**
3.1 Excavate trenches along the specified alignment to a depth of 0.80 meter below the foundation to the level.

3.2 Where different ground levels are provided in the switchyard, uniformly increase the depth of excavation in the higher level from a distance of 5 meters from the lower level so as to attain the required depth of excavation in the lower level.

3.3 Wherever the earth mat is to cross cable trenches, underground service ducts, pipes, transformer tracks, etc., increase the depth of excavation so that it can be laid at a minimum depth of 300mm below them.

3.4 Wherever the earth mat is to cross a road, increase the depth of excavation so that it can be laid 300mm below the road or at a greater depth to suit the site conditions.

3.5 Lay the M.S. Rod in the excavated trenches.

3.6 Straight Joint of M.S. Rod in the Earth Mat:

3.6.1 Place the rods so that they overlap each other by 4 times the diameter, e.g., 100mm in case of M.S. Rod of 25mm diameter. Clamp/hold the two lengths of M.S. Rods together and weld them on both sides.

3.6.2 Thereafter, place two pieces of M.S. Flat of size to be used for earthing risers and length 4 times the diameter of the rod on both sides of this joint, and weld these pieces to the rods. A typical joint is shown in Annexure – B, (III): JOINT OF M.S. ROD TO M.S. ROD IN EARTH MAT.

3.6.3 After welding, apply bituminous compound to the hot joints, and cover the joints with bitumen impregnated tape.

3.7 Cross Joint of M.S. Rod in the Earth Mat:

3.7.1 Clamp/hold together the two M.S. Rods crossing each other. First weld these together at the crossing point.

3.7.2 Fabricate four cleats in the shape of M.S. Angles from M.S. Flat of size to be used for earthing risers and of length equal to 10 times the diameter of the M.S. Rod. Weld these at all the corners of the joint. A typical joint is shown in Annexure – B, (II): JOINT OF M.S. ROD TO M.S. ROD AT ELECTRODE AND AT MESH CROSSINGS.

3.7.3 After welding, apply bituminous compound to the hot joints, and cover the joints with bitumen impregnated tape.

3.8 Joint of M.S. Rod and Earth Electrode:

3.8.1 Clamp/hold together the M.S. Rod and the earth electrode. First weld these together at the crossing point.

3.8.2 Fabricate two cleats in the shape of M.S. Angles from M.S. Flat of size to be used for earthing risers and of length equal to 10 times the diameter of the M.S. Rod. Weld these at
the joint. A typical joint is shown in Annexure – B,(IV): JOINT OF M.S. ROD TO M.S. RODATEAR THE ELECTRODE.

3.8.3 After welding, apply bituminous compound to the hot joints, and cover the joints with bitumen impregnated tape.

3.9 Backfill the excavation and compact the soil after completion of the work.

4.0 PREPARATION AND FITTING OF RISERS:

4.1 Excavate trench from the equipment/structure foundation to the nearest rod of the earth mat. The depth shall be 0.80 meter below the foundation to level.

4.2 Cut M.S. Flat of the required length and bend it by heating if required, to form a smooth and regular shape to match with the shape/form of the equipment/structure. The shape of the risers should be similar for the same type of equipment/structure.

4.3 Lay the prepared M.S. Flat riser from the equipment/structure/peak of the structure to the rod of the earth mat excavated trench and then connect it to the equipment or structure or structure peak. The fitting to the equipment/structure may be bolted type (earthing terminal/pad of the equipment) or welded type (structure). For bolted type fitting, drill necessary holes in the riser and fix it with bolts and nuts. For welded type fitting, weld a length equal to at least twice the width of the M.S. Flat.

4.4 In case joints are required to increase the length of the M.S. Flat risers, the two lengths of the M.S. Flat should overlap each other by twice the width of the M.S. Flat. After placing the M.S. flat one above the other as above, clamp/hold them together to provide good surface contact. Weld the two sides of the joint as well as the part between the flats on the topsurface. A typical joint is shown in Annexure – B, (V): JOINT OF M.S. FLATTOM.S. FLAT.

4.5 Weld the M.S. Flat riser to the rod of the earth matrix after fitting/welding to the equipment/structure/structure peak. Place the M.S. Flat below the rod, clamp/hold them together and weld on both sides of the rod. Then form a piece of M.S. Flat 50 × 6 mm into a stirrup (as shown in the drawing) and place on the joint of the rod and flat. Alternatively, cut two pieces of M.S. Angle 50 × 50 × 6 mm of length equal to the width of the M.S. Flat and place these on both sides of the joint of the rod and flat. Weld these to the other rod and the flat. A typical joint is shown in Annexure – B, (VI): JOINT OF M.S. FLATTOM.S. RODOF EARTH MAT.

4.6 After welding, apply bituminous compound to the hot joints and cover the joints with bitumen impregnated tape.

4.7 Clamp the earthing risers with the equipment support structures at 1000 mm intervals.

4.8 Backfill the excavation and compact the soil after completion of the work.

4.9 Apply red oxide paint and then green enamel paint on the portion of the risers above ground level.
4.10 A drawing showing the typical arrangement for earthing of equipment and its structure is given at Annexure–C.

4.11 Measure earth resistance of each electrode.

4.12 Ensure connectivity in between existing mesh and extended mesh in case of bay augmentation.
JOINT OF M.S. ROD TO M.S. ROD IN EARTH MAT

STEP - 1

JOINT OF M.S. ROD TO M.S. ROD (OR AS AT II)

SECTION: D - D

LENGTH OF WELDING 75 mm

SECTION: A - A

LENGTH OF WELDING 200 mm

M.S. ROD

STEP - 2

SECTION: B - B

M.S. ROD

LENGTH OF WELDING 100 mm

M.S. FLAT 50x10 mm

LENGTH OF WELDING 400 mm
JOINT OF M.S. FLAT TO M.S. FLAT

LENGTH OF WELDING
250 mm

SECTION: C - C

PLAN
JOINT OF M.S. FLAT TO M.S. ROD OF EARTH MAT

STEP - 1

LENGTH OF WELDING 100 mm

M.S. FLAT 50 mm WIDTH

M.S. ROD

SECTION: E - E

STEP - 2

VIEW ON SECTION: E - E

LENGTH OF WELDING 200 mm

M.S. FLAT 50 mm WIDTH

M.S. ROD

M.S. FLAT 50 mm WIDTH

M.S. ROD

M.S. FLAT 50 mm WIDTH

OR M.S. ANGLE 50x30x6 mm
ANNEXURE–C

TYPICAL EXAMPLE OF EARTHING OF SUB-STATION EQUIPMENT
CABLELAYINGANDWIRING

1.0 GENERALINSTRUCTIONS:

1.1 Prior to laying of cables, thenumber of cables of each size and their lengthsshall be assessed. Thecablelayingschedulesshould be prepared so that maximum length of the cable in a drum can be utilized, leaving minimum scrap lengths.

1.2 Cabledrumsshall be unloaded, handled and stored properly.

1.3 Rolling of drums shall be avoided as far as possible. The drums may be rolled for short distances provided they are rolled slowly and in the direction marked on the drum. In the absence of any indication, the drums may be rolled in the same direction as it was rolled during winding.

1.4 Pulling out of cables from stationary drums shall not be permitted.

1.5 Cables shall not be bent below the minimum permissible limits given below:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type of cable</th>
<th>Minimum bending radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Power cable</td>
<td>12D</td>
</tr>
<tr>
<td>2.</td>
<td>Control cable</td>
<td>10D</td>
</tr>
</tbody>
</table>

Where ‘D’ is overall diameter of the cable.

1.6 Cut lengths of cables which are available as surplus/ leftover material from other works shall preferably be used first. Small cut lengths of cables left after laying long lengths can be used for bus wiring and looping.

2.0 PAYINGOUTOF CABLES:

2.1 Handle the cable with care to prevent forming of kinks and damage to the insulation of the cable.

2.2 When the cable is to be taken from drums, small lengths can be unwound from the drum.

2.3 For longer lengths, place the cabledrum on a turntable or jack up the drum on a suitable size of steel shaft. The cables shall be laid in a manner so that there are no scratches or damages caused to the cable due to rubbing on the sides of the drum.

2.4 The required lengths of cables are laid between the following equipments:
   a) C&R Panels in Control Room to Marshalling Kiosk.
   b) Marshalling Kiosk to Equipment.
   c) Marshalling Kiosk to Marshalling Kiosk.
   d) Equipment to Equipment in switchyard.
   e) C&R Panel to C&R Panel/ other panels in Control Room, etc.

2.5 The cables are cut after taking into account the length required for connecting to the farthest terminal of the terminal block in the & Relay Panel/MK/equipment at both the ends.
3.0 LAYING OF CABLES IN TRENCHES:
3.1 The cables are placed in the racks in cable trenches. Power and control cables shall be laid in separate tiers. The order of placing cables (other than those directly buried) in cable trenches shall be as follows:

   a) Bottom tiers: Power Cables / Cables having A.C. supply.
   b) Middletiers: Cables from CT / CVT / PT.
   c) Uppermost tiers: Cables having D.C. supply.

3.2 The cables are securely fixed on the racks in the cable trenches. Particular care shall be taken when cables are laid in vertical & inclined cable trenches / galleries / vaults or supports.

3.3 Marking and Tagging:
3.3.1 Provide cable tag / marking strip on all cables at both ends (just before entry into the equipment enclosure), on both sides of a wall / floor crossing & on each duct / conduit entry for identification of the cable. Cable tag shall also be provided inside the switchgear, control and relay panels, etc., wherever required for cable identification.

3.3.2 The numbering of cables on the tag shall be done as per the cable schedule. Generally, cable size, identification of initial point and terminating end of equipment / panel, and a cable number are punched on the tag / marking strip.

3.3.3 Rectangular shaped cable tag / marking strip of 1.0 mm thick aluminum with the description punched on it shall be securely attached to the cable by not less than two turns of 20 SWG GI wire.

4.0 LAYING OF UNDERGROUND POWER CABLES:
4.1 Excavate trench of 30 cm width and 75 cm depth along the proposed route / alignment. The width may be increased in case a number of cables are to be laid. At crossings of cable trenches / roads / transformer tracks / pipes / earth mat conductor, etc., the depth shall be increased such that the bottom of the trench is 40 cm below them.

4.2 Cover the bottom of the trench with a layer of sand 25 cm thick.

4.3 Lay the cable in the excavated trench.

4.4 Cover the cable with bricks and backfill the trench with the excavated sand. Compact the sand by ramming.

4.5 Secure the cables on the supports above ground level.

4.6 Marking and Tagging:
4.6.1 Directly buried underground cables shall be clearly identified with cable marker made of iron plate.
4.6.2 Location of underground cable joint shall also be indicated with cable marker with an additional inscription "Cable joints".

4.6.3 The markers shall project 150 mm above ground and shall be placed at intervals of 30 meters and at every change in direction. They shall also be located on both sides of road and drain crossings.

5.0 CABLE TERMINATION:
5.1 Drill the required holes in the gland plates of the panels/equipment, etc. for fixing the cables.

5.2 Strip off the insulation of the cable for sufficient length so that any wire of the cable can be terminated at the farthest terminal in the terminal blocks.

5.2.1 For unarmoured cable, strip off the outer and inner insulation sheaths of the cable. Fix the cable gland on the cable end and then fix the cable gland on the gland plate of the equipment/panel.

5.2.2 For armoured cables, strip off the outer and inner insulation sheaths of the cable. Cut off the armouring for the stripped off length keeping a small length for fitting in the cable gland. Fit the gland nut in the cable. Bend the armouring to fit the gland. Fit the gland nut and tighten. Fit the cable gland on the gland plate of the equipment/panel.

5.3 Seal all unused openings for cables in the cable gland plate to prevent entry of vermin and dust.

6.0 WIRE TERMINATION:
6.1 Identify each core of the cable either by its physical location/marking/numbering or by testing continuity from both ends.

6.2 Mark each core of the cable at both ends with a tag/ ferrule as per cables schedule/ schematic drawing. In panels in which a large number of cables are terminated, wire identification may be difficult, therefore, the complete cable number may also be included in the tag/ ferrule one each core.

6.3 Cut each wire at the length required for terminating it on the terminal block. This should be done after proper dressing of the wire in the wiring trough.

6.4 Strip off the insulation of each core of the cable which is to be connected. Crimp the termination end/thimble/lug (pin or ring type, as required) of appropriate size onto the wire.

6.5 Connect the wire to the terminal on the terminal block and tighten to ensure secure and reliable connection.

6.6 Mark all the spare cores of the cables with tags/ ferrules indicating the cable number.

6.7 All the wires in the Control & Relay panels, equipments, etc. shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.
GENERAL INSTRUCTIONS:

1.1 Battery charging and discharging and all activities related to the erection and installation of the Battery Set should be carried out strictly as per the recommendations/directions/procedure given in the Erection & Installation Manual of the Battery Manufacturer.

STORAGE:

1.2.1 The VRLA batteries are supplied in the factory charged condition and can be stored up to a maximum of 6 months at an ambient temperature not exceeding 27°C without requiring a freshening charge.

1.2.2 If the VRLA batteries are stored for a longer duration at an ambient temperature not exceeding 27°C, then a freshening charge (as per para 3.0) should be given once in 6 months or when the Open Circuit Voltage (OCV) drops to 2.1 volts per cell, whichever is earlier.

1.2.3 If the ambient temperature during storage is above 27°C, the batteries must be given a freshening charge (as per para 3.0) at shorter intervals.

The table below shows the charging interval at the various elevated temperature before which a freshening charge is to be given:

<table>
<thead>
<tr>
<th>Ambient Temperature in °C</th>
<th>Charging Interval (in months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>6.0</td>
</tr>
<tr>
<td>37</td>
<td>4.5</td>
</tr>
<tr>
<td>42</td>
<td>3.0</td>
</tr>
<tr>
<td>47</td>
<td>2.25</td>
</tr>
<tr>
<td>52</td>
<td>1.5</td>
</tr>
</tbody>
</table>

1.3 The VRLA batteries should be charged with constant potential chargers. The charging current should be limited to a maximum of 20% of the 10-hour capacity of the Battery Set, or the capacity of the battery charger.

1.4 The recommended maximum boost charging voltage is 2.30 volts per cell.

1.5 The float voltage (2.23V / 2.25 V) of VRLA Battery Set should be set as per the manufacturer’s recommendations for maximum service life.

DO’S & DON’TS:

1.6.1 DO’S:

a) Store the batteries in a covered area.

b) Keep the batteries away from heat sources, sparks, fire, etc.

c) Clean the batteries as and when dust accumulates.

d) Read “Installation and Operating Instruction Manual” prior to installation of the VRLA batteries.

e) The terminal bolt connections should be tightened to a torque as mentioned in the manufacturer’s erection manual.
f) The electrical contact surfaces should be free from dust, etc.
g) After a discharge, the batteries should be recharged immediately.
h) Re-torque the connections once every six months.

1.6.2 DON’TS:

a) Do not store the batteries in places which are exposed to direct sunlight, rain, dust, storm, etc.
b) Do not tamper with safety valves.
c) Do not attempt to dismantle the battery.
d) Do not attempt to add water or acid in the batteries.
e) Do not overtighten the terminal bolts.
f) Do not allow any metal object to store on the battery or fall across the battery terminals.
g) Do not mix the batteries of different capacities or makes.
h) Do not mix ordinary conventional lead acid batteries with maintenance free VRLA batteries.
i) Do not install the Battery Set in an air tight enclosure.
j) Do not use an abrasive brush or steel brush to clean the electrical contact surfaces.

1.7 A minimum free space of one meter should be provided on all sides of the Battery Set for ease in assembly and carrying out periodic checks.

2.0 ERECTION:
2.1 Assemble, if required, and install the mounting frame/stand in the battery room.
2.1 Erect the modules containing the cells on the mounting frame/stand as per the Manufacturer's manual and erection drawings.
2.2 Clean terminal surfaces of the cells with clean dry cotton cloth.
2.3 Make intercell connections, as per manufacturer’s general arrangement drawings, using the intercell connectors after applying a thin layer of petroleum jelly on the bolts (only those supplied with the Battery Set should be used).

While making inter cell connections, extreme care should be taken so that, neither any interconnecting strip nor any spanner / tool falls on any cell / group of cells which may short them in the process. This may damage the cell / group of cells and can even cause an accident.

2.4 Tighten the terminals and inter cell connectors to a torque as mentioned in the manufacturer’s erection manual.
2.5 Fit battery identification label (serial no.), front cover, top cover and instruction labels, as supplied, on the cells.
2.6 Lay the cables for connecting the Battery Set to the battery charger. Strip off the insulation of the cable ends and of the wires. Crimp on terminal lugs / thimbles of suitable size at both the ends.

2.7 Connect the positive terminal of the 54th cell (for 110V Battery Set)/108th cell (for 220V Battery Set) and the negative terminal of the 1st cell of the Battery Set to the positive and negative terminals of the battery charger respectively. Also connect the positive terminal of the 48th cell (for 110V Battery Set)/96th cell (for 220V Battery Set) to the battery tap terminal of the battery charger. No such battery taps provided in 48V Battery Set.

3.0 FRESHENING CHARGE:
3.1 Give a freshening charge to the Battery Set by gradually increasing the voltage. The current should not be allowed to exceed 20% of the 10-hour capacity of the Battery Set or the capacity of the battery charger. The voltages should not be allowed to exceed 2.30 volts/ cell.

3.2 The duration of the freshening charge and the voltage at which the Battery Set is to be charged, with reference to the ambient temperature, are given below. Either of the two options given in the table below can be adopted.

<table>
<thead>
<tr>
<th>Option</th>
<th>Temperature</th>
<th>Above 32°C</th>
<th>15 – 32°C</th>
<th>Below 15°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cell Voltage</td>
<td>2.23</td>
<td>2.25</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>30hrs.</td>
<td>30hrs.</td>
<td>60 hrs.</td>
<td></td>
</tr>
<tr>
<td>2. Cell Voltage</td>
<td>2.28</td>
<td>2.30</td>
<td>2.30</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>12hrs.</td>
<td>12hrs.</td>
<td>24hrs.</td>
<td></td>
</tr>
</tbody>
</table>

4.0 DISCHARGE/CAPACITY TEST:
4.1 The Battery Set shall be discharged after keeping it open circuit for not less than 2 hours and not more 24 hours from the completion of full charge.

4.2 Discharge the Battery Set at its 10-hour rate, i.e., at a current equal to 10% of its rated ampere hour capacity till the voltage of any one cell reaches 1.75 volts or the total battery close circuit voltage reaches 1.75 x n (where n is the number of cells in the Battery Set), whichever is earlier.

   a) Maintain the discharge current within ± 1 percent of the specified rate of discharge.
   b) Record the voltmeter and ammeter reading every 5 minutes for the first 15 minutes, and thereafter every 15 minutes up to the end voltage.
   c) Note the time in hours elapsing between the beginning and end of the discharge. This shall be taken as the period of discharge.
   d) The average temperature of the electrolyte during discharge shall be the average of the temperature readings noted at hourly intervals during discharge. The temperature of the battery terminal shall be measured as it will be almost the same as the electrolyte.

4.3 During the above discharge test, the cell voltages shall not be less than the following values.

   a) After six minutes from the start of discharge: 1.98 Volts
b) Aftersix hoursofdischarge: 1.92Volts
c) Attenhoursofdischarge: 1.75Volts

4.4 The capacity of the Battery Set is obtained by multiplying the discharge current in amperes by the time in hours as observed above. This capacity is corrected to 27 Deg. C by the formula:

\[ C_{27} = C_t + C_t \times 0.43 \times (27 - t) \]

where
\( t \) is the average ambient temperature of the battery room,
\( C_{27} \) is the Capacity of the Battery Set at 27 Deg. C, and
\( C_t \) is the measured Capacity of the Battery Set at \( t \) Deg. C.

4.5 If 100% or more capacity is achieved at any time during the above dischargetest, equalize the voltage of all the cells as given at para 4.6 below. Finally charge the Battery Set as per para 5.0 and put it in operation in the floating mode as per para 7.0.

4.6 The minimum acceptable capacity of the Battery Set (corrected to 27°C) which is to be achieved during the above dischargetest is 85% of the rated capacity. If this is not achieved, the matter should be referred to the manufacturer.

4.7 If 85% or more capacity is achieved during the above dischargetest, then equalize the voltage of all the cells as given below.

a) Bypass the cell that has first reached 1.75V.
b) Continue discharging the Battery Set at its 10 hour rate.
c) Keep bypassing the cells that reach 1.75V until the voltage of all the cells reaches 1.75V.

4.8 Charge and discharge the Battery Set until 100% capacity is achieved. If 100% capacity is achieved within another four discharges, finally charge the Battery Set and put it in operation in the floating mode.

4.9 If 100% capacity of the Battery Set is not achieved even after these five discharges, the Battery Set should not be accepted and the matter should be referred to the manufacturer.

5.0 CHARGING/RECHARGING:
5.1 Immediately after the discharging is completed, the Battery Set should be charged by gradually increasing the voltage. The current should not be allowed to exceed 20% of the 10 hour capacity of the Battery Set or the capacity of the battery charger. The voltages should not be allowed to exceed 2.30 volts/cell.
5.2 Continue the charging till the charging current reduces to a negligible value.

6.0 **DISCHARGING:**
6.1 Discharging of the Battery Set is to be done as per procedure given at paras 4.1 and 4.2.

6.2 If this discharge is a capacity test, note the time in hours elapsing from the beginning to the end of the discharge. Calculate the capacity as given at para 4.3 and take necessary action as required.

7.1 If the Battery set has achieved 100% capacity, then charge the Battery set as per para 5.1.

7.2 After the Battery set has been fully charged as per para 5.2, switch off the boost charger. Switch on the float charger after setting its output voltage as per manufacturer’s recommendations.

8.0 Measure the voltages of all the cells of the Battery Set and record for future reference.
DCPANELS

1.0 GENERAL INSTRUCTIONS:
1.1 The DC supply to the various circuits/panels at 220kV and 132kV substations are connected from independent MCB’s. The typical distribution of the MCB’s is as below.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>220kV GSS</th>
<th>132kV GSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>220kV Feeder Panels</td>
<td>132kV C&amp;R feeder Panels</td>
</tr>
<tr>
<td>2</td>
<td>132kV Feeder Panels</td>
<td>33kV C&amp;R Panels</td>
</tr>
<tr>
<td>3</td>
<td>33kV C&amp;R Panels</td>
<td>Annunciation, 132kV side</td>
</tr>
<tr>
<td>4</td>
<td>Annunciation, 220kV side</td>
<td>Annunciation, 33kV side</td>
</tr>
<tr>
<td>5</td>
<td>Annunciation, 132kV side</td>
<td>LT &amp; RTCC Panels</td>
</tr>
<tr>
<td>6</td>
<td>Annunciation, 33kV side</td>
<td>PLCC/ SLDC</td>
</tr>
<tr>
<td>7</td>
<td>LT &amp; RTCC Panels</td>
<td>Emergency Light</td>
</tr>
<tr>
<td>8</td>
<td>PLCC/ SLDC</td>
<td>132 kV C&amp;R transformer panel</td>
</tr>
<tr>
<td>9</td>
<td>Emergency Light</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Bus Bar &amp; LBB Protection</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>220 kV transformer C&amp;R panels</td>
<td></td>
</tr>
</tbody>
</table>

NOTE:- Use separate MCB for each transformer panel.

1.2 At 400kV substations, two independent Battery Sets and DCPANELS are provided. The DC supply to the panels/ schemes is connected as per the DC supply scheme.

1.3 Measure insulation resistance of panel wiring with 500V Megger before connecting any cable.

2.0 ERECTION AND INSTALLATION:
2.1 Check the DCPANEL for any mechanical damage before installation.

2.2 Place the DCPANEL at its designated location in the control room as per layout.

2.3 Fix/bolt the DCPANEL on the trench provided in the floor of the control room or on the base frame if provided.

2.4 Lay the cables from the DC PANEL to the battery charger. Strip off the insulation of the cable ends and of the wires. Crimp terminal lugs/thimbles of suitable size at both the ends.

2.5 First connect the cables to the positive and then negative terminal of the DCPANEL.

2.6 Then connect the cable to the positive and then negative terminal of the battery charger.

2.7 Lay the cables from the DCPANEL to the respective C&R Panels/equipment. Strip off the insulation of the cable ends and of the wires. Crimp terminal lugs/thimbles of suitable size at both the ends.
2.8 Connect one end of the individual cables to the terminals in the terminal blocks corresponding to the designated MCB’s in DC Panel. Connect the other end of the cables in the respective C&R panels.

2.9 Lay the cable from the LTPanel to the DC Panel for AC supply. Strip off the insulation of the cable ends and of the wires. Crimp on terminal lugs/thimbles of suitable size at both the ends. Connect the cable at both the ends. Separate cable for each transformer C&R panel to DCDB.

3.0 PRE-COMMISSIONING CHECKS:

3.1 Check tightening of all terminal connections.

3.2 Check the voltage and polarity of the DC supply at the terminal of the incoming cable from battery charger.

3.3 Check the voltage on the voltmeter at the selector switch position “+veto–ve”. The voltmeter should show full DC voltage.

3.4 Check functioning of space heater and internal illumination circuits.

3.5 Check earthing of the DC Panel to the earth mat.

3.6 Check the annunciation such as “DC supply fail”, “DC earth fault”, etc. as provided in the DC Panel.

3.7 Check the working of the DC earth fault relay. Set it at the minimum setting. If the relay operates, it indicates an earth fault in the DC system connected at this stage. Identify the polarity (+ve or –ve) which is earthed as given at para 3.8.

3.8 Check the voltage on the voltmeter at the different selector switch positions of “+veto Earth” and “–veto Earth”. The voltage at “+veto Earth” and “–veto Earth” positions of selector switch should be equal. If these are not equal, it indicates an earth fault in the DC system connected at this stage.

3.9 If the “+veto Earth” voltage is less than the “–veto Earth” voltage, it indicates an earth fault in the positive circuit. If the “–veto Earth” voltage is less than the “+veto Earth” voltage, it indicates an earth fault in the negative circuit. Trace the fault and rectify the earth fault.

4.0 POST-COMMISSIONING TESTS:

4.1 Switch on the individual MCB’s and check the voltage and polarity of the DC supply at the corresponding outgoing terminals.

4.2 Carry out checking of DC earth fault, and rectification if required, by following the steps given at para 3.7 and para 3.8 after switching one each MCB.

4.3 Check the operation of the emergency lighting system. Switch on the AC supply to the DC Panel. Check that AC supply is available at the designated outgoing terminals for the emergency lighting circuit. Switch off the AC supply to the DC Panel. Check that DC supply is available at these outgoing terminals.
Check the availability of battery tap voltage. Keep the voltmeter selector switch in the position “+ve–ve”. Switch on the boost circuit and switch off the float circuit in the battery charger. The voltage on the voltmeter should correspond to the tapping voltage, i.e., per cell voltage multiplied by the tapped cell (48\textsuperscript{th} cell of 110VDC system or 96\textsuperscript{th} cell of 220VDC system).
BATTERYCHARGERS

1.0 GENERAL INSTRUCTIONS:
1.1 Maintain a minimum spacing of 15 cm between the Battery Charger and other panels on both the sides for proper ventilation.

1.2 During battery boost charging and in float operation, it should be ensured that the rating of the relevant section is not exceeded.

1.3 Place the temperature sensor in the battery room and connect it to the Battery Charger.

1.4 ALWAYS KEEP THE FLOAT CHARGER ON EVEN WHEN BOOST CHARGING THE BATTERY SET IN SERVICE.

2.0 ERECTION AND INSTALLATION:
2.1 Check the Battery Charger for any mechanical damage before installation.

2.2 Place the Battery Charger at its designated location in the control room as per layout.

2.3 Fix/bolt the Battery Charger on the trench provided in the floor of the control room.

3.0 PRE-COMMISSIONING CHECKS:
3.1 Check tightening of all terminal connections.

3.2 Check earthing of the Battery Charger to the earth mat.

4.0 PRE-COMMISSIONING TESTS:
4.1 Connect only the AC supply cable from the LTPanel. The cables to the Battery Set and the DCPanel should not be connected.

4.2 Switch on the AC supply and check the voltages on the terminal of the incoming cable.

4.3 Keep the Auto–Manual switch in Manual position. Switch on the Float Charger. Raise the voltage manually to the required output value and check the voltage and polarity on the load and battery terminals. Lower the voltage manually to check operation of the control circuit.

4.4 Calibrate the DC voltmeter.

4.5 Keep the Auto–Manual switch in Auto position. Set the output voltage to the required value.

4.6 Put the switch in the Manual position and lower the voltage. Put the switch in Auto position. The output voltages should increase to the set value. Repeat the above test by increasing the voltage. The output voltages should decrease to the set value. Adjust the voltage setting if required.
4.7 Check the annunciations such as “AC supply fail”, “DC earth fault”, “Fuse Failure”, etc. as provided.

4.8 Switch off the Float Charger.

4.9 Keep the Boost Charger voltageselecting taps (Coarse and Fine) / voltage setting at the minimum position. Switch on the Boost Charger.

4.10 Check the voltage and polarity on the battery terminals. Raise the voltage to the maximum output value and check the voltage on the battery terminals.

4.11 Set the voltage to the rated value. Put the Keyed Push Button (Boost as Float) in the ON position. Check that the rated voltage is available on the load terminals.

4.12 Switch off the Boost Charger.

4.13 Connect the cable to the Battery Set and the DCPanel.

5.0 POST–COMMISSIONING CHECKS:

5.1 The voltmeter should show the battery voltage in the Battery position. It should also show the Tap voltage in Battery Tap position.

5.2 Keep the Float Charger Auto–Manual switch in Manual position. Switch on the Float Charger. Raise the voltage manually. The float output ammeter will show load current when the output voltage exceeds the Battery voltage. Check that the charge/discharge ammeter also shows current in the charge direction. Reduce the voltage.

5.3 Put the Float Charger Auto–Manual switch in Auto Position. The float output current will start increasing. The float output ammeter will show load current when the output voltage exceeds the Battery voltage. When the load current exceeds the setting of the current limiting circuit, the float output voltage and current should automatically decrease. If this does not happen, put the Auto–Manual switch in Manual position and decrease the output voltage. Adjust the setting of the output current limiting circuit so that the output current does not exceed the rating of the Float Charger. Switch off the Float Charger.

5.4 Keep the Boost Charger voltageselecting taps (Coarse and Fine) / voltage setting at the minimum position. Switch on the Boost Charger.

5.5 Raise the voltage. The output ammeter will show load current when the output voltage exceeds the Battery voltage. Check that the charge/discharge ammeter shows current in the charge direction. Return the voltage selecting taps (Coarse and Fine) / voltage setting to the minimum position. Switch off the Boost Charger.

5.6 After connecting load to the Battery set, switch off the Float Charger (with the Boost Charger off) and check that the full Battery voltage is available on the DCPanel and feeding to the load. The charge/discharge ammeter on the Battery Chargers should show the current on the discharge side.
CONTROL & RELAY PANELS

1.0 GENERAL INSTRUCTIONS:
1.1 Check and ensure that the Control & Relay Panels being installed are meeting the requirement of DC control voltage (110V or 220V) and CT secondary rating (1A or 5A).

1.2 Check that there is no physical damage to the relays and other equipment installed in the C&R Panel.

1.3 Event Loggers, Disturbance Recorders, Bus Bar Protection schemes, LBB Protection schemes, etc. as well as special schemes/equipment for 400kV GIS should be tested / gotten tested as per their schematic diagrams.

2.0 ERECTION AND INSTALLATION:
2.1 Place the panels at their designated locations on the trenches in the Control Room as per layout.

2.2 Fix or bolt the panels (as per requirement of installation of the panels) on the channel/M.S. Angle fitted on the top of the wall so that the trench on the base frame, as provided, in the Control Room.

2.3 Level the panels and check their verticality.

2.4 In the case of Duplex type of panels, connect the control panel to the relay panel across the corridor using the fittings provided with the panels. Also fit the covers for the corridor portion.

2.5 Where a number of panels are to be placed adjacent to each other to form a board or where a panel is to be placed adjacent to an existing panel/board, these shall be bolted together. There shall be no gap between panels which are placed adjacent to each other.

2.6 Connect the Bus wiring/interconnecting wiring between the control & relay panel of the Duplex type. Also connect the similar wiring between control panel to control panel and/or relay panel to relay panel where a Board formation is made or where panels are connected to an existing board/panels as per their relevant schematic drawings.

3.0 PRE-COMMISSIONING CHECKS:
3.1 Check the tightness of all terminal connections.

3.2 Check earthing of the panels & its connection to the earth mat.

3.3 Check the availability of DC supply and AC supply in the Control & Relay Panels.

3.4 Check the polarity of DC supply in the Control & Relay Panel.
### PRE–COMMISSIONING TESTS:

**4.1** Arrange for testing, by the Protection wing, of individual relays, protection schemes, transducers, ICT's, indicating meters, integrating meters, etc. for conformity of their characteristics to the specifications and to the technical information/details/particulars intimated by the manufacturer.

**4.2** Arrange for testing and verification, by the Protection wing, of individual relays, protection schemes, transducers, ICT's, indicating meters, integrating meters, etc. for their performance at the applied voltage/current/operating supply and at the settings selected for their service conditions, and making necessary changes in the settings if and as required.

**4.3** Test the protection scheme logics for alarm and trip as per approved schematic drawings.

**4.4** Test the annunciation scheme by actuating individual alarms from the initiating equipment such as relays, protection schemes, circuit breakers, transformer, etc.

**4.5** The protection scheme logics and annunciation schemes are generally checked as below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation of</th>
<th>Check Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tripprotectionssuchas Buchholz, OSR, etc. provided on transformers</td>
<td>Operation of relevant auxiliary relays</td>
</tr>
<tr>
<td>2.</td>
<td>Alarm protectionssuchas high oil &amp; winding temperature, low oil level, etc. provided on transformers</td>
<td>Operation of relevant auxiliary relays *</td>
</tr>
<tr>
<td>3.</td>
<td>Tripprotectionssuchas differential, overcurrent, earth fault, etc. provided in C&amp;R Panels for transformers</td>
<td>Alarm annunciation</td>
</tr>
<tr>
<td>4.</td>
<td>Tripprotectionssuchas distance, overcurrent, earth fault, etc. provided in C&amp;R Panels for feeders &amp; other circuits</td>
<td>Alarm annunciation</td>
</tr>
<tr>
<td>5.</td>
<td>Alarms provided in circuit breakers</td>
<td>Operation of relevant auxiliary relays *</td>
</tr>
</tbody>
</table>
6. Lockouts provided in circuit breakers

<table>
<thead>
<tr>
<th>Operation of relevant auxiliary relays *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm annunciation</td>
</tr>
<tr>
<td>Trip circuit faulty indication</td>
</tr>
<tr>
<td>CB operation blocked</td>
</tr>
</tbody>
</table>

*if provided

Note: The operation of the Master Trip Relay should be verified for actuation of all trip protections as above. The actual tripping of the circuit breakers should be checked only two or three times with the operation of the Master Trip Relay.

4.6 Arrange for testing, by the Protection wing, of stability of protection schemes such as differential protection schemes for transformers, etc.

4.7 Test the tripping & inter-tripping of associated circuit breakers on the operation of relays/protection schemes, and tripping interlocks, etc. as provided in the scheme logic.

4.8 Testing of Carrier Trip Commands:

4.8.1 The set tests should be carried out for all the codes.

4.8.2 Put the PLC equipment on local loop test. Give the carrier send signal from the Relay Panel and verify that the carrier signal is received back in the Relay Panel.

4.8.3 Put the PLC equipment in the normal mode at both the ends.

4.8.4 Give the carrier send signal from the Relay Panel and verify that the carrier signal is received in the corresponding Relay Panel at the other end.

4.8.5 Ask the Engineer at the other end to send the carrier send signal from the Relay Panel this end. Verify that the carrier signal is received in the corresponding Relay Panel at this end.

4.8.6 Test the tripping of associated circuit breakers once or twice on the receipt of direct trip signals.

4.8.7 Test the annunciations by actuating individual alarms such as Carrier Fail, Carrier Received, etc. from the PLC equipment.

4.9 Verify the interlocks for operation of isolators.

4.10 Verify the operation of equipments from the control switches/push buttons provided for them.

4.11 Verify indication lamps/semaphores for circuit breaker/isolator status by operating the relevant equipment.
4.12 Test the internal illuminations system including operation of the door switches.

4.13 Test the functioning of space heaters and sockets, etc.

5.0 POST–COMMISSIONING CHECKS:

5.1 Check phase sequence of the VT supply in the Control & Relay panels.

5.2 Measure the voltage & current in the relevant circuits and check their readings in the relays, protections schemes, meters, etc.

5.3 Arrange for checking, by the Protection wing, of stability of transformer differential protection on load.

5.4 Arrange for checking and verification, by the Protection wing, of directional feature of over current, earth fault, and distance protections schemes, as applicable.
LT PANELS

1.0 GENERAL INSTRUCTIONS:

1.1 The AC supply to the various circuits/panels at 220kV and 132kV substations are connected from independent switch fuse units (SFUs). The typical distribution of the SFUs is as below.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>220kV GSS</th>
<th>132kV GSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Colony Lighting</td>
<td>Colony Lighting</td>
</tr>
<tr>
<td>2.</td>
<td>220kV CBB</td>
<td>132kV CBB</td>
</tr>
<tr>
<td>3.</td>
<td>132kV CBB</td>
<td>33kV/11kV CBB</td>
</tr>
<tr>
<td>4.</td>
<td>33kV CBB</td>
<td>Spare</td>
</tr>
<tr>
<td>5.</td>
<td>220/132kV Transformer</td>
<td>Yard Lighting</td>
</tr>
<tr>
<td>6.</td>
<td>Battery Charger 220V</td>
<td>Control Room Lighting</td>
</tr>
<tr>
<td>7.</td>
<td>Battery Charger 48V</td>
<td>132/33/11kV Transformer</td>
</tr>
<tr>
<td>8.</td>
<td>Yard Lighting</td>
<td>Tube Well</td>
</tr>
<tr>
<td>9.</td>
<td>Control Room Lighting</td>
<td>Battery Charger 110V</td>
</tr>
<tr>
<td>10.</td>
<td>Tube Well</td>
<td>Battery Charger 48V</td>
</tr>
<tr>
<td>11.</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>12.</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>13.</td>
<td>C&amp;R Panel</td>
<td>C&amp;R Panel</td>
</tr>
<tr>
<td>14.</td>
<td>DC&amp;RTCC Panels</td>
<td>DC&amp;RTCC Panels</td>
</tr>
</tbody>
</table>

(The supply to Colony Lighting and Tube Well shall be through separate energy meters)

1.2 At 400kV substations, two independent Station Transformers and LT Panels are provided. The AC supply to the panels/equipments/kiosks is connected as per the AC supply scheme.

2.0 ERECTION AND INSTALLATION:

2.1 Check the LT Panel for any mechanical damage before installation.

2.2 Measure insulation resistance of panel wiring and the LT bus bar (phase to phase and phase to earth) with 500V Megger before connecting any cable.

2.3 Place the LT Panel at its designated location in the control room as per layout.

2.4 Fix/bolt the LT Panel on the trench provided in the floor of the control room.

2.5 Lay the power cable from the station transformer to the LT Panel. Strip off the insulation of the power cable ends and of the wires. Crimp on aluminium terminal lugs/thimbles of suitable size at both ends.

2.6 First connect the cable to the LT Panel.

2.7 Then connect the cable to the LT terminal of the station transformer.
2.8 Lay the cables from the LTPanel to the respective bay marshalling kiosks / C&R panels/ transformer, etc. Strip off the insulation of the cable ends and of the wires. Crimp on terminal lugs/ thimbles of suitable size at both the ends.

2.9 Connect one end of the individual cables to the terminals in the terminal blocks corresponding to the designated switch fuse unit in the LTPanel. Connect the other end of the cables in the respective equipment.

2.10 Lay the cable from the DCPanel to the LTPanel for DC supply. Strip off the insulation of the cable ends and of the wires. Crimp on terminal lugs/thimbles of suitable size at both the ends. Connect the cable at both the ends.

3.0 PRE-COMMISSIONING CHECKS:

3.1 Check tightening of all terminal connections.

3.2 Check earthing of the LTPanel to the earthmat.

3.3 LTCircuitBreaker:

3.3.1 ENSURE THAT THE CLOSING SPRING IS FULLY DISCHARGED. If it is not fully discharged, then discharge the spring as per instructions given in the manufacturer's manual.

3.3.2 Carry out slow mechanical operation (closing and tripping) of Circuit Breakers as per procedure prescribed by the manufacturer. Take all the precautions mentioned in the manufacturer's manual.

3.3.3 Manually charge the closingspring and check electricallimitswitch, mechanical latches and stopper(s) as provided.

3.3.4 Close and trip the LTCB manually.

3.3.5 Charge the spring electrically and verify the operation of the limitswitch. Adjust the setting of the limitswitch if required.

3.3.6 Check operation of the LTCircuitBreaker electrically.

3.3.7 Check tripping of LTCB from ProtectionTrip.

3.3.8 Check operation of anti-pumping/anti-hunting relay by giving continuous closing and tripping signals simultaneously. The breakers should close and then trip and should not close again.

3.3.9 Check lamp indications of the LTCB for CBOPEN, CLOSED, AUTOTRIP and SPRING CHARGED conditions.

3.3.10 Lubricate all the moving parts and the pins in the operating mechanism.

3.3.11 Check the annunciations for protection trip, etc. as provided.
3.4 Check rating of fuses in switch fuse units (SFU’s).

3.5 Check operation of the outgoing Switch Fuse Units and its locking mechanism.

4.0 PRE-COMMISSIONING TESTS:
4.1 Measure IR values with 5kV Megger between incoming and outgoing terminal of the LT Circuit Breaker when the CB is OFF.

4.2 Arrange for checking of operation of Over Current and Earth fault relays & their settings, testing of LT Current Transformer, Energy Meter, etc. by the Protection Wing.

5.0 POST-COMMISSIONING TESTS:
5.1 Energize the station transformer and check the voltage and phase sequence of the AC supply at the terminal of the incoming cable from the station transformer.

5.2 Check the voltage on the voltmeter at the different positions “R–Y”, “Y–B” and “B–R”. The voltmeters should show voltage corresponding to the voltage of incoming supply.

5.3 Switch on the individual switch fuse units and check the voltage of AC supply at the corresponding outgoing terminals.

5.4 Check functioning of space heater and internal illumination circuits.

5.5 Close the doors/ openings provided in the LT Panel.
**PLCCARRIERSETS**

1.0 **GENERALINSTRUCTIONS:**

1.1 Wear grounding straps when handling the modules since they contain CMOS (compound metal oxide semiconductor) devices which can be damaged by electrostatic discharge.

1.2 Do not disturb the factory settings of the equipment.

1.3 **DO'S AND DON'TS:**

i) **DONOT** alter user settings unless it is absolutely necessary.

ii) **DONOT** insert or eject the modules from their location in the shelf when the power supply is on.

iii) **DO** ensure that all connections are firmly tight.

iv) **DO** take all the antistatic precautions.

v) **DO** ground the terminal chassis properly.

vi) **DO** keep the equipment in a dust-free environment.

vii) **DO** keep handset and measuring leads inside the PLCC terminal.

1.4 The erection and installation work should be carried out as per instructions/procedures given in the Manufacturer’s Installation and Commissioning Manual.

1.5 The work should be done under the supervision of the Work-In-Charge/Manufacturer’s Engineer and as per instructions given by him/them.

2.0 **ERECTION AND INSTALLATION:**

2.1 Fabricate the structure/frame as per the fixing dimensions of the Carrier sets. The structure/frame should have a height of at least 150 mm from floor level to facilitate cable entry into the panel.

2.2 Place the structure/frame near the cable trenches in the PLCC room in such a manner that sufficient space is available for accessing the Carrier sets from the rear for maintenance as well as from the front for setting up test instruments. Then grout the structure/frame.

2.3 Check the Carrier sets for any mechanical damage during transportation.

2.4 Erect the Carrier sets at their locations on the fabricated structures/frames. Maintain a minimum spacing of 30 mm between two carrier sets on both the sides for proper ventilation.

2.5 Level the Carrier Sets and fix them on the structure/frame.

2.6 Clean the interior of the rack of the Carrier sets with a vacuum cleaner. Insert the modules, if received separately, in their designated locations in the Carrier Terminal as per erection manual.

2.7 Lay the coaxial cable from LMDU to the Carrier Set.
2.8 Prepare the end of the coaxial cable and fix the connectors at the ends.

2.9 Fit the coaxial cable onto the Carrier Set and LMDU.

2.10 Earth the Carrier Set and the structure/frame.

3.0 PRE-COMMISSIONING CHECKS:

3.1 Measure the resistance of the earthing connection of the Carrier Set to the earth mat. The earthing connection should have resistance of less than 1.0 Ohm for safety.

3.2 Ensure that the earthing of the HF terminal of the CVT and the LMU/LMDU have been opened.

3.3 Visually check the cards for any dry solder in the circuit.

3.4 Check that all the modules are fitted in their correct locations.

3.5 Check the tightness of all terminal connections.

3.6 Check that all the inter-connector cables are fitted and properly inserted.

3.7 Check that all strappings and settings of the DIP switches in the modules and on the rear side of the PCB’s are in accordance with the programming table.

3.8 Check the internal illumination system.

3.9 Check the functioning of power sockets, etc.

3.10 Ensure that the exhaust fan is working.

4.0 PRE-COMMISSIONING TESTS:

4.1 Connect 48V from DC power source to Carrier Set and check the polarity of DC voltage at the terminals.

4.2 Switch on the MCB.

4.3 Switch on the Power Supply Unit. Measure output voltage at the test points.

4.4 Carry out setting, measurement and adjustment of frequency and levels at both ends (transmitted/received) as per commissioning manual of the manufacturer.

a) Test tone of 800Hz/1000Hz at the test point.
b) Tx & Rx frequencies.
c) IF and RF levels.
d) Output of power amplifier at 125/75 Ohm termination.
e) Pilot levels at HF coaxial.
f) AGC level.
g) 2W & 4W AF levels.
h) Any other setting/test as prescribed by the manufacturer.
4.5 Verify the following.
   a) Signaling operation by extending ground.
   b) All the alarms in all the units.
   c) Loopback status (local loop and remote loop).
   d) Communication with the remote end operator over service telephone.
   e) Any other setting/test as prescribed by the manufacturer.

4.6 Carry out the following tests on the complete system.
   a) Composite loss and return loss on coupling devices using dummy load.
   b) Composite loss (attenuation) for HF cable coupling device.
   c) End-to-end return loss of the adopted coupling mode (phase-to-phase R&B, or inter-phase Y&Y; refer Clause 12 on Wave Traps).
      i) Open behind the wave trap.
      ii) Grounded behind the wave trap.

4.7 If the end-to-end return loss for the adopted coupling mode is not satisfactory, the same shall be measured for other coupling modes (phase-to-phase R&Y and Y&B, or inter-phase R&R and B&B) to determine the optimum coupling mode. The Wave Traps and the connections to the CVT should be changed as per the optimum coupling mode.
CARRIERPROTECTIONCOUPLERS

1.0 ERECTIONANDINSTALLATION:
1.1 ChecktheCarrierProtectionCouplerforany mechanicaldamagebeforeinstallation.
1.2 CleantheProtectionCouplerwithvacuumcleaner.
1.3 FittheProtectionCouplerin thePLCCterminalifreceivedseparately.

2.0 PRE-COMMISSIONINGCHECKS:
2.1 Visualcheckforanydrysolderinthecircuit boards.
2.2 Checkthat all themodulesarefitted intheircorrectlocations.
2.3 Checktightnessofall terminalconnections.
2.4 Checkthat all theinter-connectorsarefitted andproperlyinserted.

3.0 PRE-COMMISSIONINGTESTS:
3.1 ChecktheDCvoltageandits polarityin theProtectionCoupler.
3.2 Configuretheequipmentasperprogrammingtable.
3.3 CheckTxandRxTripcommandsfortheirproperoperation.
3.4 Testtheequipmentonlocallooptest.
3.5 MakeconnectionsfromtherespectiveRelayPanelstotheMDF(maindistributionframe) oftheequipmentasperscheme.
3.7 Puttheequipmentinthenormalmodeatbothends. Verifythetransmissionandreceiptof Txand Rx commands on all the codes of the Protection Coupler by initiating trip commandsfromtheRelayPanelsat bothends.
3.8 TestAnnunciationsbyactuatingindividualalarmssuchasCarrierFail,CarrierReceived, etc. fromtheProtectionCoupler.
PLCCEXCHANGE

1.0 ERECTION AND INSTALLATION:
1.1 Fabricate the structure/frame as per the dimensions of the PLCC Exchange. The structure/frame should have a height of at least 75 cm above floor level.

1.2 Grout the structure/frame in the PLCC Room near the cable trenches. The structure should be grouted in such a manner that enough space is available for access to the Exchange from the front for setting up test instruments and from the rear for maintenance.

1.3 Check the PLCC Exchange panel for any mechanical damage before installation.

1.4 Clean the interior of the PLCC Exchange panel with a vacuum cleaner.

1.5 Place the Exchange on the structure/frame and fix it after levelling.

1.6 Earth the Exchange and the structure/frame.

2.0 PRE-COMMISSIONING CHECKS:
2.1 Connect 48 VDC Supply to the Exchange and ensure correct polarity.

2.2 Plug in the powersupply module in its respective slot.

2.3 Switch on the power supply unit.

2.4 Measure various output voltage at the specified test points.

2.5 Switch off the power supply unit and plug in all the cards into their respective slots.

2.6 Switch on the power supply unit module.

2.7 Again check the various voltages at test points. The system should work normally.

2.8 Verify the alarms provided in the Exchange.

3.0 PRE-COMMISSIONING TESTS:
3.1 Connect the local telephone lines to MDF of the Exchange.

3.2 Wire the trunk lines (Tielines) from the PLCC carriers to MDF of the exchange.

3.3 Configure the exchange/local numbers/Tieline numbers as per the procedure given in the instruction manual of the manufacturer.

3.4 Dial up the local as well as the remote end subscribers and verify the satisfactory operation of the Exchange.
COMMISSIONING OF SUBSTATION

1.0 TESTING BY THE PROTECTION WING:
1.1 All major equipment such as Transformer, Current Transformers, Capacitor Voltage Transformers.

1.2 All Control & Relay Panels including the protection schemes and relays installed on them.

1.3 All protection schemes such as Local Breaker Back Up (LBB) Protection and Bus Bar Protection Schemes as provided.

1.4 Any other protection associated schemes such as carrier aided schemes, etc. as provided.

1.5 Measure earth resistance of each electrode of Transformer neutral.

1.6 Ensure connectivity in between existing mesh and extended mesh in case of Bay augmentation.

2.0 APPROVAL OF THE CHIEF ELECTRICAL INSPECTOR:

2.1 Before energizing the SubStation, the approval of the Chief Electrical Inspector of the State Government is required as per Rule 63 of the Indian Electricity Rules, 1956.

2.2 The application is made in the prescribed questionnaire and submitted along with required drawings and information.

2.3 The inspection fee, as prescribed from time to time, is to be deposited.

2.4 A sample format of the proforma for the above application/questionnaire for a 132 kV SubStation is enclosed in Annexure – A.

3.0 FINAL CHECKING:

3.1 Measure the insulation resistance values of each phase to earth of each voltage level after closing all isolators and Circuit Breakers of that voltage level. The Transformer is not included in this measurement. In case of electromagnetic type of Potential Transformer, open the earthing link/connection of the primary winding. Keep the line isolators of all the feeders open. The values shall depend on the size of the SubStation, voltage level and the weather conditions.

3.2 Open all the isolators and Circuit Breakers after above checking.

4.0 CHARGING THE SUBSTATION:

4.1 This is to be done after the approval of the Chief Electrical Inspector has been obtained.

4.2 The concerning Executive Engineer shall be present at the time of charging the SubStation who shall ensure that all testing and checking has been done and approval of the relevant authorities has been obtained.

4.3 Initially, close only those isolators which are required for charging them in the main bus. Keep the incoming line isolator and its earth switch open.
4.4 Contact the SubStation at the other end of the incoming line. Give the clearance for charging the line.

4.5 After the line is charged, close the line Isolator and the line Circuit Breaker.

4.6 Check the phase to phase and phase to neutral voltages on the Bus voltmeter on the Control Panel.

4.7 Close the Isolators required for charging the Transformer.

4.8 Follow the precautions and directions given in para 18.0 of Clause 5 for charging the transformer.

4.9 Before taking load on the Transformer, obtain clearance from the concerning Engineer of the Discom.
## QUESTIONNAIRE UNDER RULE-63 OF INDIAN ELECTRICITY RULES, 1956

### ANNEXURE-A

| 1. Name of Substation | 132kVGSS,  

| 2. Operating Voltage of the GSS | 132/33kV  

| 3. Type & Height of the structures used | Lattice type steel  

|  | 132kV side : 7.5 Mtrs.  

|  | 33kV side : 5.5 Mtrs.  

| 4. Type of Insulators used | String of 11kVB & Stypedisc insulators, 45KN and 120K N E&M Strength for suspension and tension respectively.  

| 5. Type & Size of Bus Bar conductor and earthwire used. | a) Bus Bar of ACSR Conductor:  

|  | Name Aluminium Steel  

|  | Zebra 54/3.18mm  

|  | 7/3.18mm Panther  

|  | 21/3.00mm  

|  | 7/3.00mm b) Earthwire:  

|  | 7/3.15mm GSS wire  

| 6. Type and capacity of the transformer | 132/33kV, 20/25MVA  

| 7. Type and capacity of gang operated switches, Fuse, Oil circuit breaker, etc. | a) Isolators:  

|  | 132kV, 800 Amp.  

|  | 33kV, 630 Amp.  

|  | b) Circuit Breakers:  

|  | 132kVSF6CB, 31.5kA  

|  | 33kVVCB/SF6CB, 25kA  

| 8. Type of Lightning Arrestors used. | Station type, Metal oxide, 10kA  


| 10. Details of minimum clearance above 4.6M. ground level. |  

|  | 132kV side—  

|  | 33kV side—3.7M.  

| 11. Number of earth electrodes provided | 11kV side—3.7M.  

|
Nos. of earthelectrodes of
for the earthing of substation.

25 mm dia. M.S. Round. In addition, ear
t
mesh of 25 mm dia. M.S. Round and riser
s of 50 × 10 mm MS Flat are provided.

12. Test certificates of manufacturer for
Allequipment are as per relevant transformer, conductors, Insulators,
ISS/ IEC standards & inspected circuit breakers, etc.
by RVPNL engineers (Type and
routine tests) before dispatch from manufacturer’s works.
13. Drawing of HT/ EHT installations 
Electrical layout of substations showing the method of construction showing EHT/ HT installation and layout, etc. enclosed.

14. Actual date of completion of work

EXECUTIVE ENGINEER( ), Rajasthan Rajya Vidyut Prasaran Nigam Ltd.

Encl.:
1) Electrical layout of GSS
2) Test report of Transformer
3) Original challan for payment of inspection fee
CHAPTER – 8

QUALITY AUDIT

AND

CONTROL
## TYPICAL BOQ OF EQUIPMENTS/ ITEMS REQUIRED FOR CONVENTIONAL 132 KV AIS SUBSTATIONS (HAVING 3 NOS. 132 KV BAYS AND 7 NOS. 33 KV BAYS)

<table>
<thead>
<tr>
<th>S. NO</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>UNIT</th>
<th>QUANTITY REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A) STRUCTURES: (Including Nuts &amp; Bolts)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Structure type &quot;BT1&quot;</td>
<td>Nos.</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Structure type &quot;BT3&quot;</td>
<td>Nos.</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Structure type &quot;BT4&quot;</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Structure type &quot;BT6&quot;</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Structure type &quot;BT7&quot;</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Beam type &quot;BB1&quot;</td>
<td>Nos.</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Structure type &quot;X&quot;</td>
<td>Nos.</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>Structure type &quot;Y&quot; with stub</td>
<td>Nos.</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Structure type &quot;Y&quot; without stub</td>
<td>Nos.</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>Structure type &quot;Z&quot;</td>
<td>Nos.</td>
<td>14</td>
</tr>
<tr>
<td>11</td>
<td>Beam type &quot;GF-5.4&quot;</td>
<td>Nos.</td>
<td>19</td>
</tr>
<tr>
<td>12</td>
<td>Structure type &quot;33 KV CT&quot;</td>
<td>Nos.</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>Structure type &quot;X-15&quot;</td>
<td>Nos.</td>
<td>18</td>
</tr>
<tr>
<td>14</td>
<td>Structure type &quot;PIS&quot;</td>
<td>Nos.</td>
<td>9</td>
</tr>
<tr>
<td>15</td>
<td>Structure type &quot;AO5&quot;</td>
<td>Nos.</td>
<td>27</td>
</tr>
<tr>
<td>16</td>
<td>Structure type &quot;BO1&quot;</td>
<td>Nos.</td>
<td>12</td>
</tr>
<tr>
<td><strong>B) EQUIPMENTS:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>132/33 KV Transformer 20/25 MVA</td>
<td>Nos.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>132 KV CT (125-250-500/1A, 3C)</td>
<td>Nos.</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>145 KV Circuit Breaker 220 V DC</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>120 KV LA</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>132 KV Isolator with EB</td>
<td>Nos.</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>132 KV Isolator without EB</td>
<td>Nos.</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>132 KV Polycone Insulator</td>
<td>Nos.</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>132 KV CVT</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>132 KV Marshalling kiosk</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>33/0.4KV, 250 KVA Station Transformer</td>
<td>Nos.</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>33 KV circuit Breaker 220 V DC</td>
<td>Nos.</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>33 KV CT 125-250-500/1A, 2C</td>
<td>Nos.</td>
<td>18</td>
</tr>
<tr>
<td>13</td>
<td>33 KV CT 250-500/1Amp, 5C, 0.2 Class</td>
<td>Nos.</td>
<td>3</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>33 KV PT</td>
<td>Nos. 3</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>33 KV LA</td>
<td>Nos. 18</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>33 KV Isolator with EB 800 A</td>
<td>Nos. 5</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>33 KV Isolator without EB 800 A</td>
<td>Nos. 17</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2 X 24 KV PTs</td>
<td>Stacks 218</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>2 X 33 KV MK</td>
<td>Nos. 4</td>
<td></td>
</tr>
</tbody>
</table>

**C) CONTROL PANELS:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>132 KV feeder C &amp; R Panel (220 V DC, 1 Amp.)</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>2</td>
<td>132/33 KV, 20/25 MVA Trf. C &amp; R panel (220 V DC, 1 Amp.)</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>3</td>
<td>132 KV Bus Coupler Panel (220 V DC, 1 Amp)</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>4</td>
<td>33 KV Incomer + Bus coupler Panel (220 V DC, 1 Amp)</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>5</td>
<td>2 X 33 KV Feeder Panel (220 V DC, 1 Amp)</td>
<td>Nos. 2</td>
</tr>
<tr>
<td>6</td>
<td>1 X 33 KV Feeder Panel (220 V DC, 1 Amp)</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>7</td>
<td>LT Panel 800 A, 220 V DC</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>8</td>
<td>DC Panel 220 V DC</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>9</td>
<td>220 V, 200 AH DC Battery Set</td>
<td>Nos. 1</td>
</tr>
<tr>
<td></td>
<td>220 V, 200 AH DC Battery Charger</td>
<td>Nos. 1</td>
</tr>
</tbody>
</table>

**D) PLCC EQUIPMENTS:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 W SSB Single Channel Carrier Set without Protection Coupler</td>
<td>Set 2</td>
</tr>
<tr>
<td>2</td>
<td>Wave Trap (0.2 mH, 1250 Amp)</td>
<td>Nos. 4</td>
</tr>
<tr>
<td>3</td>
<td>Coupling Device (Phase to Phase)</td>
<td>Nos. 2</td>
</tr>
<tr>
<td>4</td>
<td>48 V, 200 A, VRLA Battery Set</td>
<td>Set 1</td>
</tr>
<tr>
<td>5</td>
<td>48 V, 25 A, SMPS Battery Charger</td>
<td>Set 1</td>
</tr>
<tr>
<td>6</td>
<td>Co- Axial Cable (75 Ohm)</td>
<td>Km. 0.5</td>
</tr>
</tbody>
</table>

|     | 5- pair Un- Armoured Telephone Cable                            | Km. 0.25 |

**E) HARDWARE:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single Tension Hardware for Zebra</td>
<td>Nos. 78</td>
</tr>
<tr>
<td>2</td>
<td>Single Tension Hardware for Panther</td>
<td>Nos. 26</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>3</td>
<td>Single Suspension Hardware for Zebra</td>
<td>Nos. 20</td>
</tr>
<tr>
<td>4</td>
<td>Single Suspension Hardware for Panther</td>
<td>Nos. 20</td>
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<tr>
<td>5</td>
<td>T - clamp Z-Z</td>
<td>Nos. 63</td>
</tr>
<tr>
<td>6</td>
<td>T - clamp Z-P</td>
<td>Nos. 60</td>
</tr>
<tr>
<td>7</td>
<td>T - clamp P-P</td>
<td>Nos. 36</td>
</tr>
<tr>
<td>8</td>
<td>PG.-clamp Z-Z</td>
<td>Nos. 114</td>
</tr>
<tr>
<td>9</td>
<td>PG.-clamp Z-P</td>
<td>Nos. 103</td>
</tr>
<tr>
<td>10</td>
<td>PG.-clamp P-P</td>
<td>Nos. 72</td>
</tr>
<tr>
<td>11</td>
<td>ACSR conductor Zebra</td>
<td>KM. 2.0</td>
</tr>
<tr>
<td>12</td>
<td>ACSR conductor Panther</td>
<td>KM. 1.0</td>
</tr>
<tr>
<td>13</td>
<td>Earthwire 7/3.15 mm</td>
<td>KM. 1.0</td>
</tr>
<tr>
<td>14</td>
<td>PI Clamp for Z</td>
<td>Nos. 4</td>
</tr>
<tr>
<td>15</td>
<td>PI clamp for P</td>
<td>Nos. 4</td>
</tr>
<tr>
<td>16</td>
<td>Disc Insulator 120 KN</td>
<td>Nos. 770</td>
</tr>
<tr>
<td>17</td>
<td>Disc Insulator 70 KN</td>
<td>Nos. 255</td>
</tr>
<tr>
<td>18</td>
<td>Earthwire Tension Clamp for 7/3.15 mm</td>
<td>Nos. 90</td>
</tr>
<tr>
<td>19</td>
<td>PG Clamps for 7/3.15 Earthwire</td>
<td>Nos. 60</td>
</tr>
<tr>
<td>20</td>
<td>Isolator Clamp for Zebra</td>
<td>Nos. 10</td>
</tr>
<tr>
<td>21</td>
<td>Isolator Clamp for Panther</td>
<td>Nos. 10</td>
</tr>
</tbody>
</table>

**F) CONTROL CABLES:**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control Cables 18 X 2.5 mm²</td>
<td>KM. 2.0</td>
</tr>
<tr>
<td>2</td>
<td>Control Cables 12 X 2.5 mm²</td>
<td>KM. 3.0</td>
</tr>
<tr>
<td>3</td>
<td>Control Cables 6 X 2.5 mm²</td>
<td>KM. 1.5</td>
</tr>
<tr>
<td>4</td>
<td>Control Cables 4 X 4 mm²</td>
<td>KM. 4.0</td>
</tr>
<tr>
<td>5</td>
<td>Control Cables 4 X 2.5 mm²</td>
<td>KM. 1.0</td>
</tr>
<tr>
<td>6</td>
<td>Control Cables 3 X 2.5 mm²</td>
<td>KM. 1.0</td>
</tr>
<tr>
<td>7</td>
<td>LT Power Cable 3.5 C X 300 mm²</td>
<td>KM. 0.25</td>
</tr>
</tbody>
</table>

**G) EARTHING MATERIAL:**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MS Rod 28 mm.</td>
<td>MT. 10</td>
</tr>
<tr>
<td>2</td>
<td>MS Flat 50 X 10 mm.</td>
<td>MT. 10</td>
</tr>
<tr>
<td>3</td>
<td>MS Flat 50 X 6 mm.</td>
<td>MT. 1</td>
</tr>
<tr>
<td>4</td>
<td>MS Channel 100 X 50 X 6 mm</td>
<td>MT. 3</td>
</tr>
<tr>
<td>5</td>
<td>Copper Earth bond</td>
<td>Nos. 100</td>
</tr>
</tbody>
</table>

**H) MISCELLANEOUS ITEMS:**
<table>
<thead>
<tr>
<th>S. No</th>
<th>Description of the Work</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>EARTH MESH WORK:</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|       | A-1 Laying of **Earth Mesh** with 25 mm. dia M.S. Rod at depth of 0.8 mtr. From the top level of foundation, including excavation of trench of required depth and back filling of the same, transportation of M.S. Rod from site store to location, welding of M.S. Rod along the length, at crossing and with earth electrode as per drawing, application of bitumen impregnated tape on all the welded joints, for the type of soil prevalent at 0.8 mtr. Below the foundation (M.S. Rod of above sizes and M.S. Flat as required shall be made available by RVPN)  
In case electricity is made by RVPN with out charges  
i) Normal Dry soil | Mtr. | 2500     |
|       | B-1 Laying of **Earth Riser** of 50 X6 mm, 50 X10 mm, 50 X12 mm, size M.S. Flat at a depth of 0.8 mtr. From the top level of foundations, including excavation of trench of required depth and back filling of the same, transportation of M.S. Flat from site store to location, preparation of risers, bending as required, fixing on and welding/ bolting of equipments/ structures and peak of towers, laying of trench, welding to the earth mesh of M.S. Rod as per requirement, application of bitumen compound and covering with bitumen tape on all welded joints, painting on all the surface of the riser above ground level with red oxide and green enamel paint, for the soil prevalent at a depth of 0.8 mtr. From the top level of the foundation (M.S. Flat of above size will be supplied by RVPNL)  
a) In case electricity is made by RVPN with out charges  
i) Normal Dry soil | Mtr. | 2500     |
<table>
<thead>
<tr>
<th>C-1</th>
<th>Placing/ driving of <strong>Earth Electrode</strong> of 25/28 mm. dia. M.S. Rod of length 3.3 mtr. To a depth of approx. 3.8 mtr. From the top level of foundation, including excavation of pits as required and black filling of the same, transportation of M.S. Rod from site store to location, cutting of M.S. Rod to desired length, preparation of one end as spike if necessary, welding of earth electrode to earth mesh as per drawing. Application of bitumen compound and and covering with bitumen impregnated tape on all welded joints, for the type of soil prevalent at 3.8 tr. Below the foundation (M.S. Rod of above sizes and M.S. Flat as required shall be made available by RVPN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In case electricity is made by RVPN with out charges</strong></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Normal Dry soil</td>
</tr>
<tr>
<td>2</td>
<td><strong>ERECTION OF SUB- STATION STEEL STRUCTURES</strong> columns, Beams, Lighting Masts and equipment structures (excluding circuit breaker and capacitor bank) of all types including transportation of structure members, nut and bolts, washer etc. from site store to location, their assembly, placing on foundation, fixing of templates with foundation bolts as requirement, leveling and preparing for grouting as required but excluding grouting, erection after grouting and tightening and punching of nuts and bolts ( Max height of structure up to 20.0 Mtr.)</td>
</tr>
<tr>
<td>3(A)</td>
<td>Stringing of <strong>132 kV/ 33 kV Bus Bars</strong> of ACSR conductor including transportation of conductors, disc insulators and tension hardware from site store to location laying and cutting required length of conductor cleaning and assembly of disc insulator as required along with fitting of bolted type or compression tension hardware as made available (compression machine shall be provided by RVPN on rent free basis) making up at one end, stringing of conductor between the beams with specified sag and tension also equalizing sag and fitting the spacers T Clamp for twin conductor for three phase of conductor in each bus section.</td>
</tr>
<tr>
<td>i)</td>
<td>Single ACSR Panther</td>
</tr>
<tr>
<td>ii)</td>
<td>Single ACSR Zebra</td>
</tr>
</tbody>
</table>
**Jumpers of ACSR conductor** (3 Nos. Y – Type) between bus to equipment or between equipment to equipment, bus to bus including transportation of conductor, disc insulators and hardware from site store to location, cleaning and assembly of disc insulator as required along with fitting on suspension hardware and erection as required, cutting required length of conductor making connection, fixing of spacers and spacer T Clamps as required, tightening of clamps/connector, dressing etc for three phases.

| i) Single ACSR Panther | Nos. 90 |
| ii) Single ACSR Zebra  | Nos. 60 |

**4 Stringing of Earth Wire** of size 7/3.15 mm. or 7/4.0 mm. including of transportation of earth wire tension hardware etc from site store to location, lying and cutting required length of earth wire, fitting of bolted type or compression type hardware as available (Compression machine shall be provided by RVPNL on rent free basis) making up at one end stringing of earth wire between structures peak with specified sag and tension, jumpering and connecting earth bond for single earth wire.

| Nos. 45 |

**5 ERECTION OF SUBSTATION EQUIPMENTS:**

(A) Erection of 33/0.400 kV, Station Transformer on ExsistingMesonaryPlateform including transporation of Transformer & accessories from site store to location, erection of Horn- Gap fuse set, Jumpering from Isolator to Horn- Gap to Transformer.

| Nos. 1 |

(B) Erection of **Current Transformers/ Potential Transformer/ CVT/ SR/ RVT Neutral CT** with clamps and connectors, on already erected steel structures including transportation from site store to location, fabrication of base frame, fixing of terminal connectors, tightening of nuts and bolts complete in all respect.

| i) 132 kV CT/ CVT | Nos. 15 |
| ii) 33 kV CT/PT    | Nos. 24 |

(C) Erection of **Lightening Arrestor** on already erected steel structures including transportation of lightening arrestor, clamp and connectors, surge counter etc. from site store to location, fabrication of base frame, fixing of terminal connectors, surge counter, tightening of nuts and bolts etc. complete in all respect.

| i) 132 kV         | Nos. 6  |
| ii) 33 kV         | Nos. 18 |
**(D)** Erection of **Isolator** on already erected steel structure including transportation of base frame PI’s, Mechanism box, clamps and connectors etc from site store to location, minor fabrication and fixing of terminal connectors etc adjustment/alignment of isolator and fixing of earth blade if provided for their smooth operation and adjustment if required after jumpering.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii) a- 132 kV without EB</td>
<td>Nos. 8</td>
</tr>
<tr>
<td>ii) b- 132 kV with EB</td>
<td>Nos. 1</td>
</tr>
<tr>
<td>iii) a- 33 kV without EB</td>
<td>Nos. 17</td>
</tr>
<tr>
<td>iii) b- 33 kV with EB</td>
<td>Nos. 5</td>
</tr>
</tbody>
</table>

**(E)** Erection of **Wave Traps** on already erected structures, beams, including transportation of wave traps, disc insulators, hardware, clamps and connectors etc. from site store to locations, cleaning and assembly of disc insulators alongwith fitting of suspension arrangement and erection and fixing of terminal connectors etc.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii) 132 kV</td>
<td>Nos. 2</td>
</tr>
</tbody>
</table>

**(G)** Erection of 132 kV **Circuit Breaker**, including transportation of equipment, structure members, nuts and bolts, clamps and connectors, accessories etc. from site store to location, assembly of support structure, their placving on foundation, levelling and preparing for grouting as required, but excluding grouting, assembly/placing of support columns/ poles, mechanism box/ control cubicle, and other accessories as per manufactures drawings, fitting of Sfspipelen as required, electrical wiring from pole to cubicle, fixing of terminal connectors as required, but excluding commissioning of CB, for all types of operating mechanism, as required

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii) 132 kV CB</td>
<td>Nos. 3</td>
</tr>
</tbody>
</table>

**(H)** Erection of 33 or 11 kV **Circuit Breaker**, including transportation of equipment, structure members, nuts and bolts, clamps and connectors, accessories etc. from site store to location, assembly of support structure, their placing on foundation, levelling and preparing for grouting as required, but excluding grouting, assembly/placing of support columns/ poles, mechanism box/ control cubicle, and other accessories as per manufacturer drawings, fitting of terminal connectors as required, but excluding commissioning of CB.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 33 or 11 kV CB (outdoor Type) VCB/ SF6</td>
<td>Nos. 7</td>
</tr>
</tbody>
</table>

**(I)** Erection of **Post Insulators** on already erected structure including transportation of PI's and nut bolts, clamps and connectors etc from site store to location, fabrication of base frame and assembly if required, fixing of clamps etc.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii) 132 kV</td>
<td>Nos. 0</td>
</tr>
</tbody>
</table>
**Erection of 132 kV Class EHV Transformer** (Tank already placed on foundation with wheels) including transportation of accessories from site store to location, erection of HV, IV, LV & Neutral Bushings, main & OLTC conservators, Radiators, Equalising Pipeline, Marshalling kiosks etc as per manufacturers drawing, preparation of oil, oil filling, de-hydration of transformer (Filter Machine, Oil tank & Operating staff shall be provided by RVPN), electrical wiring from individual equipments e.g. Buchholz Relay, MOLG, OSR etc to Marshalling Kiosk, etc but excluding Testing and Commissioning of Transformer.

a) Electricity is arranged by RVPN

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(J)</td>
<td>Erection of 132 kV Class <strong>EHV Transformer</strong> (Tank already placed on foundation with wheels) including transportation of accessories from site store to location, erection of HV, IV, LV &amp; Neutral Bushings, main &amp; OLTC conservators, Radiators, Equalising Pipeline, Marshalling kiosks etc as per manufacturers drawing, preparation of oil, oil filling, de-hydration of transformer (Filter Machine, Oil tank &amp; Operating staff shall be provided by RVPN), electrical wiring from individual equipments e.g. Buchholz Relay, MOLG, OSR etc to Marshalling Kiosk, etc but excluding Testing and Commissioning of Transformer.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Nos.</td>
<td>9</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Transformer Received Oil Filled</td>
<td>Nos. 1</td>
</tr>
</tbody>
</table>

**6** Erection of **C & R Panels** complete in all respect including transportation from site store to control room, placing on foundation/ cable trench as per layout, interconnection between C & R panels and with existing panels, fixing of side/ top covers and doors, earthing to existing earth strip in control room, connection of bus wiring to existing panels and between control and relay panels as required.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Duplex Panels</td>
<td>Nos. 3</td>
</tr>
<tr>
<td>ii) Simplex Panels, RTCC, DC Panel</td>
<td>Nos. 7</td>
</tr>
<tr>
<td>iii) LT Panel</td>
<td>Nos. 1</td>
</tr>
</tbody>
</table>

**7** Erection of **Marshalling Kiosks**/ LMU/ line matching and distribution unit (LMDC) complete in all respect including transportation from site store to location, placing on foundation/ cable trench as per layout/ preparing for grouting of foundation bolts but excluding grouting etc.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 132 kV Marshalling Kiosk</td>
<td>Nos. 3</td>
</tr>
<tr>
<td>ii) 33 kV Marshalling Kiosks</td>
<td>Nos. 4</td>
</tr>
</tbody>
</table>

**8** Erection of **Battery Charger** complete in all respect including transportation from site store to location, placing on foundation/ cable trench as per layout etc.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 220 V DC, 400 AH</td>
<td>Nos. 1</td>
</tr>
</tbody>
</table>

**9** Battery Set:

<table>
<thead>
<tr>
<th>B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly, Erection &amp; Commissioning of Maintenance Free VRLA <strong>Battery Set</strong> including Transportation of Cells, battery stand, nuts and bolts etc from site store to Battery Room, Assembly of stand, placing the cells on stand, making their interconnection, initial charging, Discharging and Final Charging as per procedure recommended by Battery Manufacturer.</td>
<td></td>
</tr>
<tr>
<td>a) Electricity is arranged by RVPN</td>
<td></td>
</tr>
</tbody>
</table>
10(A)- (i) **Laying of P.V.C. Insulated unarmored/ armored control cables** of 1.1 kV grade with copper conductor in cable trench as per specification as required, including transportation of cable drum from site store to location, laying in cable trenches, placing in the cable racks/ cable trays/ cable batten and dressing, including removing and fixing of trench covers as required, making necessary connections, testing, cable marking on both the termination ends, etc as required for all sizes from 2 X 2.5 mm² to 20 X 2.5 mm² and 4 X 4 mm² and 4 X 6 mm²

<table>
<thead>
<tr>
<th>Mtr.</th>
<th>12500</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Unarmored control cables</td>
<td>Mtr. 12500</td>
</tr>
</tbody>
</table>

(ii) **Fixing of Control Cables** in position with single compression nickel plated brass cable glands confirming to IS: 12943 and having three metal washers and rubber ring, including preparation of cable and drilling of corresponding holes in gland plates, etc as required and including cost of cable glands for each cable gland of size:

<table>
<thead>
<tr>
<th>Mtr.</th>
<th>12500</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 19 mm Cable gland</td>
<td>Nos. 150</td>
</tr>
<tr>
<td>b) 25 mm Cable gland</td>
<td>Nos. 200</td>
</tr>
<tr>
<td>c) 32 mm Cable gland</td>
<td>Nos. 60</td>
</tr>
</tbody>
</table>

(iii) **Termination of wires of Cables** with copper terminal lugs (Pin or ring type of Dowells or equivalent make as approved by Engineer - In - Charge) duly crimped by crimping tools, including wire ends ready for crimping, ferruling and dressing of wires, etc as required, including cost of terminals ends for all wires, for each cable at both ends for cables of following sizes:

<table>
<thead>
<tr>
<th>Mtr.</th>
<th>12500</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 2 X 2.5 mm²</td>
<td>Each 0</td>
</tr>
<tr>
<td>b) 3 x 2.5 mm²</td>
<td>Each 75</td>
</tr>
<tr>
<td>c) 4 x 2.5 mm²</td>
<td>Each 75</td>
</tr>
<tr>
<td>d) 6 x 2.5 mm²</td>
<td>Each 50</td>
</tr>
<tr>
<td>e) 12 x 2.5 mm²</td>
<td>Each 50</td>
</tr>
<tr>
<td>h) 18 x 2.5 mm²</td>
<td>Each 30</td>
</tr>
</tbody>
</table>

In case all the wires of any cable are not terminated then a deduction @ 4.00 shall be made for each end of the wire not terminated.

<table>
<thead>
<tr>
<th>Mtr.</th>
<th>12500</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 4 x 4 mm²</td>
<td>Each 100</td>
</tr>
</tbody>
</table>

In case all the wires of any cable are not terminated then a deduction @ 5.00 shall be made for each end of the wire not terminated.

10-(B)- (i) **Laying of P.V.C. insulated unarmored/ armored L.T. cables** of 1.1 kV grade with aluminium conductor as per IS: 1255 in ground / cable trench/ wall/ surface including transportation of cable drums from site store to locations and excavation of 30 cm. X 75 size cable
trenches, providing 25 mm. thick under layer of sand & 2nd class brick covering & refilling earth in remaining portion, fixing as per approved spacing by means of M.S.U. - clamps, etc as per specifications as required including necessary connections & testing etc. as required for following size of cables.

(ii) d) 3 ½ Core 300 MM.²

**Fixing of Power Cable** in position with single compression nickel plated brass cable glands confirming to IS: 12943 and having three metal washers and rubber ring, including preparation of cable and drilling of corresponding holes in gland plates, etc including cost of cable glands if required for each end of cable of size.

(h) 3 ½ Core 300 MM.² without material

(iii)

**Termination of wires of Cables** with aluminium conductor using ISI marked tubular aluminium terminal end as per IS : 8309 duly crimped with crimping tool, including making cable ends ready for crimmping and providing insulation tape with color code dressing of wires etc. including cost of terminal ends if required for each end of cable (4 Nos. per end) for the following size of cables.

(h) 3 ½ Core 300 MM.² without material

---

**TYPICAL BOQ OF EQUIPMENTS/ ITEMS REQUIRED FOR CONVENTIONAL 220 KV AIS SUBSTATIONS (HAVING 4 NOS. 220 KV BAY, 6 NOS. 132 KV BAYS AND 7 NOS. 33 KV BAYS)**

<table>
<thead>
<tr>
<th>S.NO</th>
<th>DESCRIPTION OF MATERIAL</th>
<th>UNIT</th>
<th>QUANTITY REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td><strong>STRUCTURES: ( Including Nuts &amp; Bolts)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Structure type &quot;AT1&quot;</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Structure type &quot;AT4&quot;</td>
<td>Nos.</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Structure type &quot;AT6&quot;</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Structure type &quot;AT8&quot;</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Structure type &quot;AT3&quot;</td>
<td>Nos.</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Beam type &quot;AB1&quot;</td>
<td>Nos.</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>Structure type &quot;BT1&quot;</td>
<td>Nos.</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Structure type &quot;BT4&quot;</td>
<td>Nos.</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Structure type &quot;BT6&quot;</td>
<td>Nos.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Structure type</td>
<td>Nos.</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>&quot;BT7&quot;</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Beam type &quot;BB1&quot;</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Structure type &quot;X&quot;</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Structure type &quot;Y&quot; with stub</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Beam type &quot;GF- 5.4&quot;</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Structure type &quot;33 KV CT&quot;</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Structure type &quot;X-15&quot;</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Structure type &quot;PIS&quot;</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Structure type &quot;AO1&quot;</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Structure type &quot;AO1(T)&quot;</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Structure type &quot;AO3&quot;</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Structure type &quot;AO4&quot;</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Structure type &quot;AO5&quot;</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Structure type &quot;BO1&quot;</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

**B) EQUIPMENTS:**

<table>
<thead>
<tr>
<th></th>
<th>220/132 KV Transformer 100 MVA</th>
<th>Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>245 KV CB ( 220 V DC)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>220 KV CT ( 400-800/1A,5C))</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>198 KV LA</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>220 KV CVT (.5 CLASS)</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>220 KV Isolator with single EB</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>220 KV Isolator without EB</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>220 KV Tendum Isolator</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>220 KV MK</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>132 KV Polycone insulator Stacks</td>
<td>280</td>
</tr>
<tr>
<td>10</td>
<td>132/33 KV transformer20/25 MVA</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>132 KV CT (125-250-500/1A, 3C)</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>132 KV CT ( 250-500/ 1A, 4C)</td>
<td>15</td>
</tr>
<tr>
<td>13</td>
<td>132 KV circuit breaker 220 V DC</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>132 KV LA</td>
<td>15</td>
</tr>
<tr>
<td>15</td>
<td>132 KV Isolator with EB</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>132 KV Isolator without EB</td>
<td>14</td>
</tr>
<tr>
<td>17</td>
<td>132 KV ploycone insulator Stacks</td>
<td>178</td>
</tr>
<tr>
<td>18</td>
<td>132 KV CVT (.5 CLASS)</td>
<td>15</td>
</tr>
<tr>
<td>19</td>
<td>132 KV Marshelling kiosk</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>33 KV circuit Breaker 220 V DC</td>
<td>7</td>
</tr>
<tr>
<td>21</td>
<td>33 KV CT 125-250-500/1A, 2C</td>
<td>18</td>
</tr>
<tr>
<td>22</td>
<td>33 KV CT 250-500/1A, 5C, 0.2 class with clamps suitable for double Zebra conductor</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>33 KV PT</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>33 KV LA</td>
<td>18</td>
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<tr>
<td></td>
<td>Description</td>
<td>Nos.</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>27</td>
<td>33 KV Isolator with EB 800 A</td>
<td>5</td>
</tr>
<tr>
<td>28</td>
<td>33 KV isolator without EB 800 A</td>
<td>17</td>
</tr>
<tr>
<td>29</td>
<td>2 X 24 KV PI's</td>
<td>220</td>
</tr>
<tr>
<td>30</td>
<td>2 X 33 KV MK</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>C) CONTROL PANELS:</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>220 KV feeder C &amp; R Panel (220 V DC) /1 Amp</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>220/ 132 KV, 100 MVA Trf. C &amp; R panel, HV side (220 V DC) /1 Amp</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>220 KV Bus Coupler Panle (220 V DC) /1 Amp</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>220/ 132 KV, 100 MVA transformer C &amp; R panel (220 V DC) - LV side /1Amp</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>132/ 33 KV, 20/25 MVA transformer C &amp; R panel (220 V DC) - HV side</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>132 KV feeder C &amp; R Panel 220 V DC</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>132 KV Bus coupler panel 220 V DC</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>33 KV Incomer + Bus coupler Panel (220 V DC)</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>2 X 33 KV feeder Panel (220 V DC)</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>LT Panel 800 AT</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>DC Panel 220 V DC</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>220 V DC Battery Set(400 AH)</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>220 V DC Battery Charger (400 AH)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>D) HARDWARE:</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Single Tension hardware for double Zebra</td>
<td>SET  80</td>
</tr>
<tr>
<td>2</td>
<td>Single Tension hardware for Zebra</td>
<td>SET  60</td>
</tr>
<tr>
<td>3</td>
<td>Single Tension hardware for Panther</td>
<td>SET  33</td>
</tr>
<tr>
<td>4</td>
<td>Single Suspension hardware for double Zebra</td>
<td>SET  20</td>
</tr>
<tr>
<td>5</td>
<td>Single suspension hardware for Zebra</td>
<td>SET  33</td>
</tr>
<tr>
<td>6</td>
<td>Single Suspension hardware for Panther</td>
<td>SET  33</td>
</tr>
<tr>
<td>7</td>
<td>Spacer T clamp ZZ-Z</td>
<td>Nos. 70</td>
</tr>
<tr>
<td>8</td>
<td>T - clamp Z-Z</td>
<td>Nos. 123</td>
</tr>
<tr>
<td>9</td>
<td>T - clamp Z-P</td>
<td>Nos. 40</td>
</tr>
<tr>
<td>10</td>
<td>T - clamp P-P</td>
<td>Nos. 80</td>
</tr>
<tr>
<td>11</td>
<td>PG.-clamp Z-Z</td>
<td>Nos. 250</td>
</tr>
<tr>
<td>12</td>
<td>PG.-clamp Z-P</td>
<td>Nos. 60</td>
</tr>
<tr>
<td>13</td>
<td>PG.-clamp P-P</td>
<td>Nos. 220</td>
</tr>
<tr>
<td>14</td>
<td>ACSR conductor Zebra</td>
<td>KM.  4</td>
</tr>
<tr>
<td>15</td>
<td>ACSR conductor Panther</td>
<td>KM.  1</td>
</tr>
<tr>
<td>16</td>
<td>Earthwire 7/4 mm</td>
<td>KM.  1.5</td>
</tr>
<tr>
<td>17</td>
<td>PL Clamp for Z</td>
<td>Nos. 40</td>
</tr>
<tr>
<td>18</td>
<td>PL clamp for P</td>
<td>Nos. 25</td>
</tr>
<tr>
<td>19</td>
<td>Disc Insulator 120 KN</td>
<td>Nos. 1584</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>20</td>
<td>Disc Insulator 70 KN</td>
<td>736</td>
</tr>
<tr>
<td>21</td>
<td>PG Clamp for Earth wire 7/4 mm</td>
<td>500</td>
</tr>
<tr>
<td>22</td>
<td>Earthwire Tension Clamp for 7/4 mm</td>
<td>150</td>
</tr>
</tbody>
</table>

**E) CONTROL CABLES:**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control cables 18 X 2.5 mm²</td>
<td>7</td>
<td>KM.</td>
</tr>
<tr>
<td>2</td>
<td>Control cables 12 X 2.5 mm²</td>
<td>6</td>
<td>KM.</td>
</tr>
<tr>
<td>3</td>
<td>Control cables 6 X 2.5 mm²</td>
<td>2.5</td>
<td>KM.</td>
</tr>
<tr>
<td>4</td>
<td>Control cables 4 X 4 mm²</td>
<td>6</td>
<td>KM.</td>
</tr>
<tr>
<td>5</td>
<td>Control cables 4 X 2.5 mm²</td>
<td>4</td>
<td>KM.</td>
</tr>
<tr>
<td>6</td>
<td>Control cables 3 X 2.5 mm²</td>
<td>4</td>
<td>KM.</td>
</tr>
<tr>
<td>7</td>
<td>Control cables 2 X 2.5 mm²</td>
<td>1</td>
<td>KM.</td>
</tr>
<tr>
<td>8</td>
<td>Control cables 4 X 6 mm²</td>
<td>4</td>
<td>KM.</td>
</tr>
<tr>
<td>9</td>
<td>LT Power cable 3.5 C X 300 mm²</td>
<td>0.2</td>
<td>KM.</td>
</tr>
</tbody>
</table>

**F) EARTHING MATERIAL:**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MS Rod 40 mm.</td>
<td>60</td>
<td>MT.</td>
</tr>
<tr>
<td>2</td>
<td>MS Flat 75 X 12 mm.</td>
<td>75</td>
<td>MT.</td>
</tr>
<tr>
<td>3</td>
<td>MS Flat 50 X 6 mm.</td>
<td>8</td>
<td>MT.</td>
</tr>
<tr>
<td>4</td>
<td>MS Channel 100 X 50 X 6 mm</td>
<td>5</td>
<td>MT.</td>
</tr>
<tr>
<td>5</td>
<td>Earth bond</td>
<td>200</td>
<td>Nos.</td>
</tr>
</tbody>
</table>

**G) PLCC ITEMS:**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wave Traps (0.5 mH) /2000A</td>
<td>8</td>
<td>Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Wave Traps (0.2 mH)/1250A</td>
<td>8</td>
<td>Nos.</td>
</tr>
<tr>
<td>3</td>
<td>Single channel PLCC carrier set suitable for speech and data for phase to phase coupling: Including Protection Coupler (40W with PC)</td>
<td>SET 4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Single channel PLCC carrier set suitable for speech and data for phase to phase coupling: Without Protection Coupler (40W W/O PC)</td>
<td>SET 4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Element protection device including LMU &amp; LMDU for phase to phase coupling</td>
<td>SET 8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Co- Axial Cable (75 Ohms)</td>
<td>2.0</td>
<td>Km.</td>
</tr>
<tr>
<td>7</td>
<td>48 V Battery Set: 360 AH maintenance free</td>
<td>1</td>
<td>Nos.</td>
</tr>
<tr>
<td>8</td>
<td>48 V SMPS Battery Charger Float &amp; Boost (50 A)</td>
<td>1</td>
<td>Nos.</td>
</tr>
<tr>
<td>9</td>
<td>Telephone Instrument</td>
<td>12</td>
<td>Nos.</td>
</tr>
<tr>
<td>10</td>
<td>Unarmoured telephone cable (5 Pair)</td>
<td>1.0</td>
<td>Km.</td>
</tr>
<tr>
<td>11</td>
<td>Unarmoured telephone cable (1 Pair)</td>
<td>1.0</td>
<td>Km.</td>
</tr>
<tr>
<td>Code No.</td>
<td>Description</td>
<td>Unit</td>
<td>Quantity</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>1.A</td>
<td>Laying of earth mesh with 28mm dia M.S. Rod at a depth of 0.80 mtr. From top level of foundations, including excavation of trench of required depth and backfilling of the same, transportation of M.S. Rods from site store to locations, welding of M.S. Rod along the length at crossings and with earth electrodes as per drawing, application of bitumen compound and covering with bitumen impregnated tape on all welded joints, for the type of soil prevalent at 0.80 meter below top level of foundations (M.S. Rod of above sizes &amp; M.S. Flat as required shall be made available by RVPN) (a) In case electricity is made available by RVPN without charges.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I) Normal dry soil Meters 6000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>II) Hard Soil/Murrram/Black cotton soil</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1.B</td>
<td>Laying of earthing risers of 50x12mm size M.S. Flat at a depth of 0.80 meter from top level of foundations, including excavation of trench of required depth and backfilling of the same, transportation of M.S. Flat from site store to locations, preparation of risers, bending as per requirement (after heating if necessary), fixing on and welding/bolting to equipment/structure and peaks of structures, laying in the trench, welding to the earth mesh of M.S. Rod as per drawing, including welding of extra length of M.S. Flat if required, application of bitumen compound and covering with bitumen impregnated tape on all welded joints, painting of all surfaces of risers above ground level with red oxide and green paint, for the type of soil prevalent at 0.80 meter below top level of foundations (M.S. Rod of above sizes &amp; M.S. Flat as required shall be made available by RVPN).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(a) In case electricity is made available by RVPN without charges

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Measurement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>I) Normal Dry soil</td>
<td></td>
<td>9000</td>
</tr>
<tr>
<td>II) Hard Soil/Murrum/Black cotton soil</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

1.C Placing/Driving of **earth electrode** of 28mm dia M.S. Rod of length 3.30 meters (approx.) to a depth of 3.80 meters from the top level of foundations, including excavation of pits as required and back filling of the same, transportation of M.S. Rod from the store to locations, cutting of M.S. Rod to desired length, preparation of one end as spike if necessary) Welding of earth electrode to earth mesh of M.S. Rod as per drawing application of bitumen compound and covering with bitumen impregnated tape on all welded joints, for the type of soil prevalent at 3.80 meters below top level of foundations (M.S. Rod of above sizes & M.S. Flat as required shall be made available by RVPN).

2.0 Erection of sub station steel structure columns, beams, lighting mast and equipment structure (excluding circuit breakers and capacitor banks) of all types including transportation of structure members, nuts and bolts, washers etc. from the site store to locations, their assembly, placing on foundation, fixing of template, with foundation bolts as required, leveling and preparing for grouting as required but excluding grouting, erection, after grouting and tightening & punching of nuts & bolts. (Maximum height of structures up to 20 meters)

3 BUS BAR WORK

A Stringing of 220KV, 132KV, 33 KV bus bar of ACSR conductor including transportation of conductor, disc insulators and tension hardware from site store to locations, laying and cutting required length of conductor, cleaning and assembly of disc insulators as required along with fitting of bolted type or compression type tension H/W as made available (compression machine shall be provided by RVPN on rent free basis), making up at one end, stringing of conductors between the beams with specified sag and tension, also equalising sag and fitting spacers spacer T-clamps for twin conductors, for three phases of conductor in each Bus section.

<table>
<thead>
<tr>
<th>Type</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Single ACSR Panther</td>
<td>4</td>
</tr>
<tr>
<td>2) Single ACSR Zebra</td>
<td>13</td>
</tr>
<tr>
<td>3) Double ACSR Zebra</td>
<td>10</td>
</tr>
</tbody>
</table>
### B JUMPERS of ACSR conductor (3 nos. Y type)

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>between bus to equipment or between equipment to equipment or between bus to bus, including transportation of conductor, disc insulators and hardware from site stores to locations, cleaning and assembly of disc insulators as required along with fitting of suspension hardware and erection as required, cutting required length of conductor, making connections, fixing of spacers &amp; spacer T-clamps as required, tightening of clamps/ connectors, dressing etc. for three phases</td>
<td>Set 500</td>
</tr>
</tbody>
</table>

#### 1) Single ACSR Zebra/ Panther conductor

- **Set 500**

#### 2) Double ACSR Zebra conductor

- **Set**
- **Each 100**

### 4 STRINGING of earth wire (size 7/3.15 mm or 7/4.00 mm)

- Including transportation of earth wire, tension hardwares etc. from site store to locations, laying and cutting required length of earth-wire, fitting of bolted type or compression type hardware as made available (compression machine shall be provided by RVPN on rent free basis), making up at one end, stringing of earthwire between structure peaks with specified sag and tension, jumpering and connecting earth bonds, for single earth wire.

- **Each 100**

### 5 ERECTION OF SUB-STATION EQUIPMENTS

#### (A) Erection of 33/0.400 kV, Station Transformer on existing masonry platform including transportation of transformer & accessories from site store to location, erection of Horn-Gap Fuse set, jumpering from Isolator to Horn-Gap to transformer.

- **Nos. 1**

#### (B) Erection of Current transformer / Capacitive voltage transformer / Potential Transformer/Series Eactors/Residual Voltage Transformer/Neutral Current Transformer with clamps & connectors on already erected steel structure including transportation from site store to locations, fabrication of base frame, fixing of terminal connectors, tightening of nuts & bolts etc. complete in all respects.

- **1) 220 KV**
- **Nos. 24**
- **2) 132 KV**
- **Nos. 33**
- **3) 33 KV**
- **Nos. 24**

#### (C) Erection of Lightning Arrestor on already erected steel structure including transportation of Lightning Arrestor, clamps & connectors, surge counter etc. from site store to locations, fabrication of base frame, fixing of terminal connectors, surge counter, tightening of nuts & bolts etc., complete in all respect.

- **1) 220 KV**
- **Nos. 9**
- **2) 132 KV**
- **Nos. 18**
3) 33 KV  
(D) Erection of **Isolators** on already erected steel structure including transportation of base frame, P.I.’s contacts, mechanism box, clamps & connectors etc. from the site store to locations, minor fabrication as required and fixing of terminal connectors etc. adjustment/alignment of isolator and its earth blade, if provided for their smooth operation and final adjustment if required after jumpering.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) <strong>220 KV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Without Earth Blade</td>
<td>Nos.</td>
<td>14</td>
</tr>
<tr>
<td>b) With Single Earth Blade</td>
<td>Nos.</td>
<td>2</td>
</tr>
<tr>
<td>c) Tandem</td>
<td>Nos.</td>
<td>4</td>
</tr>
<tr>
<td>2) <strong>132 KV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Without earth blade</td>
<td>Nos.</td>
<td>18</td>
</tr>
<tr>
<td>b) With earth blade</td>
<td>Nos.</td>
<td>4</td>
</tr>
<tr>
<td>3) <strong>33 KV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Without earth blade</td>
<td>Nos.</td>
<td>17</td>
</tr>
<tr>
<td>b) With earth blade</td>
<td>Nos.</td>
<td>5</td>
</tr>
</tbody>
</table>

(E) Erection of **Wave trap** on already erected structure beam, including transportation of wave trap, disc insulators, hardware, clamps, and connectors, etc. from site store to locations, cleaning & assembly of disc insulators along with fitting of suspension arrangement and erection, fixing of terminal connectors etc.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) <strong>220 KV</strong></td>
<td>Nos.</td>
<td>4</td>
</tr>
<tr>
<td>2) <strong>132 KV</strong></td>
<td>Nos.</td>
<td>8</td>
</tr>
</tbody>
</table>

(G) Erection of **220 KV or 132 KV Circuit Breaker**, including transportation of equipment, structure members, nuts and bolts, clamps and connectors, accessories etc. from site store to location, assembly of support structure, their placing on foundation, levelling and preparing for grouting as required, but excluding grouting, assembly/placing of support columns/ poles, mechanism box/ control cubicle, and other accessories as per manufactures drawings, fitting of Sf 6 gas pipeline as required, electrical wiring from pole to cubicle, fixing of terminal connectors as required, but excluding commissioning of CB, for all types of operating mechanism, as required.

<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) <strong>220 KV</strong></td>
<td>Nos.</td>
<td>4</td>
</tr>
<tr>
<td>2) <strong>132 KV</strong></td>
<td>Nos.</td>
<td>7</td>
</tr>
</tbody>
</table>

(H) Erection of **33 KV or 11 KV Circuit Breaker**, including transportation of equipment, structure members, nuts and bolts, clamps and connectors, accessories etc. from site store to location, assembly of support structure, their placing on foundation, levelling...
and preparing for grouting as required, but excluding grouting, assembly/placing of support columns/ poles, mechanism box. Etc. on support structure/control cubicle, and other accessories as per manufactures drawings, fitting of terminal connectors as required, but excluding commissioning of CB.

1) 33 or 11 KV CB(outdoor type) VCB/SF6. Nos. 7

(I) Erection of Post Insulator on already erected structures including transportation of PI’s nuts & bolts, clamps & connectors etc. from site store to locations, fabrication of base frame & assembly if required, fixing of clamps, etc.

1) 220 KV Nos. 36
2) 132 KV Nos. 21
3) 33 KV Nos. 12

(J) Erection of 132 kV Class **EHV Transformer** (Gas filled Tank already placed on foundation with wheels) including transportation of accessories from site store to location, erection of HV, IV, LV & Neutral Bushings, main & OLTC conservators, Radiators, Equalising Pipeline, Marshelling kiosks etc as per manufacturers drawing, preparation of oil, oil filling, de-hydration of transformer (Filter Machine, Oil tank & Operating staff shall be provided by RVPN), electrical wiring from individual equipments e.g. Buchholz Relay, MOLG, OSR etc. to Marshelling Kiosk, etc but excluding Testing and Commissioning of Transformer.

a) Electricity is arranged by RVPN

i) Transformer received oil filled Nos. 1

(K) Erection of 220 kV Class **EHV Transformer** (Gas filled Tank already placed on foundation with wheels) including transportation of accessories from site store to location, erection of HV, IV, LV & Neutral Bushings, main & OLTC conservators, Radiators, Equalising Pipeline, Marshelling kiosks etc as per manufacturers drawing, preparation of oil, oil filling, de-hydration of transformer (Filter Machine, Oil tank & Operating staff shall be provided by RVPN), electrical wiring from individual equipments e.g. Buchholz Relay, MOLG, OSR etc. to Marshelling Kiosk, etc but excluding Testing and Commissioning of Transformer.

a) If electricity is available & arranged by RVPN without charges. Nos. 1

6 Erection of Control & Relay Panels complete in all respects including transportation from site store to control room, placing on foundation/ cable trench as
per layout, interconnection between Control & Relay panels and with existing panels, fixing of side/ top covers and doors, earthing to existing earth strip in control room, connection of bus wiring to existing panel and between control and relay as required.

1) 2X2 Duplex Panel

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<thead>
<tr>
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<th>Nos. 0</th>
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2) Duplex Panel

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<th></th>
<th></th>
<th>Nos. 11</th>
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</table>

3) Simplex Panel, DC Panel, RTCC Panel, PLCC Panel etc.

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<tr>
<th></th>
<th></th>
<th>Nos. 9</th>
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4) LT Panel

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<tr>
<th></th>
<th></th>
<th>Nos. 1</th>
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</thead>
</table>

7 Erection of marshalling kiosk/ line matching unit (LMU)/ line matching & distribution unit (LMDU) complete in all respect including transportation from site store to location, placing on foundation/cable trench as per layout, preparing for grouting on foundation bolts but excluding grouting etc.

<table>
<thead>
<tr>
<th></th>
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<th>Nos. 10</th>
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</table>

1) 220 KV or 132 KV Marshalling box

<table>
<thead>
<tr>
<th></th>
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<th>Nos. 8</th>
</tr>
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</table>

2) 33 KV Marshalling Kiosk

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<tr>
<th></th>
<th></th>
<th>Nos. 2</th>
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</table>

8 BATTERY CHARGER

Erection of Battery Charger complete in all respects including transportation from site store to location, placing on foundation / cable trench as per layout etc.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Nos. 2</th>
</tr>
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</table>

i) 220 V Volt DC,400 AH

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<tr>
<th></th>
<th></th>
<th>Nos. 1</th>
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</thead>
</table>

ii) 48V Volt DC 600/400/200 AH

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<tr>
<th></th>
<th></th>
<th>Nos. 1</th>
</tr>
</thead>
</table>

9 BATTERY SET

Assembly, erection & commissioning of maintenance free VRLA type Battery set including transportation of cells, batterystand, placing the cells on stand, making their interconnections, initialcharging, discharging & final charging as per procedure recommended by the battery manufacturer.

(a) If electricity is made available by RVPN without charges.

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<tr>
<th></th>
<th></th>
<th>Nos. 2</th>
</tr>
</thead>
</table>

i) 220 V Volt DC,400 AH

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<tr>
<th></th>
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<th>Nos. 1</th>
</tr>
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</table>

ii) 48V Volt DC 600/400/200 AH

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Nos. 1</th>
</tr>
</thead>
</table>

10 (A) LAYING AND TERMINATION OF CABLES.

Control cables

i)Laying of PVC insulated unarmoured/ armoured control cables of 1.1 KV grade with copper conductor in cable trenches as per specification as required, including transportation of cable drums from site store to locations, laying in cable trenches, cutting to required length, placing them on cable racks/ cable trays/ cable batten and dressing, including removing and re-fixing trench covers as required, making necessary connections testing, cable marking on both terminating ends, etc. as required for all size from 2c X 2.5 sq.mm to 20c X 2.5 sq mm , 4cX 4 or 6 sq mm

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<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Description</td>
<td>Units</td>
<td>Quantity</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>1) Unarmoured control cable</td>
<td>meters</td>
<td>34500</td>
</tr>
<tr>
<td>ii) Fixing of control cables in position with single compression nickel plated brass cable glands confirming to IS:12943 &amp; having three metal washers and one rubber ring, including preparation of cable and drilling of corresponding holes in gland plates, etc. as required and including cost of cable glands, for each cable gland of size.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 19 mm unarmoured control cable</td>
<td>Nos.</td>
<td>400</td>
</tr>
<tr>
<td>2) 25 mm unarmoured control cable</td>
<td>Nos.</td>
<td>600</td>
</tr>
<tr>
<td>3) 32 mm unarmoured control cable</td>
<td>Nos.</td>
<td>500</td>
</tr>
<tr>
<td>Termination of wires of cables with copper conductor using copper terminal ends (pin or ring type as required of Dowell’s or equivalent make as approved by Engineer-in-Charge) duly crimped with crimping tool, including making wire ends ready for crimping, ferruling &amp; dressing of wires etc., as required, including cost of terminal ends for all wires for each cable at both ends for cable for the following size.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 2CX2.5 sq.mm.</td>
<td>Nos.</td>
<td>40</td>
</tr>
<tr>
<td>2) 3CX2.5 sq.mm.</td>
<td>Nos.</td>
<td>100</td>
</tr>
<tr>
<td>3) 4CX2.5 sq.mm.</td>
<td>Nos.</td>
<td>100</td>
</tr>
<tr>
<td>4) 6CX2.5 sq.mm.</td>
<td>Nos.</td>
<td>100</td>
</tr>
<tr>
<td>5) 10CX2.5 sq.mm</td>
<td>Nos.</td>
<td>0</td>
</tr>
<tr>
<td>6) 12CX2.5 sq.mm</td>
<td>Nos.</td>
<td>200</td>
</tr>
<tr>
<td>7) 16CX2.5 sq.mm</td>
<td>Nos.</td>
<td>0</td>
</tr>
<tr>
<td>8) 18CX2.5 sq.mm</td>
<td>Nos.</td>
<td>50</td>
</tr>
<tr>
<td>In case all the wires of any cable are not got terminated then a deduction at the rate of Rs. 4.00 shall be made for each end of the wire not terminated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) 4CX4.0 sq.mm.</td>
<td>Nos.</td>
<td>200</td>
</tr>
<tr>
<td>In case all the wires of any cable are not got terminated then a deduction at the rate of Rs. 5.00 shall be made for each end of the wire not terminated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>10 (B) LAYING of P.V.C. insulated unarmoured / armoured L.T. CABLES.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Laying of p.v.c. insulated unarmoured / armoured L.T. cables 1.1 KV grade with aluminium conductor as per IS:1255 in ground / cable trench / wall / surface including transportation of cable drums from site store to location and excavation of 30cm x 75cm size cable trench, providing 25 mm thick under layer of sand &amp; 2nd class bricks covering &amp; refilling earth in remaining portion, fixing as per approved / available spacing by means of M.S.U. – Clamps etc., as per specifications as required including necessary connections &amp; testing etc. as required for following size of cables:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 3 ½ Core 300 mm2</td>
<td>Mtr.</td>
<td>200</td>
</tr>
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<td></td>
<td></td>
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<td>---</td>
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</tr>
<tr>
<td>(ii)</td>
<td>Fixing of power cable in position with single compression nickel plated brass cable glands confirming to IS:12943 and having three metal washers and rubber ring, including preparation of cable and drilling of corresponding holes in gland plates, including cost of cable glands if required for each end of cable size.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) 3 ½ Core 300 mm² without material</td>
<td>Nos.</td>
</tr>
<tr>
<td>(iii)</td>
<td>Termination of wires of cables with aluminium conductor using ISI marked tubular aluminium terminal end as per IS: 8309 duly crimped with crimping tool, including making cable ends ready for crimping and providing insulation tape with color code dressing of wires etc. including cost of terminal ends if required for each end of cable (4 Nos. per end ) for following size of cables.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) 3 ½ Core 300 mm² without material</td>
<td>set.</td>
</tr>
</tbody>
</table>
TYPICAL SINGLE BUS BAR ARRANGEMENT
TYPICAL MAIN AND AUXILIARY BUS BAR ARRANGEMENT
TYPICAL DOUBLE BUS BAR ARRANGEMENT
TYPICAL DOUBLE MAIN AND AUXILIARY BUS BAR ARRANGEMENT
ANNEXURE-8
SECTIONAL VIEW OF 400 KV BUS BAR
BIBLIOGRAPHY

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