SECTION -PROJECT

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1.0 **GENERAL**

1.1 **PREMBLE**

Power Grid Corporation of India Ltd. (POWERGRID), a Govt. of India Enterprise is responsible for bulk Power transmission of electrical energy from various Central Govt. Power Projects to various utilities/beneficiaries and interconnecting regional grids, operating and maintaining the National electrical grid of India. It is established with mandate of "We will become a Global Transmission Company with Dominant Leadership in Emerging Power Markets with World Class Capabilities by:

- World Class: Setting superior standards in capital project management and operations for the industry and ourselves.
- Global: Leveraging capabilities to consistently generate maximum value for all stakeholders in India and in emerging and growing economies.
- Inspiring, nurturing and empowering the next generation of professionals.
- Achieving continuous improvements through innovation and state of the art technology.
- Committing to highest standards in health, safety, security and environment." as its mission.

1.2 Govt. of India (MoP) has identified the execution of "Transmission system for evacuation of power from Rajasthan REZ Ph-IV (Part-1: Bikaner Complex)-Part-A" through Tariff Based Competitive Bidding (TBCB) route for which POWERGRID is intending to participate in the bidding process. Further, POWERGRID is intending to arrange for pre-bid tie-up for the scope envisaged.

1.3 Following Transmission System is envisaged under "Transmission system for evacuation of power from Rajasthan REZ Ph-IV (Part-1: Bikaner Complex)-Part-A" through TBCB route:

A. Transmission lines:

i) LILO of both ckts of 400kV Bikaner (PG) - Bikaner-II D/c Line (Quad) at Bikaner-III PS
ii) Bikaner-II PS - Bikaner-III PS 400kV D/c Line (Quad).
iii) Bikaner-III-Neemrana-II 765kV D/c Line.

B. Substations:

i) Establishment of 6x1500 MVA, 765/400 kV & 5x500 MVA 400/220 kV Bikaner-III Pooling Station (including 400kV, 2x125MVAR, reactor at Bikaner-III)
ii) Extension of 765kV Neemrana-II S/s for termination of 765 kV D/c line Neemrana-II – Bikaner-III TL.
iii) Extension of 400kV Bikaner-II Substation for termination of 400kV Bikaner-II-Bikaner-III TL

This Specification covers Establishment of 6x1500 MVA, 765/400 kV & 5x500 MVA 400/220 kV Bikaner-III Pooling Station along with associated 400kV 125MVAR reactors, Extn of Neemrana & Extn of Bikaner-II substation only. 765/400/33kV & 400/220/33kV Auto Transformers at Bikaner-III (new) PS and 765/√3kV Shunt Reactors at Bikaner-III (New) PS & Neemrana-II S/s are being executed through separate package(s).

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2.0 SCOPE

2.1 The broad scope for the substations is as following :

S. No.	Scope
1.	**765/400/220 kV Bikaner-III (New) PS** **765kV:** • ICTs: 19x500MVA, (765/√3)/(400/√3)/33 kV, 1-phase transformers (1 no. as spare unit) along with its auxiliaries • Bus reactor: 7X110 MVAR, 765/√3kV, 1-phase reactors (1 no. as spare unit) along with its auxiliaries • Switchable Line reactors: 6X110 MVAR, 765/√3kV, 1-phase reactors for Bikaner-III (New) PS-Neemrana-II 765 KV D/C line (each 330 MVAR reactor with NGR, 132kV Surge Arrester) along with its auxiliaries • Line with Switchable Reactor bays: 2 nos.(For Bikaner-III-(new) PS-Neemrana-II 765 KV D/C line • ICT bays: 6nos. • Bus reactor bay: 2 nos. • All associate tie bays • Future Bus Reactor:3X110 MVAR, 1-Ph • Future Line with switchable reactor bays: 6 nos • Future Bus Reactor Bay: 1 Nos **400 kV:** • ICTs: 5x500MVA, (400/220/33) kV, 3-phase transformers. • Bus reactor: 2X125 MVAR, 420kV, 3-phase reactors • Bays for 765/400kV ICT's: 6nos. • Bays for 400/220kV ICT's: 5nos • Line bays: 6nos. (4 nos. for LILO of Bikaner-Bikaner-II D/c line & 2 nos. for Bikaner-II D/c line) • Bus reactor bay: 2nos. • All associate tie bays • Future ICT's: 5X 500 MVA, 3-Ph • Future Bus Reactor:1X125MVAR, 3-Ph • Future Line with switchable reactor bays: 4 nos. • Future Line bay: 4 • Future ICT bays : 5 nos. • Future Bus Reactor Bay: 1 Nos • Future Sectionalizer Bay: 2sets • Future STATCOM (2x±300MVAr) along with MSC (4x125MVAr) & MSR (2x125MVAr) **220kV** • ICT bay: 5 nos. • Line bay: 6nos. • Bus Coupler bay: 2nos.

	• Transfer Bus Coupler bay: 2nos • 220 kV Sectionalisation bay: 1 set • Future Line bay: 8 Nos • Future ICT bays : 5nos. • Future Sectionalizer Bay: 2sets • Future Bus Coupler bay: 2 Nos • Future Transfer Bus Coupler bay: 2 Nos
2.	**Extension of Neemrana-II S/s** • 765kV line bays at Neemrana-II S/s- 2 nos. • 765 kV, 330MVAr Switchable line reactors at Neemrana-II S/s – 2 nos. • Switching equipment for 765kV 330MVAr switchable line reactors at Neemrana-II S/s – 2 nos.
3.	**Extension of Bikaner-II S/s** • 400kV line bays at Bikaner-II S/s- 2 nos.

2.2 The detailed scope of work of the substation package is brought out in subsequent clauses of this section.

2.2.1 765/400/220 kV Bikaner-III (New) S/s.

2.2.1.1 Design, engineering, manufacture, testing at manufacturer's works, supply including transportation and insurance, unloading, storage, erection, testing and commissioning at site the following equipment/items, complete in all respects:

a) 2x125MVAR, 420kV, 3-Ph Bus Reactors along with associated accessories.

b) 765kV Circuit Breakers, Isolators, Current Transformers, Capacitor Voltage Transformers, Wave Traps (to be pedestal mounted), Bus Post Insulators (including BPI for Wave Trap) and 624kV Surge Arresters.

c) 400kV Circuit Breakers, Isolators, Current Transformers, Capacitor Voltage Transformers, Wave Traps (to be pedestal mounted), Bus Post Insulators (including BPI for Wave Trap) and 336kV Surge Arresters.

d) 245kV Circuit Breakers, Isolators, Current Transformers, Capacitor Voltage Transformers, Wave Traps (to be pedestal mounted), Bus Post Insulators(including BPI for Wave Trap) and 216kV Surge Arresters.

e) Controlled Switching device for 765kV & 400kV Circuit breakers as per BPS

f) LT Transformer and associated equipment:

800 kVA, 33/0.433kV, LT Transformer (1st) and associated 72.5kV class Circuit Breakers, Isolators, Current Transformers, Potential Transformers, Bus Post Insulators, conductor, clamps, connectors, structures etc. complete in all respect for tertiary loading of 765/400/33kV Autotransformer.

800 kVA, 33/0.433kV LT Transformer (2nd) and associated 33kV class Isolator, HG fuse, Surge Arrestor, Bus Post Insulator, conductor, clamps, connectors, structures etc. complete in all respect for connection with DISCOM Power supply.

g) Complete control, relay and protection system as per Section–Control and Relay panels including control, monitoring and protection of LT Transformer connected to tertiary of 765/400/33kV Autotransformer. Decentralized (distributed) type of bus bar protection system shall be provided for 765/400/220kV Bikaner-III substation. For 400kV & 220kV, Peripheral units of future bays in present section is to be provided as a loose supply.

h) Complete Substation Automation System based on IEC-61850 as per Section Substation Automation (including hardware and software) along with associated equipment.

The contractor shall also supply necessary BCUs for control and monitoring of substation auxiliary system.

Necessary interface equipment (Router, Firewall, Ethernet Switches etc.) and integration work for transferring data to RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC through optical fiber based SDH communication link is also under present scope.

Necessary configuration of data at Gateway for remote operation from NTAMC, Backup NTAMC, RTAMC & supervision from RLDC/ Backup RLDC is included in present scope. However, no work is envisaged at remote end (RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC) under the present scope.

Integration of Digital RTCC relays for 400/220kV Transformers [being supplied under separate package] with substation automation system is also included under present scope.

i) PLCC equipments including Analogue protection coupler, Digital Protection Coupler (suitable for interfacing with E1 port of SDH equipment), FO Boxes, gantry, signal converters, communication cables etc. for the Bikaner-III both ends of following lines

i. 765kV Bikaner-III (new) PS-Neemrana-II D/C line
ii. 400kV Bikaner-III(New) PS- Bikaner-II D/C Line)
iii. LILO of both Ckt of Bikaner- PG-Bikaner-II TL at Bikaner-III PS
   a) Dismantling & shifting of PLCC equipment's from Bikaner-II and Installation of the same at Bikaner-III for use in Bikaner(PG)-Bikaner-III 400kV D/C Line.
   b) 400kV Bikaner-III(New) PS- Bikaner-II D/C Line)

j) Complete Fire protection system for 765kV class new substation including HVWS and hydrant system for 420kV 125MVAr reactor & Owner supplied $(765/\sqrt{3})/(400/\sqrt{3})/33$kV, 1-Phase Autotransformers, $765/\sqrt{3}$kV, 1-Phase Reactors and 400/220/33kV, 500 MVA, 3 Phase Transformer. Smoke detection, Fire alarm & annunciation System for Switchyard panel room, Control Room building, Auxiliary Building. Fire-fighting system including alarm & annunciation panels shall be suitable for complete substation scope i.e. for all present and future 765kV, 400kV & 220kV bays. Hydrant system for control building, FFPH, Auxiliary Building, LT system etc.

k) Air Conditioning System for Control Room Building, Battery room & Switchyard Panel Rooms.

l) LT switchgear (AC/DC Distribution boards) considering all present and future bays (as per Rfp document and subsequent amendment issued by BPC). AC/DC system shall be provided as per the specified scope of work, including future provisions, in line with the LT SLD drawing no. C/ENGG/STD/LTSWGR765/SLD/01 Rev-0.

Further, ACDB & DCDB section shall be split in two parts, one for 400/220kV Switchyard, same shall be located in Control room building along with other LT Switchgears (MSB, MLDB and ELDB) and other sections for 765kV Switchyard, same shall be located in Auxiliary Building. Outgoing feeders of appropriate rating shall be provided in each section of ACDB, DCDB located in control Room building for powering up ACDB & DCDB located in Aux power room. The location of Auxiliary Building shall be decided during detailed engineering.

m) Battery and Battery chargers: The capacity of Battery & Battery charger shall be worked out by contractor for complete substation scope including future bays (as per Rfp document and subsequent amendment issued by BPC) and shall be submitted for Employer's approval. However, minimum capacity of each battery bank for 220V set and 48V set shall be 1500AH. Further, the minimum rating of each battery charger for 220V set and 48V set shall be 180A In case, battery and battery chargers of higher capacity/rating are required to cater the load requirement based on design calculations during detailed engineering, same shall be provided by contractor without additional cost.

n) 500kVA Silent type outdoor DG Set along with AMF panel.

o) 1.1 kV grade Power & Control cables (and special cables, if any) along with complete accessories including cables for oil filtration units and cabling from common marshaling box of 765kV Transformers, Reactors, 400kV Transformer & reactors to bay kiosks /Relay panel room /control room/Auxiliary building, RTCC panel to common marshalling box, Power receptacle for oil filtration unit shall also be provided under present scope of work as per BPS. Methodology for supply, installation & sizing of cables shall be as per Specific requirement.

p) 33kV HV cable along with complete accessories viz. termination kit, lugs, glands, clamps etc. for connection of LT Transformer with DISCOM supply

q) Insulator strings and associated hardware fittings as per Bid Price Schedule (BPS).

r) Erection Hardware: Clamps & connectors (including terminal connectors for employer supplied (765/√3)/(400/√3)/33kV Autotransformers, 765/√3kV Reactors associates, SA, NGR , 400/220/33kV Auto transformer), Conductor, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable sealing arrangement, insulating mats, cable supporting angles/channels, Cable Pull pit, Cable trays & covers, Guy arrangement(including insulators and hardware), Junction box, buried cable trenches etc.

s) Main Earthmat shall be provided under present scope of work. All the equipments (including employer supplied (765/√3)/(400/√3)/33kV & 400/220/33kV Autotransformers & 765/√3kV Reactors associated SA , NGR), cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat. Earthing of structures for all auxiliary buses shall also be in the present scope. Employer supplied 1-Ph Spare unit of (765/√3)/(400/√3)/33kV Autotransformers & 765/√3kV Reactors shall also be connected to grounding system through jumper/Copper flat when they are in uncharged condition.

t) LED based Lighting and illumination for the switchyard area under present scope, LED based illumination for streets, Control Room cum administrative building, Switchyard Panel Rooms, Auxiliary building, Fire Fighting Pump house, DG Set area and LT station area, security room shall be provided by the contractor.

u) Visual monitoring system for watch and ward of substation premises as per technical specifications.

v) The lightning protection (DSLP) for complete switchyard is to be provided by the contractor. The contractor shall design the lightning protection by utilizing the structures being provided under present scope. In case, additional structures (Lightning Masts) are required to meet the lightning protection, the contractor shall provide the same without any additional cost to POWERGRID. The cost for provision of lightning masts, including associated earthing materials, hardware etc. shall deemed to be included under the respective switchyard bay structures. The civil works shall be payable as per relevant item of BPS.

w) The following works pertaining to employer supplied (765/√3)/(400/√3)/33kV autotransformers, 765/√3kV Reactors {supply of Transformers & Reactors is covered in separate package}as per details specified in Specific requirements enclosed at Annex-III:

iv. Formation of neutral bus for each bank, auxiliary bus (765kV & 145kV) for switching of spare reactor with Bus reactors and Switchable Line Reactors are in present scope of work.

v. Formation of neutral bus, Delta Bus for each bank of transformer, auxiliary bus (765kV & 400kV, neutral & Delta) for switching of spare transformer with Six banks of transformers are in present scope of work.

vi. Overhead connection of HV, MV & LV bushings of (765/√3)/(400/√3)/33kV Autotransformers and HV & Neutral bushings of 765/√3kV Reactors to substation equipment's.

vii. Overhead connection of substation equipments with 765kV & 400kV auxiliary bus of (765/√3)/(400/√3)/33kV Autotransformers.

viii. Supply, laying and termination of cables along with associated accessories from Common marshaling box of (765/√3)/(400/√3)/33kV Autotransformers & 765/√3kV Reactors to BMK /Switchyard Panel Rooms/Control Room/ auxiliary Building as per requirement.

ix. NGR Bypass arrangement for Line Reactors through 145kV Circuit Breakers, Bus Post Insulators along with associated support structures, clamps and connectors, conductors, spacers etc.

x. 33kV neutral CT for each bank of transformers and Line Reactors.

x) 765kV, 400kV & 220kV Lattice and Pipe structures (galvanized) Towers, Beams, LM's (if applicable) and all Equipment support structures except support structure for circuit breaker shall be provided as per employer's drawing. The Support structure for Circuit Breaker shall be as per manufacturer's design.

Structures for auxiliary buses for formation of delta, neutral, spare switching etc. for 3-phase bank formation of transformers & reactors and structures for neutral CT in the scope of vendor under present scope.

In the bid price schedule, the structures including Fasteners & foundation bolts are indicated in MT.

Single line diagram/ Fabrication Drawings of Towers/ Gantries and equipment support structures shall be provided by POWERGRID during detailed Engineering stage except for those structures that are in the scope of vendor.

y) The broad Scope of the procurement of FO based Communication Equipment shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing, training and demonstration for acceptance, commissioning and documentation for :

i. SDH Equipment along with suitable interfaces and line cards.
ii. All cabling, wiring, Digital Distribution frame patch facilities and interconnection to the supplied equipment at the defined interfaces,
iii. System integration of all supplied subsystem
iv. Integration with the existing communication system based on SDH and PDH of employer.
v. Integration of supplied subsystem with SCADA system, PLCC equipment, PABX of RLDC/NLDC, VOIP (SIP compliant) for voice.
vi. Fibre Optic Approach Cable (FOAC) along with duct and Fibre Optic Distribution Panel (FODP).
vii. Integration of new Communication equipment in the existing regional NMS. All required support to existing NMS vendor for integration of new Communication equipment.

z) The broad Scope of the procurement of PMU shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing and demonstration for acceptance, commissioning and documentation for PMU as per BPS and these PMU shall support IEEE C 37.118 protocols. These PMUs shall be integrated with Phasor data Concentrator (PDC) at Northern Regional Load Dispatch Centre.

2.3.1.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage of mandatory spares at site as per BPS.

3.3.1.3 Civil works

The design of foundation shall be based on the soil investigation report and other parameters as per relevant IS codes & technical specification. Wind and seismic data shall be considered as per the latest NBC 2016

All RCC shall be of Design mix with M-25 grade unless specified otherwise.

I The scope of civil work shall include but not be limited to the following based on **drawings developed by POWERGRID enclosed at Annex-I**:

I.1 **Control room Building**
I.2 **Auxiliary Building**
I.3 **Switchyard Panel Room**
I.4 **Firefighting pump house & Fire water tank**
I.5 **Foundation for 765kV, 400kV, 220kV, 72.5kV, 33kV Gantries and Equipment.**
I.6 **Transformer & Reactor foundations** (including for employer supplied transformers and Reactors), associated Fire walls between transformers and Reactors, rail track, oil pits, NGR, 132kV Surge Arrester etc.
I.7 **Foundations** for DG Set, LT Transformer, sump pit and other miscellaneous structures.
I.8 **Road works**: Road shall be constructed as per POWERGRID standard drawings

provided in tender. However, Road layout shall be prepared by contractor and submitted for Employer's approval.

I.9 **Cable Trenches:**

I.9.1 Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. shall be constructed as per POWERGRID standard drawings provided in the tender. However, Cable trench layout including invert levels shall be prepared by contractor based on the standard sections and submitted for approval of POWERGRID.

I.9.2 **Mode of measurement:** Cable Trench along with its cover shall be measured in RM for payment purpose. All works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural steel, cable trench crossings (using RCC Hume Pipe (NP-3)), sumps etc. required as per technical specification and drawings for successful completion of the works are deemed to be included in the quoted rates.

I.10 **Drains:**

I.10.1 Drainage system shall be based on the standard sections. Drainage layout drawing shall be prepared by contractor and shall be submitted for Employer's approval.

I.10.2 **Mode of measurement:** Drains shall be measured in running meter. The rate shall include the cost of all works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural Steel, brickwork, screed concrete, plastering, etc. as per drawings and technical specifications.

I.11 **Switchyard fencing & Switchyard Gate**: Switchyard fencing & Gate as per tender drawings complete in all respect. Fencing layout drawings shall be prepared by the contractor and shall be approved by POWERGRID during detailed engineering.

I.12 Construction of **Boundary Wall** and **Main Gate** as per drawing.

I.13 Construction of **Security Post** as per drawing

I.14 **Car Parking Shed** as per drawings

I.15 Construction of **Rain water harvesting** as per drawing. The rate includes all such works as mentioned in the drawing

I.16 **Dry Stone Pitching**

I.17 **Retaining Wall**: If required, RCC retaining walls shall be constructed for which items such as excavation, PCC, RCC, reinforcement steel, etc. shall be measured and paid under respective items of BPS.

I.18 **Labour Hut:**

I.18.1 The reference drawings pertaining to Labour hut are attached as a part of tender drawings. The technical specifications of Labour Hut are enclosed at **Annexure IV**.

I.18.2 Mode of measurement of this item is in sqm of plinth area as per BOQ. The calculation of plinth area shall be as per IS:3861:2002. The items Excavation, PCC, RCC, Reinforcement, Misc Structural Steel and all other civil works, electrical works required as per technical specification and drawings for successful completion of the works are deemed to be included in the quoted rates.

I.20 **Miscellaneous**: For buildings, the complete civil works including internal and external finishing, stone soling for flooring, plinth protection, drain along plinth protection, electrical conduit and junction boxes, fan boxes, cable transit system etc. required to complete the building in all respect as per the drawing shall be payable in the plinth area rate. However, the quantity of the earthwork (excavation, backfilling, disposal etc.), concrete (all types of PCC & RCC), reinforcement steel, shall be measured and paid under respective items under BPS.

II The scope of civil work shall include but not limited to the following based on designs, architectural, structural, foundation **drawings to be developed by the contractor**.

II.1 **Site Levelling**

II.1.1 The item of site levelling works includes Contouring of whole plot area within the boundary as per technical specification. The final area of levelling may be less than the whole plot area, which will be decided during detailed engineering.

II.1.2 The Quantity of earthwork cutting & filling, borrowed earth and FGL shall be proposed by vendor for approval of POWERGRID based on the approved contour level drawing and site HFL data.

II.1.3 Mode of measurement of this item is in Cum of earthwork as per BOQ and technical specification. The contouring of the plot area in scope as per technical specification is also deemed to be included in quoted rates of this item.

II.2 **Soil Investigation** work including soil resistivity.

II.2.1 Soil investigation needs to be conducted as per the technical specification. The necessary soil investigation layout and final soil report shall be proposed by vendor for approval of POWERGRID.

II.2.2 Mode of measurement of this item is Lumpsum as per BOQ.

II.3 **Structure and Foundation for transformers and reactors neutral and tertiary delta formation:**

II.3.1 Structure and foundation for neutral, tertiary delta formation for Transformers and neutral formation & earthing arrangement for Reactors along with associated spare unit connection arrangement.

II.4 **Stone spreading and anti-weed treatment in the switchyard:**

II.4.1 Stone spreading and anti-weed treatment in the switchyard as per Section-Civil Works. Layout for the same shall be developed by the contractor.

II.5 **Foundation** for lighting poles, bay marshalling boxes, panels and control cubicles wherever required. The cost of these foundations shall be deemed to be included in erection/installation of corresponding item/ equipment of BPS.

II.6 **Internal & external water supply layout** for Security Hut, Control Room Building, Firefighting Pump House Building, Fire Water Tank, Labour Hut and Transit Camp.

II.7 **Internal plumbing and external sewerage layout** for Control Room Building, Security Hut, Labour Hut and Transit Camp.

II.8 Any other item/design/drawing for completion of scope of works.

2.3.2 Extension of 765 kV Neemrana-II S/s

2.3.2.1 Design, engineering, manufacture, testing at manufacturer's works, supply including transportation and insurance, unloading, storage, erection, testing and commissioning at site the following equipment/items, complete in all respects

a) 765kV Circuit breakers, Isolators, Current Transformers, Capacitor Voltage Transformers, Wave Traps (to be pedestal mounted), Bus Post Insulators (including BPI for Wave Trap) and 624kV Surge Arresters.

b) Controlled Switching device for 765kV Circuit breakers as per BPS

c) Complete Control, Relay and Protection system as per Section–Control and Relay Panels. Augmentation of existing bus Bar protection for bays under present scope make and model of bus bar protection shall be provided during execution stage. Peripheral units for present scope shall be available at Site, The Scope shall cover shifting of these peripheral units from existing panels to panels for present bays, wiring and commissioning

d) Augmentation of Substation Automation System for following bays (bay as defined in technical specification, Section-Substation Automation System):

- 765kV bays – 4 Nos

Existing Neemrana-III Substation is equipped with substation automation system (based on IEC-61850) Make & Model of existing SAS shall be shared with the successful bidder, during detailed engineering.

Under present scope Bidder shall include BCUs required for 765kV bays mentioned above, including all necessary hardware & software to integrate with the existing substation automation system.

The scope of bidder shall include but not limited to integration of IEDs under present scope of work with existing substation automation (which is based on IEC 61850) and capability enhancement of same as required including up-dating of system database, displays, development of additional displays and reports as per requirement.

Necessary configuration of data at Gateway for remote operation from NTAMC, Backup NTAMC, RTAMC & supervision from RLDC/ Backup RLDC is included in present scope. However, no work is envisaged at remote end (RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC) under the present scope.

e) Smoke detection, Fire alarm & Annunciation System for Switchyard panel Rooms.

f) Air Conditioning System for Switchyard Panel Room.

g) 1.1 kV grade Power & Control cables (and special cables, if any) along with complete accessories including cables for oil filtration units and cabling from common marshaling box of 765kV Reactors to bay kiosks /Relay panel room /control room. Power receptacle for oil filtration unit shall also be provided under present scope of work as per BPS. Methodology for supply, installation & sizing of cables shall be as per Specific requirement.

h) Insulator strings and associated hardware fittings as per Bid Price Schedule (BPS).

i) Erection Hardware: Clamps & connectors (including terminal connectors for employer supplied (765/√3kV Reactors associates, SA, NGR), Conductor, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable sealing arrangement, insulating mats, cable supporting angles/channels, Cable Pull pit, Cable trays & covers, Guy arrangement(including insulators and hardware), Junction box, buried cable trenches etc.

j) Existing Main Earthmat is to be extended for bays under present scope. All the equipments (including employer supplied 765/√3kV Reactors associated SA , NGR), cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat. Earthing of structures for all auxiliary buses shall also be in the present scope.

k) LED based Lighting and illumination for the switchyard area under present scope, LED based illumination for Switchyard Panel Rooms shall be provided by the contractor.

l) Augmentation of Visual monitoring system (VMS) for 765kV bays under present scope, and their integration with existing Substation VMS system. The bidder shall provide 2(Two)

Numbers of color IP camera, with PAN, TILT and ZOOM facilities, suitably located in the switchyard for monitoring of 765kV bays and equipments under present scope. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc., as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 765kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Specific Requirement Rev 07, which shall, be read only for the Augmentation scope of existing VMS system

m) The following works pertaining to employer supplied 765/√3kV Reactors (supply of Reactors is covered in separate package) as per details specified in Specific requirements enclosed at Annex-III:

i. Formation of neutral bus for each bank, auxiliary bus (765kV & 145kV) for switching of spare reactor with Bus reactors and Switchable Line Reactors are in present scope of work.

ii. Overhead connection of HV & Neutral bushings of 765/√3kV Reactors to substation equipment's.

iii. Supply, laying and termination of cables along with associated accessories from Common marshaling box of 765/√3kV Reactors to BMK /Switchyard Panel Rooms/Control Room/ auxiliary Building as per requirement.

iv. NGR Bypass arrangement for Line Reactors through 145kV Circuit Breakers, Bus Post Insulators along with associated support structures, clamps and connectors, conductors, spacers etc.

v. 33kV neutral CT for each bank of Reactor.

n) 765kV Lattice and Pipe structures (galvanized) Towers, Beams and all Equipment support structures except support structure for circuit breaker shall be provided as per drawings issued by the employer. The Support structure for Circuit Breaker shall be as per manufacturer's design.

In the bid price schedule, the gantry support and equipment support structures including Fasteners & foundation bolts are indicated in Metric Tonnes.

Single line diagram/ Fabrication Drawings of Towers/ Gantries and equipment support structures shall be provided by POWERGRID.

o) The broad Scope of the procurement of FO based Communication Equipment shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing, training and demonstration for acceptance, commissioning and documentation for :

i. SDH Equipment along with suitable interfaces and line cards.
ii. All cabling, wiring, Digital Distribution frame patch facilities and interconnection to the supplied equipment at the defined interfaces,
iii. System integration of all supplied subsystem

iv. Integration with the existing communication system based on SDH and PDH of employer.
v. Integration of supplied subsystem with SCADA system, PLCC equipment, PABX of RLDC/NLDC, VOIP (SIP compliant) for voice.
vi. Fibre Optic Approach Cable (FOAC) along with duct and Fibre Optic Distribution Panel (FODP).
vii. Integration of new Communication equipment in the existing regional NMS. All required support to existing NMS vendor for integration of new Communication equipment.

p) The broad Scope of the procurement of PMU shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing and demonstration for acceptance, commissioning and documentation for PMU as per BPS and these PMU shall support IEEE C 37.118 protocols. These PMUs shall be integrated with Phasor data Concentrator (PDC) at Northern Regional Load Dispatch Centre.

2.3.2.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage of mandatory spares at site as per BPS.

2.3.2.3 Civil works
The design of foundation shall be based on the soil investigation report and other parameters as per relevant IS codes & technical specification.

Wind and seismic data shall be considered as per the latest NBC 2016

All RCC shall be of Design mix with M-25 grade unless specified otherwise.

I The scope of civil work shall include but not be limited to the following based on **drawings developed by POWERGRID**:

I.1 **Switchyard Panel Room**
I.2 **Foundation for 765kV Gantries and Equipment.**
I.3 **Reactor foundations** (including for employer supplied reactors), associated Fire walls between transformers, rail track, oil pits, NGR, 132kV Surge Arrester etc.
I.4 **Dry Stone Pitching**
I.5 **Retaining Wall**: If required, RCC retaining walls shall be constructed for which items such as excavation, PCC, RCC, reinforcement steel, etc. shall be measured and paid under respective items of BPS.
I.6 **Road works**: Road shall be constructed as per POWERGRID standard drawings provided in tender. However, Road layout shall be prepared by contractor and submitted for Employer's approval.
I.7 **Cable Trenches:**
I.7.1 Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. shall be constructed as per POWERGRID standard drawings provided in the tender. However, Cable trench layout including invert levels shall be prepared by contractor based on the standard sections and submitted for approval of POWERGRID.
I.7.2 **Mode of measurement:** Cable Trench along with its cover shall be measured in RM for payment purpose. All works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural steel, cable trench crossings (using RCC Hume Pipe (NP-3)), sumps etc. required as per technical specification and drawings for successful completion of the works are

deemed to be included in the quoted rates.

I.8 **Drains:**

I.8.1 Drainage system shall be based on the standard sections. Drainage layout drawing shall be prepared by contractor and shall be submitted for Employer's approval.

I.8.2 **Mode of measurement:** Drains shall be measured in running meter. The rate shall include the cost of all works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural Steel, brickwork, screed concrete, plastering, etc. as per drawings and technical specifications.

I.9 **Miscellaneous**: For buildings, the complete civil works including internal and external finishing, stone soling for flooring, plinth protection, drain along plinth protection, electrical conduit and junction boxes, fan boxes, cable transit system etc. required to complete the building in all respect as per the drawing shall be payable in the plinth area rate. However, the quantity of the earthwork (excavation, backfilling, disposal etc.), concrete (all types of PCC & RCC), reinforcement steel, shall be measured and paid under respective items under BPS.

II The scope of civil work shall include but not limited to the following based on designs, architectural, structural, foundation **drawings to be developed by the contractor**.

II.1 **Site Levelling**

II.1.1 The item of site levelling works includes Contouring of Area under present Scope as per technical specification.

II.1.2 The Quantity of earthwork cutting & filling, borrowed earth and FGL shall be proposed by vendor for approval of POWERGRID based on the approved contour level drawing and site HFL data.

II.1.3 Mode of measurement of this item is in Cum of earthwork as per BOQ and technical specification. The contouring of the plot area in scope as per technical specification is also deemed to be included in quoted rates of this item.

II.2 **Soil Investigation** work including soil resistivity.

II.3 **Stone spreading and anti-weed treatment in the switchyard:**

II.3.1 Stone spreading and anti-weed treatment in the switchyard as per Section-Civil Works. Layout for the same shall be developed by the contractor.

II.3.2 Removal and re-spreading of stone after doing antiweed treatment

II.4 **Structure and Foundation for transformers and reactors neutral and tertiary delta formation:**

II.4.1 Structure and foundation for tertiary delta formation for neutral formation & earthing arrangement for Reactors along with associated spare unit connection arrangement.

II.5 **Foundation** for lighting poles, bay marshalling boxes, panels and control cubicles wherever required. The cost of these foundations shall be deemed to be included in erection/installation of corresponding item/ equipment of BPS.

II.6 Any other item/design/drawing for completion of scope of works.

2.3.3 Extension of 400kV Bikaner-II S/s

2.3.3.1 Design, engineering, manufacture, testing at manufacturer's works, supply including transportation and insurance, unloading, storage, erection, testing and commissioning at site the following equipment/items, complete in all respects

a) 400kV Circuit breakers, Isolators, Current Transformers, Capacitor Voltage Transformers, Wave Traps (to be pedestal mounted), Bus Post Insulators (including BPI for Wave Trap) and 336kV Surge Arresters.

b) Complete Control, Relay and Protection system as per Section–Control and Relay Panels. Augmentation of existing bus Bar protection for bays under present scope make and model of bus bar protection shall be provided during execution stage. Peripheral units for present scope shall be available at Site, The Scope shall cover shifting of these peripheral units from existing panels to panels for present bays, wiring and commissioning

c) Augmentation of Substation Automation System for following bays (bay as defined in technical specification, Section-Substation Automation System):

- 400kV bays – 4 Nos

Existing Bikaner-III Substation is equipped with substation automation system (based on IEC-61850). Make & Model of existing SAS shall be shared with the successful bidder, during detailed engineering.

Under present scope Bidder shall include BCUs required for 400kV bays mentioned above, including all necessary hardware & software to integrate with the existing substation automation system.

The scope of bidder shall include but not limited to integration of IEDs under present scope of work with existing substation automation (which is based on IEC 61850) and capability enhancement of same as required including up-dating of system database, displays, development of additional displays and reports as per requirement.

Necessary configuration of data at Gateway for remote operation from NTAMC, Backup NTAMC, RTAMC & supervision from RLDC/ Backup RLDC is included in present scope. However, no work is envisaged at remote end (RLDC/ Backup RLDC /RTAMC/ NTAMC / Backup NTAMC) under the present scope.

d) Smoke detection, Fire alarm & Annunciation System for Switchyard panel Rooms.

e) Air Conditioning System for Switchyard Panel Room.

f) 1.1 kV grade Power & Control cables (and special cables, if any) along with complete accessories. Methodology for supply, installation & sizing of cables shall be as per Specific requirement.

g) Insulator strings and associated hardware fittings as per Bid Price Schedule (BPS).

h) Erection Hardware: Clamps & connectors, Conductor, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable sealing arrangement, insulating mats, cable supporting angles/channels, Cable Pull pit, Cable trays & covers, Junction box, buried cable trenches etc.

i) Existing Main Earthmat is to be extended for bays under present scope. All the equipments, cable trenches, auxiliary earthmat for isolators etc. shall be earthed by connecting them to the main Earthmat. Earthing of structures for all auxiliary buses shall also be in the present scope.

j) LED based Lighting and illumination for the switchyard area under present scope, LED based illumination for Switchyard Panel Rooms shall be provided by the contractor.

k) Augmentation of Visual monitoring system (VMS) for 400kV bays under present scope, and their integration with existing Substation VMS system. The bidder shall provide 2(Two)

Numbers of color IP camera, with PAN, TILT and ZOOM facilities, suitably located in the switchyard for monitoring of 400kV bays and equipments under present scope. The scope of bidder shall include providing all Items, Accessories, Line Interface units, Fiber patch cords, Power supply units, Junction Boxes, Cables, Fiber Optic Cables, Hardware and Software, etc., as are applicable to the product design, to meet functional requirements. Compatibility enhancement of exiting VMS system, as needed, shall be done to integrate visual monitoring for 400kV bays under present scope with existing Visual monitoring system of the station. A copy of specification for Visual Monitoring system is enclosed at Specific Requirement Rev 07, which shall, be read only for the Augmentation scope of existing VMS system

l) 400kV Lattice and Pipe structures (galvanized) Towers, Beams and all Equipment support structures except support structure for circuit breaker shall be provided as per drawings issued by the employer. The Support structure for Circuit Breaker shall be as per manufacturer's design.

In the bid price schedule, the Gantry structures and Equipment support structures including Fasteners & foundation bolts are indicated in Metric Tonnes.

Single line diagram/ Fabrication Drawings of Towers/ Gantries and equipment support structures shall be provided by POWERGRID.

m) The broad Scope of the procurement of FO based Communication Equipment shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing, training and demonstration for acceptance, commissioning and documentation for :

viii. SDH Equipment along with suitable interfaces and line cards.
ix. All cabling, wiring, Digital Distribution frame patch facilities and interconnection to the supplied equipment at the defined interfaces,
x. System integration of all supplied subsystem
xi. Integration with the existing communication system based on SDH and PDH of employer.
xii. Integration of supplied subsystem with SCADA system, PLCC equipment, PABX of RLDC/NLDC, VOIP (SIP compliant) for voice.
xiii. Fibre Optic Approach Cable (FOAC) along with duct and Fibre Optic Distribution Panel (FODP).
xiv. Integration of new Communication equipment in the existing regional NMS. All required support to existing NMS vendor for integration of new Communication equipment.

n) The broad Scope of the procurement of PMU shall include planning, designing, engineering, supply, transportation, insurance, delivery at site, unloading handling, storage, installation, termination, testing and demonstration for acceptance, commissioning and documentation for PMU as per BPS and these PMU shall support IEEE C 37.118 protocols. These PMUs shall be integrated with Phasor data Concentrator (PDC) at Northern Regional Load Dispatch Centre.

2.3.2.2 Design, engineering, manufacture, testing and supply including transportation & insurance, storage of mandatory spares at site as per BPS.

2.3.2.3 Civil works

The design of foundation shall be based on the soil investigation report and other parameters as per relevant IS codes & technical specification.

Wind and seismic data shall be considered as per the latest NBC 2016

All RCC shall be of Design mix with M-25 grade unless specified otherwise.

The scope of civil work shall include but not be limited to the following based on **drawings developed by POWERGRID**:

I.1 **Switchyard Panel Room**

I.2 **Foundation for 400kV Gantries and Equipment.**

I.3 **Dry Stone Pitching**

I.4 **Retaining Wall**: If required, RCC retaining walls shall be constructed for which items such as excavation, PCC, RCC, reinforcement steel, etc. shall be measured and paid under respective items of BPS.

I.5 **Road works**: Road shall be constructed as per POWERGRID standard drawings provided in tender. However, Road layout shall be prepared by contractor and submitted for Employer's approval.

I.6 **Cable Trenches:**

I.6.1 Cable trenches along with covers including road/rail crossing, sump pits, culverts etc. shall be constructed as per POWERGRID standard drawings provided in the tender. However, Cable trench layout including invert levels shall be prepared by contractor based on the standard sections and submitted for approval of POWERGRID.

I.6.2 **Mode of measurement:** Cable Trench along with its cover shall be measured in RM for payment purpose. All works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural steel, cable trench crossings (using RCC Hume Pipe (NP-3)), sumps etc. required as per technical specification and drawings for successful completion of the works are deemed to be included in the quoted rates.

I.7 **Drains:**

I.7.1 Drainage system shall be based on the standard sections. Drainage layout drawing shall be prepared by contractor and shall be submitted for Employer's approval.

I.7.2 **Mode of measurement:** Drains shall be measured in running meter. The rate shall include the cost of all works such as Excavation, PCC, RCC, Reinforcement, Misc. Structural Steel, brickwork, screed concrete, plastering, etc. as per drawings and technical specifications.

I.8 **Miscellaneous**: For buildings, the complete civil works including internal and external finishing, stone soling for flooring, plinth protection, drain along plinth protection, electrical conduit and junction boxes, fan boxes, cable transit system etc. required to complete the building in all respect as per the drawing shall be payable in the plinth area rate. However, the quantity of the earthwork (excavation, backfilling, disposal etc.), concrete (all types of PCC & RCC), reinforcement steel, shall be measured and paid under respective items under BPS.

II The scope of civil work shall include but not limited to the following based on designs, architectural, structural, foundation **drawings to be developed by the contractor**.

II.1 **Site Levelling**

II.1.1 The item site levelling works includes Contouring of area under present scope as per technical specification

II.1.2 The Quantity of earthwork cutting & filling, borrowed earth and FGL shall be proposed by vendor for approval of POWERGRID based on the approved contour level drawing and site HFL data.

II.1.3 Mode of measurement of this item is in Cum of earthwork as per BOQ and technical specification. The contouring of the plot area in scope as per technical specification is also deemed to be included in quoted rates of this item.

II.2 **Stone spreading and anti-weed treatment in the switchyard:**

II.2.1 Stone spreading and anti-weed treatment in the switchyard as per Section-Civil Works. Layout for the same shall be developed by the contractor.

II.3 **Foundation** for lighting poles, bay marshalling boxes, panels and control cubicles wherever required. The cost of these foundations shall be deemed to be included in erection/installation of corresponding item/ equipment of BPS.

II.4 Any other item/design/drawing for completion of scope of works.

2.4 The work to be done under this specification shall include all labour, plant, equipment, material and performance of all work necessary for the complete installation and commissioning of switchyard. All apparatus, appliances, material and labour etc. not specifically mentioned or included, but are necessary to complete the entire work or any portion of the work in compliance with the requirements implied in this specification is deemed to be included in the scope of contractor.

2.5 Before proceeding with the construction work the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Employer shall endeavor to provide the information, it shall not be binding for the Employer to provide the same. The bidders are advised to visit the substation sites (for existing substations) and acquaint themselves with the topography, infrastructure and also the design philosophy. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for the Civil and construction/installation work including cement and steel shall be supplied by the Contractor. The complete design (unless specified otherwise in specification elsewhere) and detailed engineering shall be done by the Contractor based on conceptual tender drawings.

2.6 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies, project management, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.

2.7 Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagram, electrical layout, foundation & cable trench layouts (including invert levels), erection key diagrams, direct stroke lightning protection, electrical and physical clearance diagrams, Control and protection schematics, wiring and termination schedules, design of firefighting system, outdoor lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.

2.8 Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

2.9 Employer has standardized its technical specification for various equipments and works for different voltage levels. Items, which are not applicable for the scope of this package as per schedule of quantities described in BPS, the technical specification for the items should not be referred to.

3.0 SPECIFIC EXCLUSIONS

The following items of work are specifically excluded from the scope of the specifications

A) 765/400/220kV Bikaner-III (new) PS

i) Employer's site office and stores.

ii) Transit camp.

iii) Store building

iv) Supply, erection, testing & commissioning of 500 MVA, (765/√3)/(400/√3)/33kV, single phase autotransformers.

v) Supply, erection, testing & commissioning of 110 MVAR, 765/√3 kV, single phase Bus/ Shunt reactor, NGR & 132kV LA.

vi) Supply, erection, testing & commissioning of 500MVA, 400/220/33kV three phase Auto transformer.

vii) Cabling from IMB to CMB of 765kV Transformer/Reactor.

B) 765/400/220kV Neemrana-II S/S

i) Extension of ACDB & DCDB

ii) Approach Road.

iii) Cabling from IMB to CMB of 765kV Reactor.

C) 765/400/220kV Bikaner-II S/S

i) Extension of ACDB & DCDB

ii) Approach Road

4.0 PHYSICAL AND OTHER PARAMETERS

4.1 Location of the Substation - The location of substation is indicated below:

Sr. No	Name of Substation	Name of State	Nearest Rail Head
1.	765/400/220kV Bikaner-III (New) PS	Rajasthan	Bikaner
2.	765/400kV Neemrana-II PS	Rajasthan	Alwar
3.	400/220kV Bikaner-II PS	Rajasthan	Bikaner

4.2 **Meteorological data**

The meteorological data are as below

Station Name	**765/400/220kV Bikaner-III (new) PS**	**Extension of 765kV Neemrana-II**	**Extension of 400kV Bikaner-II S/s**
Altitude	Less than 1000 meter	Less than 1000 meter	Less than 1000 meter

	above mean sea level (MSL)	above mean sea level (MSL)	above mean sea level (MSL)
Snow fall	NIL	NIL	NIL
Seismic Zone	NBC 2016	NBC 2016	NBC 2016
Wind Zone	NBC 2016	NBC 2016	NBC 2016
Min./Max. Ambient Temperature	0 / 50 degree centigrade	0 / 50 degree centigrade	0 / 50 degree centigrade
Coastal Area consideration	No	No	No

4.3 Fault level shall be considered as mentioned below:-

Sl. No.	Name of Substation	765kV	400kV	220kV
1.	765/400/220kV Bikaner-III (New) PS	50kA for 1 Sec	63kA for 1 Sec	50kA for 1 sec
2.	765/400kV Neemrana-II PS	50kA for 1 Sec	NA	NA
3.	400/220kV Bikaner-II PS	NA	63kA for 1 Sec	50kA for 1 sec

5.0 **SCHEDULE OF QUANTITIES**

The requirement of various items/equipments and civil works are indicated in Bid price Schedules. All equipments/items, Structures and civil works for which quantities has been given in the BPS shall be payable on unit rate basis. During actual execution, any variation in such quantities shall be paid based on the unit rate under each item incorporated in Letter of award.

Wherever the quantities of items/works are indicated in Set/LOT/LS, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Bid price schedules.

No cost compensation shall be considered on account of “Set/LOT/LS” items in any case of number of bays specified in section project remains unchanged.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be included in the bid price and shall be provided at no extra cost to Employer.

6.0 BASIC REFERENCE DRAWINGS

The substation shall be designed considering current ratings as indicated below-

Sl. No	Description of bay	765/400/220kV Bikaner-III (new) PS			Extn of Neemrana-II S/s	Extn of Bikaner--II S/s
		765kV	400kV	220 kV	765kV kV	400 kV
1.	Bus Bar	4000A	4000A	4000A	4000A	4000A
2.	Line bay	3150A	3150A	1600A	3150A	3150A
3.	ICT bay	3150A	3150A	1600A		-
4.	Bus Reactor bay	3150A	3150A	-		-
5.	Bus Coupler bay	-	-	3150A		-
6.	Transfer Bus coupler bay	-	-	1600A		-
7	Bus Sectionalizer			3150A		

Following switching schemes are proposed for the substations envisaged under this specification:

Name of s/s	765kV	400 kV	220 kV
765/400/220kV Bikaner-III (New) PS	One & half breaker scheme	One & half breaker scheme	Double main & Transfer
765/400kV Neemrana-II PS	One & half breaker scheme	--	--
400/220kV Bikaner-II PS	--	One & half breaker scheme	Double main & Transfer

6.1 The reference drawings, which form a part of the specifications, are given at **Annexure-I**. The bidder shall maintain the phase to earth clearance, phase to phase clearance and sectional clearances, clearances between buses, bus heights but may alter the locations of equipment to obtain the statutory electrical clearances required for the substation.

6.2 It is responsibility of contractor to develop general arrangement drawing, layout drawings, single line drawing, foundation & cable trench layout, erection key diagram & all other layout drawings for present scope of work.

6.5 INPUTS TO BE PROVIDED DURING DETAILED ENGINEERING

i) Location of identified land and Plot plan for land shall be provided to successful bidder during detailed engineering.

ii) Transmission line side conductor type & configuration of conductors for transmission lines of various voltage levels.

7.0 **DIFFERENT SECTIONS OF TECHNICAL SPECIFICATION**

For the purpose of present scope of work, technical specification (Vol. II) shall consist of following sections and they should be read in conjunction with each other.

1	Section-Project	Rev 00
2	Section-General Technical Requirement (GTR)	Rev 15
3	Section-Switchgear- CB	Rev 11
4	Section-Switchgear- ISO	Rev 12

5	Section-Switchgear- Instrument Transformer	Rev 11
6	Section-Switchgear-Surge Arrester	Rev 12
7	Section-Power and Control Cables	Rev 06
8	Section-Lighting System	Rev 07
9	Section-Fire Protection System	Rev 06
10	Section – LT Transformer	Rev 05
11	Section – DG Set	Rev 05
12	Section – Battery & Battery Charger	Rev 06
13	Section – LT Switchgear	Rev 05
14	Section-Air Conditioning System	Rev 04
15	Section-Switchyard Erection	Rev 10
16	Section- Structures	Rev 06
17	Section-Civil Works	Rev 11A with correction slips
18	Section-Control and Relay Panels	Rev 09
19	Section-Substation Automation System	Rev 04
20	Section-PLCC	Rev 05
21	Section-Telecommunication Systems	Rev 03
22	Section – PMU	Rev 00
23	Section Shunt Reactors up to 400kV, Neutral Grounding Reactor an Surge Arrester	Rev 11

In case of any discrepancy between Section-PROJECT and Section-GTR and other technical specifications on scope of works, Section-PROJECT shall prevail over all other sections.

In case of any discrepancy between Section-GTR and individual sections for various equipments, requirement of individual equipment section shall prevail.

8.0 SPARES

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of BPS. The breakup of mandatory spares is enclosed at Annex-II.

The bidder is clarified that no mandatory spares shall generally be used during the commissioning of the equipment. Any spares required for commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for commissioning purpose shall be taken back by the contractor.

Wherever spares in BPS/Technical Specification has been specified as “each type/each rating/each type & rating”: If the offered spare/spares are sufficient to replace the respective main equipment of all types/ratings, then such offered spare/spares shall be acceptable. It implies that common spare/spare set fulfilling the spare requirement of all types/ratings shall also be acceptable, provided it is configurable at site itself without special assistance of OEM

Mandatory Spares, wherever mentioned, are envisaged for the equipment/items being supplied under the main equipment heads under present scope meeting the requirements of Technical Specifications. The component/sub-component of an equipment/item specified in BPS under

Mandatory Spare, which is not applicable as per the offered design of respective main equipment, shall not be referred to.

9.0 **SPECIFIC REQUIREMENT**

9.1 The specific requirements as mentioned at C/ENGG/SPEC/SEC-PROJECT/SPECIFIC REQUIREMENT Rev. no 07 enclosed at Annex-III and relevant/applicable clauses shall be referred for specified scope of work. Any discrepancy between clause 9.0 Section-PROJECT and Annex-III on scope of works, the requirement stipulated at clause 9.0 of section project shall prevail.

9.2 Clause **No. 9.2 of Section GTR rev 15 is amended as :**

The reports for all type tests as per technical specification shall be furnished by the Contractor along with equipment / material drawings. However, type test reports of similar equipments/ material already accepted in POWERGRID shall be applicable for all projects with similar requirement. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID/representative authorized by POWERGRID/representative of Utility /representative of accredited test lab/ representative of The National Accreditation Board for Certification Bodies (NABCB) certified agency shall also be acceptable.

Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted within the years specified below from the date of NOA. In case the test reports are of the test conducted earlier than the years specified below from the date of NOA, the contractor shall repeat these test(s) at no extra cost to the Employer:-

S. No.	**Name of Equipment**	**Validity of type test(in years)**
1	Power Transformer	5
2	LT Transformer	5
3	Shunt Reactor	5
4	OLTC	10
5	Bushing of Power Transformers/Reactors	7
6	Fittings and accessories for Power transformers & Reactors	10
7	Circuit Breaker	10
8	Isolator	10
9	Lighting Arrester	10
10	Wave Trap	10
11	Instrument transformer	10
12	GIS & Hybrid GIS	15
13	LT Switchgear	10
14	Cable and associated accessories	10
15	Relays	7
16	Capacitors	10
17	Battery and Battery charger	10
18	Conductor & Earth wire	10
19	Insulators (Porcelain/Glass)	10
20	Composite Insulators	5
21	PLCC	5

Note:- For all other equipment's validity of type test shall be 10 years from date of NOA. Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the type tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies**.**

9.3 The core details for 245kV, 2500A, 120% extended Current Transformer shall be as follows:

i. Primary ratio tap: 2500-1600-800/1-1-1-1-1A
ii. Class: PX, PX, 0.2S, PX, PX
iii. Core: 5
iv. Min. Knee point voltage Vk: 2500-1600-800 V for each core except metering
v. Burden: 20VA (For Metering core)
vi. Max. CT sec. winding resistance Rct (ohms): 12.5/8/4 for 2500/1600/800 tapping
vii. Max. excitation current at Vk (Imax in mA): 16/25/50 for 2500/1600/800 tapping

9.4 **Following** items for Reactor are excluded from the scope of this specification:

i) Online Dissolved Gas (Multi-gas) and Moisture analyser
ii) On line dissolved Hydrogen and Moisture Measuring Equipment
iii) Temperature measuring unit
iv) Ethernet switch, LIU patch cords etc. and associated cables

As Ethernet switch is not included in present scope, OTI & WTI shall be integrated in SCADA through 4-20 mA signals.

9.5 Minimum specified creepage distance for insulator string/ longrod insulators/ outdoor bushings shall be 31 mm/kV.

9.6 Technical Specification of 33kV Horn Gap fuse shall be as follows:

Rated voltage	33kV
Maximum Continuous voltage	36 kV
Rated current	50 Amps
Rated short time withstand (in KA)	25KA for 1 sec.
Lighting Impulse voltage withstand	170 KV (Between Live and earth) 195 KV (Across open terminals)
One minute Power frequency voltage withstand (Dry and Wet)	70 KV (Between Live and earth) 80 KV (Across open terminals)

9.7 Technical Parameters of 36kV Neutral Current Transformer (Outdoor type) for bank of 765kV, 1-Ph Transformer
Location: Common Neutral Side (for each three phase bank)

a. Rated current: 3000A (120% extended)

b. Ratio: 3000/1 A
c. Minimum knee point voltage: 3000 V
d. Accuracy class: PX
e. Maximum CT Resistance: 12 Ohms
f. Application: REF (High Impedance)
g. Maximum magnetization current (at knee-point voltage): 20 mA

9.8 Technical Parameters of 36kV Neutral Current Transformer (Outdoor type) for bank of 765kV, 1-Ph Reactor
Location: Common Neutral Side (for each three phase bank)

a. Rated current: 300A (200% extended)
b. Ratio: 300/1 A
c. Minimum knee point voltage: 300 V
d. Accuracy class: PX
e. Maximum CT Resistance: 1 Ohms
f. Application: Earth fault protection
g. Maximum magnetization current at Vk/4 (Vk= knee-point voltage): 40 mA

9.9 **Standalone Disturbance Recorder as mentioned at clause no. 37. I) (Line Protection Panel) of Section-CRP Rev-09 is not envisaged under present scope. (for 765kV)**

9.10 Each circuit of a double circuit transmission line shall be terminated in different diameters.

9.11 Two transformers of same HV rating shall not be connected in the same diameter and similarly two bus reactors of same HV rating shall also not be connected in the same diameter

9.12 **New Clause No. 2.0. f) of Section Switchgear Isolator rev 12 as under:-**

The values of transfer current and recovery voltage of 220kV class bus isolators shall be specified by manufacturer & Bus Isolators shall be type tested for bus transfer current switching duty as per latest IEC62271-102. Test reports is to be submitted for the Employer's review."

9.13 Following clause in the Standard technical specification of –Power & Control Cable Rev 06 has been modified: -

Sl. No	Description
1.	1.2.2. **XLPE Power Cables** 1.2.2.1. The XLPE (90°C) insulated cables shall be of FRLSH type, C2 category conforming to IS: 7098 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS:5831. All cables shall be of armoured type. For single core cables, the armouring shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS:5831 for all XLPE cables
2.	1.2.3. **PVC Power Cables**

	1.2.3.1. The PVC (70°C) insulated power cables shall be of FRLSH type, C2 category, conforming to IS: 1554 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. All cables shall be of armoured type. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.
3.	1.2.4. **PVC Control Cables** 1.2.4.1. The PVC (70°C) insulated control cables shall be of FRLSH type C2 category conforming to IS: 1554 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables. All cables shall be of armoured type. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour.
4.	**5 TYPE TESTS** 5.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IS. 5.2 ***XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V):-*** 5.2.1 Following type tests (on one size in a contract) as per IS: 7098 (Part 1) – 1988 including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V: a) Physical tests for insulation i) Hot set test ii) Shrinkage test b) Physical tests for outer sheath i) Shrinkage test ii) Hot deformation iii) Heat shock test iv) Thermal stability **c) Test for Smoke density (as per relevant IS/IEC standard)** **d) Test for halogen acid gas evolution**. **e) Flame Retardant on Single cable.** **f) Flame Retardant on bunched cable.** 5.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for the following tests a) Water absorption (gravimetric) test. b) Ageing in air oven c) Loss of mass in air oven d) Short time current test on power cables of sizes 240 sqmm and above on i) Conductors. ii) Armours. e) Test for armouring wires/strips.

	f) Oxygen and Temperature Index test. g) Flammability test. **h) Smoke density test (on sheathing material) (as per relevant IS/IEC standard)**
5.	5.3 ***PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-*** 5.3.1 Following type tests (on one size in a contract) as per IS: 1554 (Part 1) -1988 including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V: a) Physical tests for insulation and outer sheath i) Shrinkage test ii) Hot deformation iii) Heat shock test iv) Thermal stability b) High voltage test (water immersion test only a.c. test as per clause no. 16.3.1). **c) Test for Smoke density (as per relevant IS/IEC standard)** **d) Test for halogen acid gas evolution**. **e) Flame Retardant on Single cable** 5.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for the following a) High voltage test (water immersion d.c. test as per clause no. 16.3.2 of IS: 1554 (Part 1) - 1988). b) Ageing in air oven. c) Loss of mass in air oven. d) Short time current test on power cables of sizes 240 sqmm and above on i) Conductors. ii) Armours. e) Test for armouring wires/strips. f) Oxygen and Temperature Index test. g) Flammability test **h) Flame Retardant on bunched cable** **i) Test for Specific optical density of smoke (as per relevant IS/IEC standard)**

Note:- In technical data sheet for 1.1kV XLPE/PVC Power cable & PVC control cable, wherever Type & Category of Cable is written FR & C1 shall be read as FR-LSH & C2, other details kept the same.

9.14 Equipment/Material/Items from a Indian manufacture who have specified transfer of technology (TOT) arrangement with an entity from a country which shares land border with India shall be accepted only if the Indian Manufacturer is complying the requirement of prevailing Guideline by Government of India under Rule 144(xi) of the General financial Rule (GFR) 2017.

9.15 **CLAUSE 24 of GTR Rev.15 shall be read as below:-**

24.0 TECHNICAL REQUIREMENT OF EQUIPMENTS

Following equipment shall be offered from the Indian Manufacturing facilities of manufacturer(s) who meets the technical requirements as stipulated here, provided the same equipment are not covered under the Bidder's Qualifying requirement of the Bidding Documents.

Legend:

* : voltage class of respective equipment as applicable.

\# : **satisfactory operation** means certificate issued by the Employer/Utility certifying the operation without any adverse remark.

@ : **Circuit Breaker Bay** means a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs

NOA: means Notification Of Award

24.1 Technical requirements for 765/400/220/132kV* Air Insulated Switchgear (AIS) Equipment*:

A) Circuit Breaker

(i) The manufacturer(s) whose 765/400/220/132kV* Circuit Breaker(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715/345/220/132kV* or higher voltage class Circuit Breaker(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered Circuit Breaker and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715/345/220/132kV* or higher Voltage class Circuit Breaker(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two (2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered Circuit Breaker(s) to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the Circuit Breaker(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor.

B) Isolator, Current Transformer, Capacitive Voltage transformer, Inductive Voltage transformer, Surge Arrester and Wave Trap)

(i) The manufacturer whose 765/400/220/132kV* equipment(s) are offered, must have manufactured, type tested (as per IS/IEC or equivalent standard) and supplied 715/345/220/132kV* or higher voltage class equipment(s), which are in satisfactory operation# for at least two (2) years as on the date of NOA.

OR

(ii) The manufacturer, who have established manufacturing and testing facilities in India for the offered equipment(s) and not meeting the requirement stipulated in (i) above, can also be considered provided that:

a) 715/345/220/132kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IS/IEC standard) as on the date of NOA

b) Manufacturer has manufactured, type tested (as per IS/IEC or equivalent standard) and supplied equipment(s) of 345kV or above voltage class (applicable for 765kV* Equipment)/220kV or above voltage class (applicable for 400kV* equipment) /132kV or above voltage class (applicable for 220kV* equipment) / 66kV or higher voltage class (applicable for 132kV* equipment), which are in satisfactory operation# for at least two (2) years as on the date of NOA.

c) Warranty obligations for additional warranty of two (2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment(s) to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipment(s)* for the additional warranty period in addition to the contract Performance guarantee to be submitted by the contractor.

OR

(iii) The manufacturer, who have established manufacturing and testing facilities in India for the offered equipment(s) based on technological support of a parent company or collaborator and not meeting the requirement stipulated in (i) above, can also be considered provided that:

a) 715/345/220/132kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IS/IEC standard) as on the date of NOA.

b) The parent company or collaborator meets the qualifying requirements stipulated under (i) given above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply the 765/400/220/132kV* Air Insulated Switchgear (AIS) Equipment(s)* in India, shall be submitted.

c) The parent company/collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor

Legends:

* : voltage class of respective equipment as applicable.

: satisfactory operation means certificate issued by the Employer/Utility certifying the operation without any adverse remark.

24.2 Technical Requirement for 765kV class Transformer

(i) The Manufacturer whose 765kV Transformer(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA, and the same transformer (s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715 kV or higher voltage class either One (1) no. 1-phase Transformer of at least 166 MVA capacity or One (1) no. 1-phase Reactor of at least 80 MVAR capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 765kV transformer in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of **10%** of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor

24.3 Technical Requirement for 765kV class Reactor

(i) The Manufacturer whose 765kV Reactor(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Reactor of at least 110 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 36.7 MVAR and the same Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

OR

The Manufacturer must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA and the bidder should have designed, manufactured, tested & supplied 345 kV or higher voltage class one (1) number 3-phase Reactor of at least 50 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 16.7 MVAR and the same Transformer(s) & Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715 kV or higher voltage class either One (1) no. 1-phase Reactor of at least 80 MVAR capacity or One (1) no. 1-phase Transformer of at least 166 MVA capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 765kV Reactor in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of **10%** of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.4 Technical Requirement for 400kV, 220kV, 132kV class Transformer

(i) The manufacturer whose transformer(s) are offered must have designed, manufactured, tested and supplied transformers as per table below:

345kV or above class 3-phase transformers of at least 200 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 66.7 MVA	applicable for supply of 400kV class Transformer

220kV or above class 3-phase transformers of at least 50 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 16.7 MVA	applicable for supply of 220kV class Transformer
commissioned 132kV or above class 3-phase transformers of at least 20 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 6.7 MVA	applicable for supply of 132kV class Transformer

These Transformer(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 220kV (applicable for supply of 400kV class Transformer)/ 132kV (applicable for supply of 220kV class Transformer)/ 66kV (applicable for supply of 132kVclass Transformer)or higher voltage class transformers must have been designed, manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV/220kV/132kV* transformer in India, shall be submitted.

c) The collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.5 Technical Requirement for 400kV, 220kV and 132kV class Reactor

(i) The Manufacturer whose 400kV/220kV/132kV* Reactor(s) are offered must have designed, manufactured, tested & supplied Reactor as per table below:

345kVor above class 3-phase shunt reactor of at least 50 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors, each having capacity of at least 16.7 MVAR	applicable for supply of 400kV class Reactors
220kV or above class 3-phase shunt reactor of at least 20 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 6.67 MVAR	applicable for supply of 220kV class Transformer
132kV or above class 3-phase shunt reactor of at least 15 MVAR capacity	applicable for supply of 132kV class Transformer

or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 5 MVAR	

These Reactor(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Such manufacturer has designed, manufactured based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied 400kV class transformer or 220kV or above class shunt reactors (applicable for supply of 400kV class Reactors) / 220kV class transformer or 132kV or above class shunt reactors (applicable for supply of 220kV class Reactors)/ 132kV class transformer or 66kV or above class shunt reactors (applicable for supply of 132kV class Reactors) as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply the Reactor in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.6 Technical Requirement for 400 kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 400kV grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 400kV grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

OR

b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 400kV grade XLPE insulated Cable as on the date of NOA.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.

24.7 Technical Requirement for 220KV,132kV,110kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 220kV/132kV/110kV* or higher grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 220kV/132kV/110kV* or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

OR

b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 220kV/132kV/110kV* or higher grade XLPE insulated Cable as on the date of NOA.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor

24.8 Technical Requirement for 66kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 66kV or higher grade XLPE insulated cable which must be in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 66kV or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

24.9 Technical Requirement for 1.1 KV Grade PVC Control Cable

The manufacturer(s), whose PVC control cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV grade PVC insulated control cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 27C x 2.5 Sq.mm or higher size as on the date of NOA.

24.10 Technical Requirement for 1.1 KV Grade PVC Power Cable

The manufacturer(s), whose PVC Power Cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV or higher grade PVC insulated power cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 150 Sq. mm or higher size as on the date of NOA.

24.11 Technical Requirement for 1.1 KV Grade XLPE Power Cables

The manufacturer(s), whose XLPE Power cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 630 Sq. mm or higher size as on the date of NOA.

24.12 Technical Requirement for LT Switchgear

i) The manufacturer whose LT Switchgear(s) are offered, must be a manufacturer of LT Switchboards of the type and rating being offered. He must have designed, manufactured, tested and supplied atleast 50 nos. draw out circuit breaker panels, out of which atleast 5 nos. should have been with relay and protection schemes with current transformer. He must have also manufactured atleast 50 nos. MCC panels comprising of MCCBs (ie Moulded Case Circuit Breakers) modules of the type offered which must be in satisfactory operation[#] as on the date of NOA.

ii) The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design, atleast one hundred circuit breakers of the make and type being offered must have been in satisfactory operation[#] as on the date of NOA.

24.13 Technical Requirements for Battery

The manufacturer whose Batteries are offered, must have designed, manufactured and supplied DC Batteries of the type specified and being offered, having a capacity of atleast 600 AH and these must be satisfactory operation[#] for atleast two (2) years in power sector or industrial installations as on the date of NOA.

24.14 Technical Requirements for Battery Charger

The manufacturer, whose Battery Chargers are offered, must have designed, manufactured and supplied Battery Chargers generally of the type offered, with static automatic voltage regulators and having a continuous output of atleast ten (10) KW and these must have been in satisfactory operation[#] as on the date of NOA.

24.15 Technical Requirements for LT Transformer

i) The manufacturer, whose LT transformer(s) are offered, must have designed, manufactured, type tested including short circuit test as per IEC/IS or equivalent standards and supplied transformer(s) of atleast 33kV class of 315kVA or higher. The transformer must have been in satisfactory operation[#] for atleast two (2) years as on the date of NOA.

ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that At least 33kV class of 315kVA or higher rating LT transformer(s) must have been designed, manufactured in the above Indian works, type tested (as per IEC/IS standard) including short circuit test and supplied as on the date of NOA.

Note In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor

24.16 Technical Requirements for Composite Long Rod Polymer Insulator (765kV & 400kV)

(i) The manufacturer whose Composite Long rod Insulator are offered, must have designed, manufactured, tested and supplied Composite Long rod Insulator of 120KN or higher electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied Composite Long rod Insulator of 120KN or above electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# as on the date of NOA.

b) Contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor

24.17 **Technical Requirements for Control, Relay & Protection System and Sub-station Automation System**

The manufacturer whose Control, Relay & Protection System (Control & protection Intelligent Electronic Devices (IEDs)), and Sub-station Automation System (as applicable) are offered, must have designed, manufactured, tested, installed and commissioned Control, Relay & Protection system along with Sub-station Automation System which must have been in satisfactory operation# on (i) 400 kV system [applicable for 765kV substation] & (ii) specified voltage level or above [applicable for 400kV & below substation] for atleast two (2) years as on the date of NOA.

AND

The Manufacturer or their joint venture or subsidiary company or parent company must be a manufacturer of control and protection IEDs and must have established repair, testing and integration (at least for 4 bays) facilities for Control, Relay & Protection System and Sub-station Automation System in India.

24.18 Technical Requirements for analog and digital PLCC panels (765kV, 400kV, 220kV & 132kV)

(i) The manufacturer whose PLCC panels are offered, must have designed, manufactured, tested, supplied and commissioned PLCC panels for (i) 400kV system or above [applicable for 765 kV & 400 kV substation], (ii) 220 kV System or above [applicable for 220 kV Substation] & (iii) 132 kV system or above [applicable for 132 kV substation] and the same must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) PLCC panels must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

c) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply PLCC panels in India, shall be submitted.

24.19 Technical Requirement of Communication Equipment

The SDH equipment shall be offered from a manufacturer(s) who is a **"Local Supplier"** as per DPIIT PP notification & has been Manufacturing SDH equipments for the last three (3) years and SDH equipment Manufactured by such manufacturer(s) shall have been satisfactory operation in 110kV or higher voltage Power Substations for at least two (2) years as on the date of NOA

24.20 Technical Requirement for 400kV GIS Equipment

(i) The manufacturer whose 400kV GIS bays are offered must have designed, manufactured, type tested** (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 345kV or above voltage class in one (1) Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Atleast one no. 345kV or above voltage class GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above CB bay (as per IEC or equivalent standard) as on the date of NOA.

b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV or above voltage level GIS equipment in India, shall be submitted.

c) The Collaborator(s) shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.

Note :-

(**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable

24.21 Technical Requirement for 220/132/66 kV* level GIS/Hybrid GIS/MTS Equipment:

(i) The manufacturer whose 220/132/66 kV* level GIS/Hybrid GIS/MTS bays are offered must have designed, manufactured, type tested** (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 220/110/66kV* or above voltage class in one (1) Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Atleast one no. 220/110/66kV* or above voltage level GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above GIS bay (as per IEC or equivalent standard) as on the date of NOA.

b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 220/110/66*kV or above voltage level GIS equipment in India shall be submitted.

c) The Collaborator(s) shall furnish performance guarantee for an amount of 10 % of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.

Note: 1. (*) voltage class of respective equipment as applicable

2. (@) For the purpose of technical requirement, one no. of circuit breaker bay shall be considered as a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs. GIS means SF6 Gas insulated Switchgear.

3. Experience with combination of GIS CB bay/Hybrid GIS CB Bay/MTS CB Bay is also acceptable if supply of only Hybrid/MTS equipment is envisaged. Hybrid GIS means outdoor SF6 Gas insulated switchgear connected to outdoor Air insulated bus-bar System (AIS bus-bars System), MTS means outdoor SF6 Gas insulated Mixed Technology Switchgear connected to outdoor AIS bus bar system. (**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable

4.(**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable

TECHNICAL SPECIFICATION
SECTION-GENERAL TECHNICAL REQUIREMENTS

पावरग्रिड

पावर ग्रिड कार्पोरेशन आफ इन्डिया लिमिटेड

(भारत सरकार का उद्यम)

Power Grid Corporation of India Limited

(A Government of India Enterprises)

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SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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1.0 FOREWORD

The provisions under this section are intended to supplement requirements for the materials, equipment's and services covered under other sections of tender documents and are not exclusive.

2.0 GENERAL REQUIREMENT

2.1 a) All equipment/materials/items, as per Annexure-K, as applicable under present scope of works, shall be procured and supplied from domestic manufacturers only

Any imported equipment/material/item/parts/component (comprising of embedded systems) to be supplied under the contract shall be tested in the certified laboratories to check for any kind of embedded malware/trojans/cyber threats and for adherence to Indian Standards as per the directions issued by Ministry of Power/Govt. of India from time to time. In case of such import from specified "prior reference" countries, the requirement of prior permission from the Govt. of India including protocol for testing in certified and designated laboratories by Ministry of Power/Govt. of India shall also be complied with by the contractor.

The bidder/contractor shall list out the products and components producing Toxic e-waste under the contract and shall furnish to the Employer the procedure of safe disposal at the time of closing of the contract

2.1 b) The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.

2.2 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to Employer.

2.3 Wherever a material or article is specified or defined by the name of a particular brand, Manufacturer or Vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

2.4 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components which are minor in nature and incidental to the requirement but not specifically stated in the specification and bid price schedule, which are necessary for commissioning and satisfactory operation of the switchyard/ substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

2.5 The Contractor shall also be responsible for the overall co-ordination with internal /external agencies; Supplier of Employer's supplied equipments, project management, training of Employer's manpower, loading, unloading, handling, insurance, moving to final destination for successful erection, testing and commissioning of the substation /switchyard.

2.6 The Contractor shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Employer.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of India.

3.2 The equipment offered by the contractor shall at least conform to the requirements specified under relevant IS standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. The Contractor shall also note that the list of standards presented in this specification at Annex-C is not complete. Whenever necessary, the list of standards shall be considered in conjunction with specific IS. If the IS standard is not available for an equipment/material, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted.

3.3 The Contractor shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

3.4 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.5 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-C/ individual sections for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out during detailed engineering along with English language version of such standard. The equipment conforming to standards other than specified under Annexure-C/individual sections for various equipments shall be subject to Employer's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 Switching surge over voltage and power frequency over voltage is specified in the system parameters below. In case of the 400kV system, the initial value of the temporary overvoltages could be 2.0 p.u. for 1-2 cycles. The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.

4.2 All equipments shall also perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.

4.3 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.4 The Contractor shall design terminal connectors of the equipment taking into account various forces as mentioned at Sl.No.4.3 that are required to withstand.

4.5 The equipment shall also comply to the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be "match marked".

b) All piping, if any between equipment control cabinet/operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.6 **System Parameter**

765kV, 400kV & 220kV System

SL No	Description of parameters	765kV System	400kV System	220kV System
1.	System operating voltage	765kV	400kV	220kV
2.	Maximum operating voltage of the system (rms)	800kV	420kV	245kV
3.	Rated frequency	50HZ	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	2100kVp	1550kVp	1050 kVp
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	1550kVp	1050kVp	-
iii)	One minute power frequency dry withstand voltage (rms)	830kV	630kV	-
iv)	One minute power frequency dry and wet withstand voltage (rms)	-	-	460kV
6.	Corona extinction voltage	508 kV	320kV	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	2500 µV at 508 kV rms	1000 µV at 266kV rms	1000 µV at 156kV rms
8.	Minimum creepage distance - for Equipment other than Insulator string	20000 mm (24800 mm for coastal area)	10500 mm (13020 mm for coastal area)	6125 mm (7595 mm for coastal area)
	Minimum creepage distance - for Insulator String	As specified in Section-Switchyard Erection		
9.	Min. clearances			
i.	Phase to phase	7600mm (for conductor-conductor configuration) 9400mm (for rod-conductor configuration)	4000mm (for conductor-conductor configuration) 4200mm (for rod -conductor configuration)	2100 mm

SL No	Description of parameters	765kV System	400kV System	220kV System
ii.	Phase to earth	4900mm (for conductor-structure) 6400mm (for rod- structure)	3500 mm	2100 mm
iii)	Sectional clearances	10300 mm	6500 mm	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA/50kA (as applicable)	40kA/50kA/ 63 kA (as applicable)	40kA/ 50kA(as applicable)
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

132kV, 66kV, 52kV , 33kV & 11kV System

SL No	Description of parameters	132 kV System	66kV System	52 kV System	33 kV System	11kV System
1.	System operating voltage	132kV	66kV	52kV	33kV	11kV
2.	Maximum operating voltage of the system(rms)	145kV	72.5kV	52kV	36kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3	3	3
5.	Rated Insulation Levels					
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kVp	325 kVp	250 kVp	170 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	140kV	95kV	70kV	28kV
6.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	500 µV at 92kV rms	-	-	-	-
7.	Minimum creepage distance	3625 mm (4495mm for coastal area)	1813 mm (2248mm for coastal area)	1300mm (1612 mm for coastal area)	900 mm (1116mm for coastal area)	300 mm (372mm for coastal area)

SL No	Description of parameters	132 kV System	66kV System	52 kV System	33 kV System	11kV System
8.	Min. Clearance					
i.	Phase to phase	1300 mm	750 mm	530mm	320 mm	280 mm
ii.	Phase to earth	1300 mm	630 mm	480mm	320 mm	140 mm
iii.	Sectional clearances	4000 mm	3100 mm	3100mm	2800 mm	2800 mm
9.	Rated short circuit current	40kA/ 31.5 kA (as applicable) for 1 sec	31.5 kA for 3 sec/25kA for 3 Sec*	25kA for 1 Sec	25 kA for 3 sec	25 kA for 3 sec
10.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed

Notes:

1. The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable as per relevant IEC/IS.
2. The insulation and RIV levels of the equipments shall be as per values given in the Technical Specification of respective equipment.
3. Corona and radio interference voltage test and seismic withstand test procedures for equipments shall be in line with the procedure given at **Annexure-A** and **Annexure-B** respectively.
4. "*" For tertiary loading Equipment's fault level shall be 25kA for 3 Sec. For other switchyard equipment shall be as specified in Section project.
5. Costal Area is to be considered only if defined in Section project.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents which are to be submitted to the Employer is enclosed in **Annexure-E**. In case any additional drawings/documents are required, the same shall also be submitted during execution of the contract.

5.2 The contractor shall submit all engineering Documents (Drawings/Design documents/data/detailed bill of quantity/ type test reports) through online Document Review and Engineering Approval Management System (Herein after DREAMS) for the approval of the employer

5.3 Drawings

5.3.1 All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Drawings submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. POWERGRID has standardized a large number of drawings/documents of various make including type test reports which can be used for all projects having similar requirements and in such cases no project specific approval (except for list of applicable drawings alongwith type test reports) is required. However, distribution copies of standard drawings/documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in SI units.

5.3.3 The review of these data by the Employer will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.5 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Employer in Writing.

5.7 Approval Procedure

The following schedule shall be followed generally for approval and for providing final documentation.

i)	Approval/comments/ by Employer on initial submission	As per L2 schedule
ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of receipt of resubmission.
iv)	Furnishing of distribution copies (2 hard copies to each substation and one scanned copy (pdf format)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one scanned softcopy in	2 weeks from the date of final approval

		pdf format to each substation plus one for corporate centre & one hardcopy per substation)	
	(b)	Routine Test Reports (one copy for each substation)	-do-
vi)		Furnishing of instruction/ operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	On completion of Engineering
(vii)		As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre & per substation)	On completion of entire works

NOTE :

(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) All drawings should be submitted in "DREAMS" Portal, further substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version as a supporting document in DREAMS. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

For civil drawings associated documents shall be submitted in STAAD/excel format as supporting document in DREAMS.

(3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.

(5) The Contractor shall furnish to the Employer catalogues of spare parts.

(6) All As-built drawings/documents shall be certified by site indicating the changes before final submission.

5.8 The list of major drawings/documents to be approved to qualify for second advance as per Section SCC, shall be as per **Annexure–D**.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 In case where the equipment, materials or components are indicated in the specification as “similar” to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it is to be understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Employer.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer’s recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer’s tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer’s limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.1.7 All oil, grease and other consumables used in the Works/Equipment shall be purchased in India unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in India. If such is the case, he shall declare source of oil/grease /other consumables in the GTP/Drawings, where such oil or grease is available. He shall help Employer in establishing equivalent Indian make and Indian Contractor. The same shall be applicable to other consumables too.

6.2 Provisions For Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 240V as supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.2 FUNGI STATIC VARNISH

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

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall comply with following degree of protection as detailed here under:

a) Installed out door: IP- 55
b) Installed indoor in air conditioned area: IP-31
c) Installed in covered area: IP-52
d) Installed indoor in non-air conditioned area where possibility of entry of water is limited: IP-41.

e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IS/IEC60947; IS/IEC/60529 . Type test report for of relevant Degree of Protection test, shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, Customer Name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IS/ IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall offer the equipment meeting the requirement of the technical specification. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the contractor & Employer agree upon any such changes, the specification shall be modified accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at POWERGRID Corporate Centre, Gurgaon (Haryana) or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract, whether manufactured or performed within the Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work as applicable, are in accordance with the specifications, the Contractor shall ensure suitable quality assurance programme to control such activities at all points necessary. A quality assurance programme of the Contractor shall be in line with ISO requirements & shall generally cover the following:

a) The organisation structure for the management and implementation of the proposed quality assurance programme.

b) System for Document and Data Control.

c) Qualification and Experience data of Bidder's key personnel.

d) The procedure for purchases of materials, parts, components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

e) System for shop manufacturing and site erection controls including process controls, fabrication and assembly control.

f) System for Control of non-conforming products including deviation dispositioning, if any and system for corrective and preventive actions based on the feedback received from the Customers and also internally documented system for Customer complaints.

g) Inspection and test procedure both for manufacture and field activities.

h) System for Control of calibration of testing and measuring equipment and the indication of calibration status on the instruments.

i) System for indication and appraisal of inspection status.

j) System of Internal Quality Audits, Management review and initiation of corrective and Preventive actions based on the above.

k) System for authorising release of manufactured product to the Employer.

l) System for maintenance of records.

m) System for handling, storage and delivery.

n) A quality plan detailing out the specific quality control measures and procedure adopted for controlling the quality characteristics relevant to each item of equipment furnished and /or service rendered.

o) System for various field activities i.e. unloading, receipt at site, proper storage, erection, testing and commissioning of various equipment and maintenance of records. In this regard, the Employer has already prepared Standard Field Quality Plan for transmission line/substation equipments as applicable, Civil/erection Works which is required to be followed for associated works.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

8.2 Quality Assurance Documents

The Contractor shall ensure availability of the following Quality Assurance Documents:

i) All Non-Destructive Examination procedures, stress relief and weld repair procedure actually used during fabrication, and reports including radiography interpretation reports.

ii) Welder and welding operator qualification certificates.

iii) Welder's identification list, welding operator's qualification procedure and welding identification symbols.

iv) Raw Material test reports on components as specified by the specification and in the quality plan.

v) The Manufacturing Quality Plan(MQP) indicating Customer Inspection Points (CIPs) at various stages of manufacturing and methods used to verify that the inspection and testing points in the quality plan were performed satisfactorily.

vi) Factory test results for testing required as per applicable quality plan/technical specifications/GTP/Drawings etc.

vii) Stress relief time temperature charts/oil impregnation time temperature charts, wherever applicable.

8.3 INSPECTION, TESTING & INSPECTION CERTIFICATE

8.3.1 Contractor shall procure bought out items from sub-vendors as per the list in "Compendium of Vendors" available on POWERGRID web-site www.powergridindia.com after ensuring compliance to the requirements/conditions mentioned therein. Contractor shall explore first the possibilities of procuring the bought out items from POWERGRID approved existing vendors. In case of their unavailability / non-response, Contractor may approach POWERGRID for additional sub-vendor approval. In that case, the assessment report of proposed sub vendor by Contractor along with the enclosures as per **Annexure-F** shall be submitted within 60 days of the award. The proposal shall be reviewed and approval will be accorded based on the verification of the document submitted and/or after the physical assessment of the works as the case may be. The physical assessment conducted by POWERGRID, if required, shall be on chargeable basis. Charges shall be as per the POWERGRID norms prevailing at that time, which shall be intimated by POWERGRID separately. If proposal for sub-vendor is submitted after 60 days, the Contractor's proposal normally will not be considered for current LOA. However, POWERGRID may process the case for developing more vendors for referred items, if found relevant. In all cases, It is the responsibility of the Contractor that Project activities do not suffer on account of delay in approval/non approval of a new sub-vendor.

The responsibility and the basis of inspection for various items & equipment is placed at **Annexure-G** along with the requirement of MQP (Manufacturing Quality Plan), ITP(Inspection & Test Plan), FAT(Factory Acceptance Test) which should be valid & POWERGRID approved and Level of inspection envisaged against each item.

Contractor shall ensure that order for items where MQP/ITP/FAT is required will be placed only on vendors having valid MQP/ITP/FAT and where the supplier's MQP/ITP/FAT is either not valid or has not been approved by POWERGRID, MQP shall be generally submitted as per POWERGRID format before placing order.

Items not covered under MQP/ITP/FAT shall be offered for inspection as per POWERGRID LOA/technical Specifications/POWERGRID approved data sheets/ POWERGRID approved drawings and relevant Indian/International standards.

Inspection **Levels**: For implementation of projects in a time bound manner and to avoid any delay in deputation of POWERGRID or its authorized representative, involvement of POWERGRID for inspection of various items / equipment will be based on the level below:

Level –I: Contractor to raise all inspection calls and review the report of tests carried out by the manufacturer, on his own, as per applicable standards/ POWERGRID specification, and submit to concerned POWERGRID inspection office/Inspection Engineer. CIP/MICC will be issued by POWERGRID based on review of test reports/certificates of manufacturers.

Level – II: Contractor to raise all inspection calls and carry out the inspection on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during inspection, the same would be intimated to

Contractor and CIP/MICC will be issued by POWERGRID. Else, Contractor would submit their test reports/certificates to POWERGRID. CIP/MICC will be issued by POWERGRID based on review of test reports/ certificates.

Level - III: Contractor to raise inspection calls for both, stage (as applicable) & final inspection and carry out the stage inspections (if applicable) on behalf of POWERGRID on the proposed date of inspection as per applicable standards/specification. However, in case POWERGRID wishes to associate itself during stage inspection, the same would be intimated to Contractor and CIP will be issued by POWERGRID. Else, Contractor would submit the test reports / certificates of stage inspection after their own review and CIP will be issued by POWERGRID based on review of test reports / certificates. Final inspection will be carried out by POWERGRID and CIP/MICC will be issued by POWERGRID.

Level – IV: Contractor to raise inspection calls for both, stage (as applicable) & final inspections. POWERGRID will carry out the inspection for both stage & final inspection as per applicable standards/specification and CIP/MICC will be issued by POWERGRID.

8.3.2 Contractor shall ensure that to implement the above inspection levels, particularly for the quality control and inspection at sub-vendor's works, they would depute sufficient qualified & experienced manpower in their Quality Control and Inspection department. Further, to assure quality of construction, Contractor shall have a separate workforce having appropriate qualification & experience and deploy suitable tools and plant for maintaining quality requirement during construction in line with applicable Field Quality Plan (FQP).

8.3.3 The Employer, his duly authorised representative and/or outside inspection agency acting on behalf of the Employer shall have at all reasonable times access to the Contractor's premises or Works and shall have the power at all reasonable times to ensure that proper Quality Management practices / norms are adhered to, inspect and examine the materials & workmanship of the Works, to carry out Quality/Surveillance Audit during manufacture or erection and if part of the Works is being manufactured or assembled at other premises or works. The Contractor shall obtain for the Employer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. The item/equipment, if found unsatisfactory with respect to workmanship or material is liable to be rejected. The observations for improvements during product/ process inspection by POWERGRID shall be recorded in Quality Improvement Register (available & maintained at works) for review & timely compliance of observations.

8.3.4 Contractor shall submit inspection calls over internet through POWERGRID website. The required vendor code and password to enable raising inspection call will be furnished to the main Contractor within 30 days of award of contract on submission of documents by Contractor. After raising the inspection calls, Contractor shall then proceed as per the message of that particular call which is available on the message board.

8.3.5 The Employer reserves the right to witness any or all type, acceptance and routine tests specified for which the Contractor shall give the Employer/Inspector Twenty one (21) days written notice of any material being ready for testing for each stage of testing as identified in the approved quality plan as customer inspection point(CIP) for indigenous inspections. All inspection calls for overseas material shall be given at least forty five (45) days in advance. Such tests shall be to the Contractor's account except for the expenses of the Inspection Engineer. The Employer/inspector, unless witnessing of the tests is waived by Employer, will attend such tests within Twenty one (21) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector three copies of tests, duly certified. Contractor shall ensure, before giving notice for type test, that all drawings and quality plans have been got approved. The equipment shall be dispatched to site only after approval of Routine and Acceptance test results and Issuance of Dispatch Clearance in writing by the Employer. CIP/Material Inspection clearance certificate (MICC) shall be issued by the Employer after inspection of the equipment or review of test reports as applicable. Employer may waive off the presence of Employer's inspecting engineer. In that case test will be carried out as per approved QP and test certificate will be furnished by the supplier for approval. CIP/MICC will be issued only after review and approval of the test reports.

8.3.6 Contractor shall generally offer material for inspection as per supply bar chart approved by POWERGRID and not before 30 days from schedule indicated in the bar chart. In case Contractor offers material(s) for inspection prior to 30 days from the scheduled date with necessary approval of POWERGRID, POWERGRID shall inspect the material and issue CIP only. However, in such an exceptional case, MICC shall be issued only as per provision of original / revised approved supply schedule.

8.3.7 Contractor shall minimize the number of inspection calls by offering optimum quantities in each inspection call at the respective manufacturer's works.

8.3.8 Contractor shall inspect the material themselves and only after they are fully convinced about the Quality, they shall offer the material for POWERGRID inspection and shall also ensure that relevant portion of LOA/NOA, approved drawing and data sheets along with applicable Quality Plans are available at the works of Contractor or their Sub-vendor before the material is offered for inspection.

8.3.9 Contractor shall ensure that material which has been cleared for dispatch after inspection will be dispatched within 30 days in case of domestic supplies and within 60 days in case of Off-shore supplies from the date of issuance of CIP. Material which is not dispatched within stipulated time as above will be reoffered for POWERGRID inspection or specific approval of POWERGRID QA&I shall be obtained for delayed dispatch.

8.3.10 The Employer or IE shall give notice in writing to the Contractor, of any objection either to conformance to any drawings or to any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Employer/Inspection Engineer giving reasons therein, that no modifications are necessary to comply with the Contract.

8.3.11 All Test Reports and documents to be submitted in English during final inspection of equipment by POWERGRID or as and when required for submission.

8.3.12 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer/Inspection Engineer(IE) shall issue a certificate to this effect within fifteen (15) days after completion of tests & submission of documents by Contractor/manufacturer but if the tests are not witnessed by the Employer/IE, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Employer/IE. Contractor shall, on completion of all tests, submit test reports within Ten (10) days to POWERGRID IE. Failure of the Employer/IE to issue such a certificate shall not prevent the Contractor from proceeding with the Works.

The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract.

8.3.13 In all cases, where the Contract provides for tests whether at the premises or works of the Contractor or of any Sub- Contractor, the Contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer/Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer/Inspection Engineer or to his authorised representative to accomplish testing.

8.3.14 The inspection and acceptance by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract, or if such equipment is found to be defective at a later stage.

8.3.15 The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor’s premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

8.3.16 The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.

8.3.17 Rework/ Re-engineering, if any, on any item/equipment shall be carried out only after mutual discussions and in accordance with mutually agreed procedure. Contractor shall submit Joint Inspection Report of equipments under Re-Work/Re-Engineering alongwith procedure for the same to POWERGRID for approval, before taking up the Re-Work/Re-Engineering, failing which POWERGRID reserves the right to reject the equipment.

8.3.18 Contractor may establish a field test Laboratory to execute Civil Construction testing requirements at site with the condition that all testing equipment shall be calibrated from POWERGRID approved accredited Testing laboratories, with calibration certificates kept available at site and all testing personnel employed in the Field Testing Laboratories to be qualified and experienced Engineers or testing to be carried out at POWERGRID approved Third Party Laboratories.

8.3.19 Contractor shall ensure that all possible steps are taken to avoid damages to the equipment during transport, storage and erection.

8.3.20 Contractor shall implement additional stringent quality checks and preparation during installation of GIS at site (if applicable) as per POWERGRID approved guidelines/Technical specifications.

8.3.21 Contractor shall ensure commissioning of all CSDs along with Circuit Breakers wherever applicable.

8.3.22 For EHV transformers/reactors:

Insulation oil shall be as per POWERGRID Technical specifications and same grade shall be used for impregnation of the active part & testing at the works of Transformer/Reactor Manufacturer and as well as for filling the Transformer/Reactors at site. Contractor to ensure that windings for Transformer/Reactors are made in air-conditioned environment. Core-coil assembly shall be performed in positive pressurized dust controlled environment. Dust measurements shall be monitored regularly at Transformer / Reactor Manufacturer works. Contractor shall ensure that respective civil foundations & Fire walls for Transformer/Reactors units to be commissioned, shall be made ready at concerned sites before receipt of Transformer/Reactors units. All the requisite material for Neutral & Delta Bus formation required for charging of complete bank of 765KV class 1-ph Transformer/Reactor units shall be made available at the concerned sites before receipt of the Transformer/Reactor units at site.

8.3.23 The Employer reserves the right to increase or decrease their involvement in inspections at Contractor's Works or at his Sub-Contractor's premises or at the Employer's site or at any other place of Work based on performance of Contractor/sub-Contractor.

9.0 TYPE TESTING & CLEARANCE CERTIFICATE

9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective sections.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor along with equipment / material drawings. However, type test reports of similar equipments/ material already accepted in POWERGRID shall be applicable for all projects with similar requirement. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID/representative authorized by POWERGRID/representative of Utility /representative of accredited test lab/ representative of The National Accreditation Board for Certification Bodies(NABCB) certified agency shall also be acceptable.

Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted within the years specified below from the date of NOA. In case the test reports are of the test conducted earlier than the years specified below from the date of NOA, the contractor shall repeat these test(s) at no extra cost to the Employer.

S.No	Name of Equipment	Validity of type test(in years)
1	Power Transformer	5
2	LT Transformer	5
3	Shunt Reactor	5
4	OLTC	10
5	Bushing of Power Transformers/Reactors	7
6	Fittings and accessories for Power transformers & Reactors	10
7	Circuit Breaker	10
8	Isolator	10
9	Lighting Arrester	10
10	Wave Trap	10
11	Instrument transformer	7
12	GIS & Hybrid GIS	10
13	LT Switchgear	10
14	Cable and associated accessories	10
15	Relays	7
16	Capacitors	10

17	Battery & Battery Charger	7
18	Conductor & Earth wire	10
19	Insulators (Porcelain/Glass)	10
20	Composite Insulators	5
21	PLCC	5

Note

For all other equipment's validity of type test shall be 10 years from date of NOA

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the type tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.3 The Employer intends to repeat those type tests which are indicated in the price schedule and the same shall be payable as per provision of contract. The price of conducting type tests shall be included in Bid price and break up of these shall be given in the relevant schedule of Bid Proposal Sheets. These Type test charges would be considered in bid evaluation. In case Bidder does not indicate charges for any of the type tests or does not mention the name of any test in the price schedules, it will be presumed that the particular test has been offered free of charge. Further, in case any Bidder indicates that he shall not carry out a particular test, his offer shall be considered incomplete and shall be liable to be rejected. The Employer reserves the right to waive the repeating of type tests partly or fully and in case of waival, test charges for the same shall not be payable.

9.4 The Employer reserves the right to witness any or all the type tests. The Employer shall bear all expenses for deputation of Employer's representative(s) for witnessing the type tests except in the case of re-deputation if any, necessitated due to no fault of the Employer.

9.5 The list of makes of various items, for which Type test reports are not required to be submitted are specified at Annexure-J.

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Employer will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be arranged by the Contractor at his own cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3.4 **PRECOMMISSIONING, COMMISSIONING, TRIAL-RUN & COMPLETION**

As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract, Vol.-I of the Bidding Documents.

(i) Pre commissioning	:	As per relevant Sections
(ii) Commissioning	:	Charging of the Facilities at rated voltage.

Further, wherever appearing in these specifications, the words–'commissioning checks', 'installation checks', 'site tests', 'performance guarantee tests for fire protection system', are to be considered as 'pre commissioning checks'.

(iii) Trial-run	:	Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72 (Seventy two) hours continuously. In case of interruption due to problem/ failure in the respective equipment, the contractor shall rectify the problem and after rectification, continuous 72 (Seventy two) hours period start after such rectification.
(iv) Completion	:	Upon successful completion of Trial-run.

'Guarantee Test(s)' and/or 'Functional Guarantees' are applicable only for Substation Automation System as specified in Section-'Substation Automation System.'

10.3. The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However necessary fee shall be reimbursed by POWERGRID on production of requisite documents.

11.0 PACKAGING & PROTECTION

11.1 All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Employer to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Employer takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to IS: 2629.

12.2 HOT DIP GALVANISING

12.2.1 The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above **and 900 gm/sq.m for coastal area (if defined in Section Project)** For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq.m minimum **and 900 gm/sq.m for coastal area (if specified in Section-Project).**

12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

12.2.3 After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate or alternate approved treatment shall be provided to avoid formation of white rust after hot dip galvanization.

12.2.4 The galvanized steel shall be subjected to four numbers of one minute dips in copper sulphate solution as per IS-2633.

12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

12.2.6 Galvanised material must be transported properly to ensure that galvanised surfaces are not damaged during transit. Application of touch-up zinc rich paint at site shall be allowed with approval of Engineer Incharge.

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS-6005 “Code of practice for phosphating iron and sheet”. All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 Hot Phosphating shall be done for phosphating process under pretreatment of sheets After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective sections of the equipments. Glossy white colour inside the equipments /boards /panels/junction boxes is also acceptable. The exterior colour for panels shall be matching with the existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

12.3.5 In case the contractor proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted during detailed engineering for Employer's review & approval.

12.3.6 The colour scheme as given below shall be followed for Fire Protection and Air Conditioning systems

S.No.	PIPE LINE	Base colour	Band colour
Fire Protection System			
1	Hydrant and Emulsifier system pipeline/NIFPS	FIRE RED	-
2	Emulsifier system detection line – water	FIRE RED	Sea Green
3	Emulsifier system detection line –Air	FIRE RED	Sky Blue
4	Pylon support pipes	FIRE RED	
Air Conditioning Plant			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

The direction of flow shall be marked by → (arrow) in black colour.

Base Colour Direction of flow Band Colour

12.3.7 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures, the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting. For stainless steel surfaces, no painting is envisaged.

12.3.8 Band colour is required for Emulsifier system detection line only if both water and air detection lines are present at the same substation. Further, band colour shall be applied at an interval of 2 meters approx. along the length and minimum width of band shall be 25mm.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 The contractor must ensure that the open storage platform (as per Drawing No. C-ENGG-CVL-STD-PLATFORM-01, Rev.0) is constructed for storage of outdoor type equipment/material prior to commencement of delivery at site. Outdoor equipment shall be stored on open storage platform, properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress.

However, all indoor equipments including control & protection panels, Communication equipments and operating mechanism boxes etc. of outdoor equipments shall be stored indoors.

Storage of equipment on top of another one is not permitted if the wooden packing is used and there is possibility of equipment/packing damage. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.5 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

13.6 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the weeks. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.

13.7 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.9 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.

13.10 The words 'erection' and 'installation' used in the specification are synonymous.

13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.12 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.13 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

13.14 Erection, testing and commissioning of Transformers, Reactors, Circuit breakers, Isolators, Substation automation system, Control & protection panels, PLCC, PMU, Telecommunication Equipments, NIFPS System etc. shall be done by the contractor under the supervision of respective equipment manufacturers. Charges for the above supervision shall be included by the bidder in the erection charges for the respective equipment in the BPS.

14.0 TOOLS

14.1 TOOLS & PLANTS (T&P)

The Contractor shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further, all consumables, wastage and damages shall be to the account of contractor.

All such T&P shall be taken back by the contractor after commissioning of the system.

14.2 SPECIAL TOOLS AND TACKLES

The contractor shall supply all special tools and tackles required for Operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. The list of special tools and tackles, if any, shall be finalized during detail engineering and the same shall be supplied without any additional cost implication to the Employer.

14.3 FACILITIES TO BE PROVIDED BY THE EMPLOYER

14.3.1 Employer shall make available the auxiliary supplies at a single point in the substation on chargeable basis. The prevailing energy rates of the state shall be applicable. All further distribution from the same for construction supply shall be made by the contractor. However, in case of failure of power due to any unavoidable circumstances, the contractor shall make his own necessary arrangements like diesel generator sets etc. at his own cost so that progress of work is not affected and Employer shall in no case be responsible for any delay in works because of non-availability of power.

14.3.2 Employer shall make available construction water supply at a single point in the substation. All further distribution for the same shall be made by the Contractor. In case of non-availability or inadequate availability of water for construction work, the contractor shall make his own arrangement at his own cost and the Employer shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

15.0 AUXILIARY SUPPLY

15.1 The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following table:

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase/Wire	Neutral connection
415V	± 10%	50 ± 5%	3/4 Wire	Solidly Earthed.
240V	± 10%	50 ± 5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	Isolated 2 wire System	-
110V	95V to 120V	DC	Isolated 2 wire System	-
48V	--	DC	2 wire system (+) earthed	-

Combined variation of voltage and frequency shall be limited to ± 10%.

15.2 Pickup value of binary input modules of Intelligent Electronic Devices, Digital protection couplers, Analog protection couplers shall not be less than 50% of the specified rated station auxiliary DC supply voltage level.

16.0 SUPPORT STRUCTURE

16.1 The equipment support structures shall be suitable for equipment connections at the first level i.e 14.0 meter, 8.0 meter, 5.9 meter and 4.6 meter from plinth level for 765kV, 400kV, 220kV and 132kV substations respectively. All equipment support structures shall be supplied alongwith brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.

16.2 The minimum vertical distance from the bottom of the lowest porcelain/polymer part of the bushing, porcelain/polymer enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

17.1 All power clamps and connectors shall conform to IS:5561 or other equivalent international standard and shall be made of materials listed below :

Sl. No.	Description	Materials
a)	For connecting ACSR conductors/AAC conductors/ Aluminium tube	Aluminum alloy casting, conforming to designation **4600** of IS:617 and all test shall conform to IS:617
b)	For connecting equipment terminals mad of copper with ACSR conductors/AAC conductors/ Aluminium tube	Bimetallic connectors made from aluminum alloy casting, conforming to designation **4600** of IS:617 with 2mm thick bimetallic liner/strip and all test shall conform to IS:617
c)	For connecting G.I	Galvanised mild steel shield wire
d)	Bolts, nuts & plain washers	Electro-galvanised for sizes below M12, for others hot dip galvanised.
e)	Spring washers	Electro-galvanised mild steel suitable for atleast service condition-3 as per IS:1573

17.2 Necessary clamps and connectors shall be supplied for all equipment and connections. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.

17.3 Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

17.4 Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, are also included in the scope of Work.

17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner/strip of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic liner/strips shall be provided for Bi-metallic clamps.

17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS AL tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

17.8 Current carrying parts (500A and above) of the clamp/connector shall be provided with minimum four numbers of bolts preferably for 132kV and above.

17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.

17.10 Power Clamps and connectors shall be designed to control corona as per requirement.

17.11 Tests

Clamps and connectors should be type tested on minimum three samples as per IS:5561 and shall also be subjected to routine tests as per IS:5561. Following type test reports shall be submitted for approval. Type test once conducted shall hold good. The requirement of test conducted within last ten years, shall not be applicable.

i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)

ii) Short time current test

iii) Corona (dry) and RIV (dry) test [for 132kV and above voltage level clamps]

iv) Resistance test and Pullout strength test

v) Cantilever Strength test on bus support clamps & connectors

18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS/IEC 61439-0, as applicable, and the clauses given below:

18.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes, Out door ACDB cum DCDB panels shall be made of stainless steel of atleast 1.5 mm thick or aluminum enclosure of atleast 1.6 mm thick and shall be dust, water and vermin proof. Stainless steel used shall be of grade SS304 (SS316 for coastal area) or better. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

Control cabinets, junction boxes, marshalling boxes & terminal boxes, out-door ACDB cum DCDB panels shall have adequate space/clearance as per guidelines/technical specifications to access/replace any component. Necessary component labelling to be also done on non-conducting sheet.

For CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES MARSHALLING BOXES FOR OUTDOOR EQUIPMENT Junction Box, wire should be as per IS or equivalent IEC with FRLS grade

Machine laid PU Foam gasket may be permitted for use in Control Cabinets etc.

18.3 A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

18.4 Cabinet/boxes with width more than 700 mm shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere.

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene/PU gaskets. The gasket shall be tested in accordance with approved quality plan, IS:11149 and IS:3400. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

Further, the gasketing arrangement shall be such that gaskets are pasted in slots (in door fabrication/gasket itself) in order to prevent ingression of dust and moisture inside the panels so that no internal rusting occurs in panels during the operation of the equipment.

18.6 All boxes/cabinets shall be designed for the entry of cables by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

18.7 A 240V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

18.8 LED based illumination of minimum 9 watts shall be provided. The switching of the fittings shall be controlled by the door switch.

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.

18.10 Earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

18.12 The following routine tests alongwith the routine tests as per IS:5039 shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

18.13 The enclosure of bay marshalling kiosk, junction box, terminal box and control cabinets shall conform to IP-55 as per IS/IEC60947 including application of 1kV rms for 1 (one) minute, after IP-55 test.

19.0 DISPOSAL OF PACKING MATERIAL & WASTE FROM CONSTRUCTION SITE

After completion of the work, Contractor shall dispose-off all the packing & waste materials including empty conductor drums, cable drums, wooden containers, oil drums, gas cylinders and other waste/scrapped materials from construction site at his own cost and shall make the substation area properly cleaned.

20.0 TERMINAL BLOCKS AND WIRING

20.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

20.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non-breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But the terminal blocks shall be non-disconnecting stud type except for the secondary junction boxes of Current Transformer and Voltage Transformer.

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

20.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

20.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

20.6 The terminal blocks shall be of extensible design, multilayer terminal arrangement is not allowed in any junction box (Common MB, Individual MB, JB etc.). There should be sufficient space at both sides of terminals so that ferrule number of wires / TB numbers are clearly visible during wire removal or insertion.

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

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

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

a)	All circuits except CT/PT circuits	Minimum of two of 2.5 sq mm copper flexible.
b)	All CT/PT circuits	Minimum of 4 nos. of 2.5 sq mm copper flexible.

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

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

20.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

20.13 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.

21.0 LAMPS & SOCKETS

21.1 Lamps & Sockets

All lamps shall use a socket base as per IS-1258, except in the case of signal lamps.

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard Indian plugs. They shall be switched sockets with shutters.

21.2 Hand Lamp:

A 240 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

21.3 Switches and Fuses:

21.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switch fuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

21.3.2 All fuses shall be of HRC cartridge type conforming to relevant IS mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

22.0 BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS:

22.1 Bushings shall be manufactured and tested in accordance with IS:2099 & IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155/IS:5621.The support insulators shall be manufactured and tested as per IS:2544/IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.

The bidder may also offer composite hollow insulators, conforming to IEC-61462.

22.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

22.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

22.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

22.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

22.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

22.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

22.8 Void

22.9 **RTV Coating on porcelain insulators (for coastal area)**

RTV coating shall be done at site on all porcelain insulators (i.e. bushings, hollow and solid insulators, disc insulators etc.) for substation(s) in coastal area if defined in section Project. The cost of RTV coating shall be deemed to be included in the respective equipment/items' erection cost. The technical details of RTV coating is attached in **Annexure-H.**

22.10 In case, different designs of lattice and pipe structures other than Employer supplied structures are required to be adopted in view of higher creep age (31mm/kV) of the switchgear/equipment's, insulator strings, bushings & bus post insulators etc., Design, supply & erection of such structures shall be in the scope of contractor against respective standard structure. However dimensional details (except height) shall not be less than that specified in standard structure drawing of respective equipment's.

23.0 MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

23.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IS: 4691. For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per IS: 4691.

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they will drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

23.2 Operational Features

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that will rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system having the particulars as given in Clause 15.0 of this Section.

23.3 Starting Requirements:

a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in IS:325.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS:325 (for 3-phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in IS: 4729. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

23.5 TESTING AND COMMISSIONING

An indicative list of tests is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./Instructions of the equipment Contractor or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

(c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

24. TECHNICAL REQUIREMENT OF EQUIPMENTS

Following equipment shall be offered from the **Indian Manufacturing facilities** of manufacturer(s) who meets the technical requirements as stipulated here, provided the same equipment are not covered under the Bidder's Qualifying requirement of the Bidding Documents.

Legend:

* : voltage class of respective equipment as applicable.

: **satisfactory operation** means certificate issued by the Employer/Utility certifying the operation without any adverse remark.

@ : **Circuit Breaker Bay** means a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs

NOA: means Notification Of Award

24.1 Technical requirements for 765/400/220/132/110kV* Air Insulated Switchgear (AIS) Equipment* (i.e Circuit Breaker, Isolator, Current Transformer, Capacitive Voltage transformer, Inductive Voltage transformer, Surge Arrester and Wave Trap)

(i) The manufacturer(s) whose 765/400/220/132/110kV* equipment(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715/345/220/132/110kV* or higher voltage class equipment(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered equipment and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715/345/220/132/110kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor

24.2 Technical Requirement for 765kV class Transformer

(i) The Manufacturer whose 765kV Transformer(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA, and the same transformer (s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715 kV or higher voltage class either One (1) no. 1-phase Transformer of at least 166 MVA capacity or One (1) no. 1-phase Reactor of at least 80 MVAR capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 765kV transformer in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of **3%** of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor

24.3 Technical Requirement for 765kV class Reactor

(i) The Manufacturer whose 765kV Reactor(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Reactor of at least 110 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 36.7 MVAR and the same Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

OR

The Manufacturer must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA and the bidder should have designed, manufactured, tested & supplied 345 kV or higher voltage class one (1) number 3-phase Reactor of at least 50 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 16.7 MVAR and the same Transformer(s) & Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 715 kV or higher voltage class either One (1) no. 1-phase Reactor of at least 80 MVAR capacity or One (1) no. 1-phase Transformer of at least 166 MVA capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 765kV Reactor in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of **3%** of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.4 Technical Requirement for 400kV, 220kV, 132kV class Transformer

(i) The manufacturer whose transformer(s) are offered must have designed, manufactured, tested and supplied transformers as per table below:

345kV or above class 3-phase transformers of at least 200 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 66.7 MVA	applicable for supply of 400kV class Transformer
220kV or above class 3-phase transformers of at least 50 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 16.7 MVA	applicable for supply of 220kV class Transformer
commissioned 132kV or above class 3-phase transformers of at least 20 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 6.7 MVA	applicable for supply of 132kV class Transformer

These Transformer(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 220kV (applicable for supply of 400kV class Transformer)/ 132kV (applicable for supply of 220kV class Transformer)/ 66kV (applicable for supply of 132kVclass Transformer)or higher voltage class transformers must have been designed, manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV/220kV/132kV* transformer in India, shall be submitted.

c) The collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.5 Technical Requirement for 400kV, 220kV and 132kV class Reactor

(i) The Manufacturer whose 400kV/220kV/132kV* Reactor(s) are offered must have designed, manufactured, tested & supplied Reactor as per table below:

345kVor above class 3-phase shunt	applicable for supply of 400kV class

reactor of at least 50 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors, each having capacity of at least 16.7 MVAR	Reactors
220kV or above class 3-phase shunt reactor of at least 20 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 6.67 MVAR	applicable for supply of 220kV class Transformer
132kV or above class 3-phase shunt reactor of at least 15 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 5 MVAR	applicable for supply of 132kV class Transformer

These Reactor(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Such manufacturer has designed, manufactured based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied 400kV class transformer or 220kV or above class shunt reactors (applicable for supply of 400kV class Reactors) / 220kV class transformer or 132kV or above class shunt reactors (applicable for supply of 220kV class Reactors)/ 132kV class transformer or 66kV or above class shunt reactors (applicable for supply of 132kV class Reactors) as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply the Reactor in India, shall be submitted.

c) the collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

24.6 Technical Requirement for 400 kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 400kV grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 400kV grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

OR

b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 400kV grade XLPE insulated Cable as on the date of NOA.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.

24.7 Technical Requirement for 220KV,132kV,110kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 220kV/132kV/110kV* or higher grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 220kV/132kV/110kV* or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

OR

b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 220kV/132kV/110kV* or higher grade XLPE insulated Cable as on the date of NOA.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor

24.8 Technical Requirement for 66kV Grade XLPE Power Cables

(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 66kV or higher grade XLPE insulated cable which must be in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied 66kV or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.

24.9 Technical Requirement for 1.1 KV Grade PVC Control Cable

The manufacturer(s), whose PVC control cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV grade PVC insulated control cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 27C x 2.5 Sq.mm or higher size as on the date of NOA.

24.10 Technical Requirement for 1.1 KV Grade PVC Power Cable

The manufacturer(s), whose PVC Power Cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV or higher grade PVC insulated power cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 150 Sq. mm or higher size as on the date of NOA.

24.11 Technical Requirement for 1.1 KV Grade XLPE Power Cables

The manufacturer(s), whose XLPE Power cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 630 Sq. mm or higher size as on the date of NOA.

24.12 Technical Requirement for LT Switchgear

i) The manufacturer whose LT Switchgear(s) are offered, must be a manufacturer of LT Switchboards of the type and rating being offered. He must have designed, manufactured, tested and supplied atleast 50 nos. draw out circuit breaker panels, out of which atleast 5 nos. should have been with relay and protection schemes with current transformer. He must have also manufactured atleast 50 nos. MCC panels comprising of MCCBs (ie Moulded Case Circuit Breakers) modules of the type offered which must be in satisfactory operation# as on the date of NOA.

ii) The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design, atleast one hundred circuit breakers of the make and type being offered must have been in satisfactory operation# as on the date of NOA.

24.13 Technical Requirements for Battery

The manufacturer whose Batteries are offered, must have designed, manufactured and supplied DC Batteries of the type specified and being offered, having a capacity of atleast 600 AH and these must be satisfactory operation# for atleast two (2) years in power sector or industrial installations as on the date of NOA.

24.14 Technical Requirements for Battery Charger

The manufacturer, whose Battery Chargers are offered, must have designed, manufactured and supplied Battery Chargers generally of the type offered, with static automatic voltage regulators and having a continuous output of atleast ten (10) KW and these must have been in satisfactory operation# as on the date of NOA.

24.15 Technical Requirements for LT Transformer

i) The manufacturer, whose LT transformer(s) are offered, must have designed, manufactured, type tested including short circuit test as per IEC/IS or equivalent standards and supplied transformer(s) of atleast 33kV class of 315kVA or higher. The transformer must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that At least 33kV class of 315kVA or higher rating LT transformer(s) must have been designed, manufactured in the above Indian works, type tested (as per IEC/IS standard) including short circuit test and supplied as on the date of NOA.

Note In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor

24.16 Technical Requirements for Composite Long Rod Polymer Insulator (765kV & 400kV)

(i) The manufacturer whose Composite Long rod Insulator are offered, must have designed, manufactured, tested and supplied Composite Long rod Insulator of 120KN or higher electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) The manufacturer must have designed, manufactured, type tested and supplied Composite Long rod Insulator of 120KN or above electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# as on the date of NOA.

b) Contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.

Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor

24.17 **Technical Requirements for Control, Relay & Protection System and Sub-station Automation System**

The manufacturer whose Control, Relay & Protection System (Control & protection Intelligent Electronic Devices (IEDs)), and Sub-station Automation System (as applicable) are offered, must have designed, manufactured, tested, installed and commissioned Control, Relay & Protection system along with Sub-station Automation System which must have been in satisfactory operation# on (i) 400 kV system [applicable for 765kV substation] & (ii) specified voltage level or above [applicable for 400kV & below substation] for atleast two (2) years as on the date of NOA.

AND

The Manufacturer or their joint venture or subsidiary company or parent company must be a manufacturer of control and protection IEDs and must have established repair, testing and integration (atleast for 4 bays) facilities for Control, Relay & Protection System and Sub-station Automation System in India.

24.18 Technical Requirements for analog and digital PLCC panels (765kV, 400kV, 220kV & 132kV)

(i) The manufacturer whose PLCC panels are offered, must have designed, manufactured, tested, supplied and commissioned PLCC panels for (i) 400kV system or above [applicable for 765 kV & 400 kV substation], (ii) 220 kV System or above [applicable for 220 kV Substation] & (iii) 132 kV system or above [applicable for 132 kV substation] and the same must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) PLCC panels must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.

c) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply PLCC panels in India, shall be submitted.

24.19 Technical Requirement of Communication Equipment

The SDH equipment shall be offered from a manufacturer(s) who is a **"Local Supplier"** as per DPIIT PP notification & has been Manufacturing SDH equipments for the last three (3) years and SDH equipment Manufactured by such manufacturer(s) shall have been satisfactory operation in 110kV or higher voltage Power Substations for at least two (2) years as on the date of NOA

24.20 Technical Requirement for 400kV GIS Equipment

(i) The manufacturer whose 400kV GIS bays are offered must have designed, manufactured, type tested** (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 345kV or above voltage class in one (1) Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Atleast one no. 345kV or above voltage class GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above CB bay (as per IEC or equivalent standard) as on the date of NOA.

b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV or above voltage level GIS equipment in India, shall be submitted.

c) The Collaborator(s) shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.

Note :-

(**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable

25.0 Technical Requirement of Sub-contractors:

The sub-contractor must have either of the following experience of having successfully completed similar works during last 7 years as on the last day of month previous to the one in which the sub-contractor is proposed to be engaged:

a) Three similar works costing not less than the amount equal to 40% of the cost of the work to be sub-contracted.

OR

b) Two similar works costing not less than the amount equal to 50% of the cost of the work to be sub-contracted.

OR

c) One similar work costing not less than the amount equal to 80% of the cost of the work to be sub-contracted.

1. Minimum Average Annual Turnover **(MAAT) for best three years i.e. 36 months out of last five financial years of the sub-contractor should be……….:

**Annual Gross Revenue from operations/ Gross operating income as incorporated in the profit & loss account excluding Other Income.

Note:

a) Similar work shall mean the work which are of similar in nature to the work to be sub-contracted e.g. for the scope of civil work to be sub-contracted, the experience should be of civil work.

b) The aforesaid qualifying requirement shall however, not be applicable for engaging labour as per extant policy.

c) The cost of the work to be sub-contracted shall be considered as available in the Contract Agreement. However, if the value is not available in the Contract Agreement, the same shall be the estimated value for such work.

d) The above criteria is in addition to extant policy on selection of sub-contractor as per WPPP, Vol-II.

e) The MAAT requirement shall be worked out basis the following formula:

Minimum Average Annual Turnover (MAAT) = Cost of the work to be sub-contractedx1.5/Completion period in years**

**The completion period shall be considered as 1 year even if the same is less than 1 year.

26.0 **Technical Requirement of Sub-contractors of GIS Packages**

In case of GIS is supplied from Indian GIS manufacturer, the erection, testing & commissioning of GIS shall be executed either by the bidder himself or by the Subcontractor meeting the following technical requirement:

The bidder/Subcontractor must have erected, tested and commissioned at least two (2) nos. GIS/AIS Circuit breaker equipped bays@ of voltage class** as specified below or higher in one (1) substation or switchyard during the last seven (7) years and these bays must be in satisfactory operation# as on the date of NOA.

S.no	Voltage class of GIS Package	Minimum Voltage class Circuit Breaker Equipped of Bay(**)
1	765kV & 400kV GIS	345kV
2	220kV	220kV
3	132kV	110kV
4	66kV	66kV

Further, the sub-contractor shall also meet the requirement specified at Clause No. 25.0 of this section.

Note:

1. (@) For the purpose of technical requirement, one no. of circuit breaker bay shall be considered as a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs. GIS means SF6 Gas insulated Switchgear. AIS Means Air Insulated Switchgear.

2. # satisfactory operation means certificate issued by the Owner/Utility certifying the operation without any adverse remark.

ANNEXURE-A

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona (for 400kV & above) both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV) for 132kV and above.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be carried out in accordance with relevant IEC of respective equipment or NEMA standard Publication No. 107-1964.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 765kV, 400 kV, 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of specified corona extinction voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 3 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the three values at which visible corona (negative or positive polarity) disappears.

The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Employer's inspector if, in his opinion, it will not prejudice other test

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.

d) Results and observations with regard to location and type of interference sources detected at each step.

e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.

f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

SEISMIC WITHSTAND TEST PROCEDURE

The seismic withstanding test on the complete equipment (for 400kV and above) shall be carried out along with supporting structure. Seismic Withstand Test carried out using either lattice or pipe structure is acceptable.” **Seismic Calculations certified by NABL Labs shall also be acceptable**

The Bidder shall arrange to transport the structure from his Contractor’s premises/ POWERGRID sites for the purpose of seismic withstand test only.

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

The frequency range for the earthquake spectra shall be as per IEC–62271-300.

LIST OF GENERAL STANDARDS AND CODES

CODES	TITLE
--	India Electricity Rules
--	Indian Electricity Act
--	Indian Electricity (Supply) Act
--	Indian Factories Act
IS-5	Colors for Ready Mixed Paints and Enamels
IS-335	New Insulating Oils
IS-617	Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purposes
IS-1448 (P1 to P 145)	Methods of Test for Petroleum and its Products
IS-2071 (P1 to P3)	Methods of High Voltage Testing
IS-12063	Classification of degrees of protection provided by enclosures of electrical equipment
IS-2165 ; P1:1997, P2:1983	Insulation Coordination
IS-3043	Code of Practice for Earthing
IS-6103	Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids
IS-6104	Method of Test for Interfacial Tension of Oil against Water by the Ring Method
IS-6262	Method of test for Power factor & Dielectric Constant of Electrical Insulating Liquids
IS-6792	Method for determination of electric strength of insulating oils
IS-5578	Guide for marking of insulated conductors
IS-11353	Guide for uniform system of marking & identification of conductors & apparatus terminals.
IS-8263	Methods for Radio Interference Test on High voltage Insulators
IS-9224 (Part 1,2&4)	Low Voltage Fuses
IEC-60060 (Part 1 to P4)	High Voltage Test Techniques
IEC 60068	Environmental Test
IEC-60117	Graphical Symbols
IEC-60156	Method for the Determination of the Electrical Strength of Insulation Oils
IEC-60270	Partial Discharge Measurements
IEC-60376	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437	Radio Interference Test on High Voltage Insulators
IEC-60507	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems
IEC-62271-1	Common Specification for High Voltage Switchgear & Control gear Standards
IEC-60815	Guide for the Selection of Insulators in respect of Polluted Conditions

CODES	TITLE
IEC-60865 (P1 & P2)	Short Circuit Current - Calculation of effects
ANSI-C.1/NFPA.70	National Electrical Code
ANSI-C37.90A	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21, C63.3	Specification for Electromagnetic Noise and Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings
ANSI-SI-4	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	Drawing Symbols
ANSI-Z55.11	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	Quality Assurance Program Requirements
CSA-Z299.2-1979h	Quality Control Program Requirements
CSA-Z299.3-1979h	Quality Verification Program Requirements
CSA-Z299.4-1979h	Inspection Program Requirements
TRANSFORMERS AND REACTORS	
IS:10028 (Part 2 & 3)	Code of practice for selection, installation & maintenance of Transformers (P1:1993), (P2:1991), (P3:1991)
IS-2026 (P1 to P4)	Power Transformers
IS-3347 (part 1 to Part 8)	Dimensions for Porcelain transformer Bushings for use in lightly polluted atmospheres
IS-3639	Fittings and Accessories for Power Transformers
IS-6600	Guide for Loading of oil immersed Transformers
IEC-60076 (Part 1 to 5)	Power Transformers
IEC-60214	On-Load Tap-Changers
IEC-60289	Reactors
IEC- 60354	Loading Guide for Oil - Immersed power transformers
IEC-60076-10	Determination of Transformer and Reactor Sound Levels
ANSI-C571280	General requirements for Distribution, Power and Regulating Transformers
ANSI-C571290	Test Code for Distribution, Power and Regulation Transformers
ANSI-C5716	Terminology & Test Code for Current Limiting Reactors
ANSI-C5721	Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA
ANSI-C5792	Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise

CODES	TITLE
ANSI-CG,1EEE-4	Standard Techniques for High Voltage Testing
IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests –External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044, BS 3938	Current transformers
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration

CODES	TITLE
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
IS-3618	Specification for phosphate treatment of iron & steel for protection against corrosion
IS-6005	Code of practice for phosphating of Iron and Steel
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IS-10593	Method of evaluating the analysis of gases in oil filled electrical equipment in service
IS-2099	Bushings for alternating voltages above 1000 volts

CODES	TITLE
IS-3347 Part I to 8	Dimension for porcelain transformer bushing
DIN-42530	Bushing up to 1000kV from 250A-5000A for liquid filled Transformer
IS-2026 Part 1 to 5	Power transformer
IS-4691	Degrees of protection provided by enclosure for rotating electrical machinery
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IS:325 / IEC -60034	Performance of cooling fan / oil pump motor
IS-13947 part 1 to 5	Specification for low voltage switchgear and control gear
IS:3400	Methods of test for vulcanised rubber
IS:7016 part 1 to 14	Methods of test for coated and treated fabrics
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS:3637	Gas operated Relays
IS:335	New Insulating oils – Specification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IS:3400 / BS 903 / IS:7016	Air cell (Flexible Air Separator)
IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG, Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)
CIRCUIT BREAKERS	
IEC-62271-100	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
IEC-62271-101	High-voltage switchgear and control gear - Part 101: Synthetic testing
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
IEC-62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
IEC-62271-109	High-voltage switchgear and control gear - Part 110: Inductive load switching
CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS	
IS-2705- (P1 to P4)	Current Transformers

CODES	TITLE
IS:3156- (P1 to P4)	Voltage Transformers
IS-4379	Identification of the Contents of Industrial Gas Cylinders
IEC-61869 (Part-1)	Instrument transformers - Part 1: General requirements
IEC-61869 (Part-2)	Instrument transformers - Part 2: Additional requirements for current transformers
IEC-61869 (Part-3)	Instrument transformers - Part 3: Additional requirements for inductive voltage transformers
IEC-61869 (Part-4)	Instrument transformers - Part 4: Additional requirements for combined transformers
IEC-61869 (Part-5)	Instrument transformers - Part 5: Additional requirements for capacitor voltage transformers
IEC-61869 (Part-6)	Instrument transformers - Part 6: Additional general requirements for low-power instrument transformers
IEC-61869 (Part-9)	Instrument transformers - Part 9: Digital interface for instrument transformers
IEC-61869 (Part-102)	Instrument transformers - Part 102: Ferroresonance oscillations in substations with inductive voltage transformers
IEC-61869 (Part-103)	Instrument transformers - The use of instrument transformers for power quality measurement
BUSHING	
IS-2099	Bushings for Alternating Voltages above 1000V
IEC-60137	Insulated Bushings for Alternating Voltages above 1000V
SURGE ARRESTERS	
IS-3070 (PART2)	Lightning arresters for alternating current systems : Metal oxide lightning arrestors without gaps
IEC-60099-4	Metal oxide surge arrestors without gaps
IEC-60099-5	Selection and application recommendation
ANSI-C62.1	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	Surge Arresters
CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS	
IS-722, IS-1248	Electrical relays for power system
IS-3231, 3231 (P-3)	Protection
IS:5039	Distributed pillars for Voltages not Exceeding 1000 Volts
IEC-60068.2.2	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60529	Degree of Protection provided by enclosures
IEC-60947-4-1	Low voltage switchgear and control gear
IEC-61095	Electromechanical Contactors for household and similar purposes
IEC-60439 (P1 & 2)	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	Switchgear Assemblies, including metal enclosed bus
ANSI-C37.50	Test Procedures for Low Voltage Alternating Current Power

CODES	TITLE
	Circuit Breakers
ANSI-C39	Electric Measuring instrument
ANSI-C83	Components for Electric Equipment
IS: 8623: (Part I to 3)	Specification for Switchgear & Control Assemblies
NEMA-AB	Moulded Case Circuit and Systems
NEMA-CS	Industrial Controls and Systems
NEMA-PB-1	Panel Boards
NEMA-SG-5	Low voltage Power Circuit breakers
NEMA-SG-3	Power Switchgear Assemblies
NEMA-SG-6	Power switching Equipment
NEMA-5E-3	Motor Control Centers
1248 (P1 to P9)	Direct acting indicating analogue electrical measuring instruments & their accessories
Disconnecting switches	
IEC-62271-102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	High Voltage switches
ANSI-C37.32	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	Test Code for high voltage air switches
NEMA-SG6	Power switching equipment
PLCC and line traps	
IS-8792	Line traps for AC power system
IS-8793	Methods of tests for line traps
IS-8997	Coupling devices for PLC systems
IS-8998	Methods of test for coupling devices for PLC systems
IEC-60353	Line traps for A.C. power systems
IEC-60481	Coupling Devices for power line carrier systems
IEC-60495	Single sideboard power line carrier terminals
IEC-60683	Planning of (single Side-Band) power line carrier systems
CIGRE	Teleprotection report by Committee 34 & 35
CIGRE	Guide on power line carrier 1979
CCIR	International Radio Consultative Committee
CCITT	International Telegraph & Telephone Consultative Committee
EIA	Electric Industries Association
Protection and control equipment	
IEC-60051: (P1 to P9)	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories
IEC-60255 (Part 1 to 23)	Electrical relays
IEC-60297 (P1 to P4)	Dimensions of mechanical structures of the 482.6mm (19 inches)

CODES	TITLE
	series
IEC-60359	Expression of the performance of electrical & electronic measuring equipment
IEC-60387	Symbols for Alternating-Current Electricity meters
IEC-60447	Man machine interface (MMI) - Actuating principles
IEC-60521	Class 0.5, 1 and 2 alternating current watt hour metres
IEC-60547	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	Screw threads
ANSI-B18	Bolts and Nuts
ANSI-C37.1	Relays, Station Controls etc
ANSI-C37.2	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	Requirements for electrical analog indicating instruments
MOTORS	
IS-325	Three phase induction motors
IS-4691	Degree of protection provided by enclosure for rotating electrical machinery
IEC-60034 (P1 to P19:)	Rotating electrical machines
IEC-Document 2	Three phase induction motors
(Central Office) NEMA-MGI	Motors and Generators
Electronic equipment and components	
MIL-21B, MIL-833 & MIL-2750	Environmental testing
EC-60068 (P1 to P5)	Printed boards
IEC-60326 (P1 to P2)	Material and workmanship standards
IS-1363 (P1 to P3)	Hexagon head bolts, screws and nuts of product grade C
IS-1364 (P1 to P5)	Hexagon head bolts, screws and nuts of products grades A and B
IS-3138	Hexagonal Bolts and Nuts (M42 to M150)
ISO-898	Fasteners: Bolts, screws and studs
ASTM	Specification and tests for materials
Clamps & connectors	
IS-5561	Electric power connectors
NEMA-CC1	Electric Power connectors for sub station
NEMA-CC 3	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors
Bus hardware and insulators	
IS: 2121	Fittings for Aluminum and steel cored Al conductors for overhead

CODES	TITLE
	power lines
IS-731	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 V
IS-2486 (P1 to P4)	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V
IEC-60120	Dimensions of Ball and Socket Couplings of string insulator units
IEC-60137	Insulated bushings for alternating voltages above 1000 V
IEC-60168	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V
IEC-62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V
IEC-61462	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for ac systems Characteristics of String Insulator Units of the cap and pin type
IEC-60372 (1984)	Locking devices for ball and socket couplings of string insulator units : dimensions and tests
IEC-60383 (P1 and P2)	Insulators for overhead lines with a nominal voltage above 1000 V
IEC-60433	Characteristics of string insulator units of the long rod type
IEC-60471	Dimensions of Clevis and tongue couplings of string insulator units
ANSI-C29	Wet process porcelain insulators
ANSI-C29.1	Test methods for electrical power insulators
ANSI-C92.2	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	Iron and steel hardware
CISPR-7B	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	Zinc Coating (Hot-Dip) on iron and steel hardware
Strain and rigid bus-conductor	
IS-2678	Dimensions & tolerances for Wrought Aluminum and Aluminum Alloys drawn round tube
IS-5082	Wrought Aluminum and Aluminum Alloy Bars. Rods, Tubes and Sections for Electrical purposes
ASTM-B 230-82	Aluminum 1350 H19 Wire for electrical purposes

CODES	TITLE
ASTM-B 231-81	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)
Batteries	
IS:1651	Stationary Cells and Batteries, Lead-Acid Type (with Tubular Positive Plates)
IS:1652	Stationary Cells and Batteries, Lead-Acid Type (with Plante Positive Plates)
IS:1146	Rubber and Plastic Containers for Lead-Acid Storage Batteries
IS:6071	Synthetic Separators for Lead-Acid Batteries
IS:266	Specification for Sulphuric Acid
IS:1069	Specification for Water for Storage Batteries
IS:3116	Specification for Sealing Compound for Lead-Acid Batteries
IS:1248	Indicating Instruments
IS:10918	Vented type nickel Cadmium Batteries
IEC:60896-21&22	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
IEC: 60623	Vented type nickel Cadmium Batteries
IEC:60622	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
IEC:60623	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
IEC:60896-11	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE-485	Recommended practices for sizing of Lead Acid Batteries
IEEE-1115	Sizing of Ni-Cd Batteries
IEEE-1187	Recommended practices for design & installation of VRLA Batteries
IEEE-1188	Recommended practices for design & installation of VRLA Batteries
IEEE-1189	Guide for selection of VRLA Batteries
Battery Charger	
IS:3895	Mono-crystalline Semiconductor Rectifier Cells and Stacks
IS:4540	Mono-crystalline Semiconductor Rectifier Assemblies and Equipment
IS:6619	Safety Code for Semiconductor Rectifier Equipment
IS:2026	Power Transformers

CODES	TITLE
IS:2959	AC Contactors for Voltages not Exceeding 1000 Volts
IS:1248	Indicating Instruments
IS:2208	HRC Fuses
IS:13947 (Part-3)	Air break switches, air break disconnectors & fuse combination units for voltage not exceeding 1000V AC or 1200V DC
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:6005	Code of practice for phosphating of Iron and Steel
IS:3231	Electrical relays for power system protection
IS:3842	Electrical relay for AC Systems
IS:5	Colours for ready mix paint
IEEE-484	Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations
IEEE-485	Sizing large lead storage batteries for generating stations and substations
Wires and cables	
ASTMD-2863	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IS-694	PVC insulated cables for working voltages upto and including 1100 Volts
IS-1255	Code of practice for installation and maintenance of power cables, upto and including 33 kV rating
IS-1554 (P1 and P2)	PVC insulated (heavy duty) electric cables (part 1) for working voltage upto and including 1100 V Part (2) for working voltage from 3.3 kV upto and including 11kV
IS:1753	Aluminium conductor for insulated cables
IS:2982	Copper Conductor in insulated cables
IS-3961 (P1 to P5)	Recommended current ratings for cables
IS-3975	Mild steel wires, formed wires and tapes for armouring of cables
IS-5831	PVC insulating and sheath of electric cables
IS-6380	Elastometric insulating and sheath of electric cables
IS-7098	Cross linked polyethylene insulated PVC sheathed cables for working voltage upto and including 1100 volts
IS-7098	Cross-linked polyethyle insulated PVC sheathed cables for working voltage from 3.3kV upto and including 33 kV
IS-8130	Conductors for insulated electrical cables and flexible cords
IS-1753	Aluminum Conductors for insulated cables
IS-10418	Specification for drums for electric cables
IEC-60096 (part 0 to p4)	Radio Frequency cables
IEC-60183	Guide to the Selection of High Voltage Cables

CODES	TITLE
IEC-60189 (P1 to P7)	Low frequency cables and wires with PVC insulation and PVC sheath
IEC-60227 (P1 to P7)	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V
IEC-60228	Conductors of insulated cables
IEC-60230	Impulse tests on cables and their accessories
IEC-60287 (P1 to P3)	Calculation of the continuous current rating of cables (100% load factor)
IEC-60304	Standard colours for insulation for low-frequency cables and wires
IEC-60331	Fire resisting characteristics of Electric cables
IEC-60332 (P1 to P3)	Tests on electric cables under fire conditions
IEC-60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	Tests on gases evolved during combustion of electric cables
AIR conditioning and ventilation	
IS-659	Safety code for air conditioning
IS-660	Safety code for Mechanical Refrigeration
ARI:520	Standard for Positive Displacement Refrigeration Compressor and Condensing Units
IS:4503	Shell and tube type heat exchanger
ASHRAE-24	Method of testing for rating of liquid coolers
ANSI-B-31.5	Refrigeration Piping
IS:2062	Steel for general structural purposes
IS:655	Specification for Metal Air Dust
IS:277	Specification for Galvanised Steel Sheets
IS-737	Specification for Wrought Aluminium and Aluminium Sheet & Strip
IS-1079	Hot rolled cast steel sheet & strip
IS-3588	Specification for Electrical Axial Flow Fans
IS-2312	Propeller Type AC Ventilation Fans
BS-848	Methods of Performance Test for Fans
BS-6540 Part-I	Air Filters used in Air Conditioning and General Ventilation
BS-3928	Sodium Flame Test for Air Filters (Other than for Air Supply to I.C. Engines and Compressors)
US-PED-2098	Method of cold DOP & hot DOP test
MIL-STD-282	DOP smoke penetration method
ASHRAE-52	Air cleaning device used in general ventilation for removing particle matter
IS:3069	Glossary of Terms, Symbols and Units Relating to Thermal Insulation Materials

ANNEXURE-C

CODES	TITLE
IS:4671	Expanded Polystyrene for Thermal Insulation Purposes
IS:8183	Bonded Mineral Wool
IS:3346	Evaluation of Thermal Conductivity properties by means of guarded hot plate method
ASTM-C-591-69	Standard specification for rigid preformed cellular urethane thermal insulation
IS:4894	Centrifugal Fans
BS:848	Method of Performance Test for Centrifugal Fans
IS:325	Induction motors, three-phase
IS:4722	Rotating electrical machines
IS:1231	Three phase foot mounted Induction motors, dimensions of
IS:2233	Designations of types of construction and mounting arrangements of rotating electrical machines
IS:2254	Vertical shaft motors for pumps, dimensions of
IS:7816	Guide for testing insulation resistance of rotating machines
IS:4029	Guide for testing three phase induction motors
IS: 4729	Rotating electrical machines, vibration of, Measurement and evaluation of
IS:4691	Degree of protection provided by enclosures for rotating electrical machinery
IS:7572	Guide for testing single-phase ac motors
IS:2148	Flame proof enclosure for electrical apparatus
BS:4999(Part-51)	Noise levels
Galvanizing	
IS-209	Zinc Ingot
IS-2629	Recommended Practice for Hot-Dip galvanizing on iron and steel
IS-2633	Methods for testing uniformity of coating of zinc coated articles
ASTM-A-123	Specification for zinc (Hot Galavanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips
ASTM-A-121-77	Zinc-coated (Galvanized) steel barbed wire
Painting	
IS-6005	Code of practice for phosphating of iron and steel
ANSI-Z551	Gray finishes for industrial apparatus and equipment
SSPEC	Steel structure painting council
Fire protection system	
--	Fire protection manual issued by tariff advisory committee (TAC) of India
HORIZONTAL CENTRIFUGAL PUMPS	
IS:1520	Horizontal centrifugal pumps for clear, cold and fresh water
IS:9137	Code for acceptance test for centrifugal & axial pumps

CODES	TITLE
IS:5120	Technical requirement – Rotodynamic special purpose pumps
API-610	Centrifugal pumps for general services Hydraulic Institutes Standards
BS:599	Methods of testing pumps
PTC-8.2	Power Test Codes - Centrifugal pumps
DIESEL ENGINES	
IS:10000	Methods of tests for internal combustion engines
IS:10002	Specification for performance requirements for constant speed compression ignition engines for general purposes (above 20 kW)
BS:5514	The performance of reciprocating compression ignition (Diesel) engines, utilizing liquid fuel only, for general purposes
ISO:3046	Reciprocating internal combustion engines performance
IS:554	Dimensions for pipe threads where pressure tight joints are required on threads
ASME Power Test Code	Internal combustion engine PTC-17
--	Codes of Diesel Engine Manufacturer's Association, USA
PIPING VALVES & SPECIALITIES	
IS:636	Non percolating flexible fire-fighting delivery hose
IS:638	Sheet rubber jointing and rubber inserting jointing
IS:778	Gun metal gate, globe and check valves for general purpose
IS:780	Sluice valves for water works purposes (50 to 300 mm)
IS:901	Couplings, double male and double female instantaneous pattern for fire fighting
IS:902	Suction hose couplings for fire-fighting purposes
IS:903	Fire hose delivery couplings branch pipe nozzles and nozzle spanner
IS:1538	Cast iron fittings for pressure pipes for water, gas and sewage
IS:1903	Ball valve (horizontal plunger type) including floats for water supply purposes
IS:2062	SP for weldable structural steel
IS:2379	Colour Code for the identification of pipelines
IS:2643	Dimensions of pipe threads for fastening purposes
IS:2685	Code of Practice for selection, installation and maintenance of sluice valves
IS:2906	Sluice valves for water-works purposes (350 to 1200 mm size)
IS:3582	Basket strainers for fire-fighting purposes (cylindrical type)
IS:3589	Electrically welded steel pipes for water, gas and sewage (150 to 2000 mm nominal diameter)
IS:4038	Foot valves for water works purposes
IS:4927	Unlined flax canvas hose for fire fighting

CODES	TITLE
IS:5290	Landing valves (internal hydrant)
IS:5312 (Part-I)	Swing check type reflex (non-return) valves
IS:5306	Code of practice for fire extinguishing installations and equipment on premises
Part-I	Hydrant systems, hose reels and foam inlets
Part-II	Sprinkler systems
BS:5150	Specification for cast iron gate valves
MOTORS & ANNUNCIATION PANELS	
IS:325	Three phase induction motors
IS:900	Code of practice for installation and maintenance of induction motors
IS:996	Single phase small AC and universal electric motors
IS:1231	Dimensions of three phase foot mounted induction motors
IS:2148	Flame proof enclosure of electrical apparatus
IS:2223	Dimensions of flange mounted AC induction motors
IS:2253	Designations for types of construction and mounting arrangements of rotating electrical machines
IS:2254	Dimensions of vertical shaft motors for pumps
IS:3202	Code of practice for climate proofing of electrical equipment
IS:4029	Guide for testing three phase induction motors
IS:4691	Degree of protection provided by enclosure for rotating electrical machinery
IS:4722	Rotating electrical machines
IS:4729	Measurement and evaluation of vibration of rotating electrical machines
IS:5572	Classification of hazardous areas for electrical (Part-I) installations (Areas having gases and vapours)
IS:6362	Designation of methods of cooling for rotating electrical machines
IS:6381	Construction and testing of electrical apparatus with type of protection ‘e’
IS:7816	Guide for testing insulation for rotating machine
IS:4064	Air break switches
IEC DOCUMENT 2 (Control Office) 432	Three Phase Induction Motor
VDE 0530 Part I/66	Three Phase Induction Motor
IS:9224 (Part-II)	HRC Fuses
IS:6875	Push Button and Control Switches
IS:694	PVC Insulated cables
IS:1248	Indicating instruments
IS:375	Auxiliary wiring & busbar markings

CODES	TITLE
IS:2147	Degree of protection
IS:5	Colour Relay and timers
IS:2959	Contactors
PG Test Procedures	
NFPA-13	Standard for the installation of sprinkler system
NFPA-15	Standard for water spray fixed system for the fire protection
NFPA-12A	Standard for Halong 1301 Fire Extinguishing System
NFPA-72E	Standard on Automatic Fire Detectors
--	Fire Protection Manual by TAC (Latest Edition)
NFPA-12	Standard on Carbon dioxide extinguisher systems
IS:3034	Fire of industrial building
--	Electrical generating and distributing stations code of practice
IS:2878	CO2 (Carbon dioxide) Type Extinguisher
IS:2171	DC (Dry Chemical Powder) type
IS:940	Pressurised Water Type
D.G. SET	
IS:10002	Specification for performance requirements for constant speed compression ignition (diesel engine) for general purposes
IS:10000	Method of tests for internal combustion engines
IS:4722	Rotating electrical machines-specification
IS:12063	Degree of protection provided by enclosures
IS:12065	Permissible limit of noise levels for rotating electrical machines
--	Indian Explosive Act 1932
Steel structures	
IS-228 (1992)	Method of Chemical Analysis of pig iron, cast iron and plain carbon and low alloy steels.
IS-802 (P1 to 3)	Code of practice for use of structural steel in overhead transmission line towers
IS-806	Code of practice for use of steel tubes in general building construction
IS-808	Dimensions for hot rolled steel beam, column channel and angle sections
IS-814	Covered electrodes for manual arc welding of carbon of carbon manganese steel
IS-816	Code of Practice for use of metal arc welding for general construction in Mild steel
IS-817	Code of practice for training and testing of metal arc welders. Part 1 : Manual Metal arc welding
IS-875 (P1 to P4)	Code of practice for design loads (other than earthquake) for buildings and structures
IS-1161	Steel tubes for structural purposes

ANNEXURE-C

CODES	TITLE
IS-1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates
IS-1363 (P1 to P3)	Hexagonal head bolts, screws & nuts of products grade C
IS-1364	Hexagon head bolts, screws and nuts of product grades A and B
IS-1367 (P1 to P18)	Technical supply condition for threaded steel fasteners
IS-1599	Methods for bend test
IS-1608	Method for tensile testing of steel products
IS-1893	Criteria for earthquake resistant design of structures
IS-1978	Line Pipe
IS-2062	Steel for general structural purposes
IS-2595	Code of practice for Radiographic testing
IS-3063	Single coil rectangular section spring washers for bolts, nuts and screws
IS-3664	Code of practice for ultrasonic pulse echo testing by contact and immersion methods
IS-7205	Safety code for erection of structural steel work
IS-9595	Recommendations for metal arc welding of carbon and carbon manganese steels
ANSI-B18.2.1	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	Square and hexagonal nuts
ANSI-G8.14	Round head bolts
ASTM-A6	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	Specifications of structural steel
ASTM-A47	Specification for malleable iron castings
ASTM-A143	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	Specification for high strength low alloy structural steel
ASTM-A283	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	Specification for High strength low alloy structural manganese vanadium steel
ASTM-A572	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	Code for welding in building construction welding inspection
AWS D1-1	Structural welding code
AISC	American institute of steel construction
NEMA-CG1	Manufactured graphite electrodes

ANNEXURE-C

CODES	TITLE
Piping and pressure vessels	
IS-1239 (Part 1 and 2)	Mild steel tubes, tubulars and other wrought steel fittings
IS -3589	Seamless Electrically welded steel pipes for water, gas and sewage
IS-6392	Steel pipe flanges
ASME	Boiler and pressure vessel code
ASTM-A120	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	Seamless carbon steel pipe for high temperature service
ASTM-A284	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction
ASTM-A234	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures
ASTM-S181	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	Forgings, carbon steel for piping components
ASTM-A307	Carbon steel externally threated standard fasteners
ASTM-A193	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	Flat rolled electrical steel for magnetic applications
ASTM-A197	Cupola malleable iron
ANSI-B2.1	Pipe threads (Except dry seal)
ANSI-B16.1	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	Factory-made wrought steel butt welding fittings
ANSI-B16.11	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	Ferrous pipe plug, bushings and locknuts with piple threads
ANSI-B16.25	Butt welding ends
ANSI-B18.1.1	Fire hose couplings screw thread
ANSI-B18.2.1	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2	Square and hexagonal nuts
NSI-B18.21.1	Lock washers
ANSI-B18.21.2	Plain washers
ANSI-B31.1	Power piping
ANSI-B36.10	Welded and seamless wrought steel pipe
ANSI-B36.9	Stainless steel pipe
Other civil works standards	

ANNEXURE-C

CODES	TITLE
IS-269	33 grade ordinary portland cement
IS2721	Galvanized steel chain link fence fabric
IS-278	Galvanized steel barbed wire for fencing
IS-383	Coarse and fine aggregates from natural sources for concrete
IS-432 (P1 and P2)	Mild steel and medium tensile steel bars and hard-dawn steel wire for concrete reinforcement
IS-456	Code of practice for plain and reinforced concrete
IS-516	Method of test for strength of concrete
IS-800	Code of practice for general construction in steel
IS-806	Steel tubes for structural purposes
IS-1172	Basic requirements for water supply, drainage and sanitation
IS-1199	Methods of sampling and analysis of concrete
IS-1566	Hard-dawn steel wire fabric for concrete reinforcement
IS-1742	Code of Practice for Building drainage
IS-1785	Plain hard-drawn steel wire for pre-stressed concrete
IS-1786	High strength deformed Steel Bars and wires for concrete reinforcement
IS-1811	Methods of sampling Foundry sands
IS-1893	Criteria for earthquake resistant design of structures
IS-2062	Steel for general structural purposes
IS-2064	Selection, installation and maintenance of sanitary appliances-code of practices
IS-2065	Code of practice for water supply in buildings
IS-2090	High tension steel bars used in pre-stressed concrete
IS-2140	Standard Galvanized steel wire for fencing
IS-2470 (P1 & P2)	Code of practice for installation of septic tanks
IS-2514	Concrete vibrating tables
IS-2645	Integral cement waterproofing compounds
IS-3025 (Part 1 to Part 48)	Methods of sampling and test (Physical and chemical) for water and waste water
IS-4091	Code of practice for design and construction of foundations for transmission line towers and poles
IS-4111 (Part 1 to P5)	Code of practice for ancillary structures in sewerage system
IS-4990	Plywood for concrete shuttering work
IS-5600	Sewage and drainage pumps
National building code of India 1970	
USBR E12	Earth Manual by United States Department of the interior Bureau of Reclamation
ASTM-A392-81	Zinc/Coated steel chain link fence fabric
ASTM-D1557-80	test for moisture-density relation of soils using 10-lb (4.5 kg)

CODES	TITLE
	rame land 18-in. (457 mm) Drop
ASTM-D1586(1967)	Penetration Test and Split-Barrel Sampling of Soils
ASTM-D2049-69	Test Method for Relative Density of Cohesionless Soils
ASTM-D2435	Test method for Unconsolidated, (1982) Undrained Strengths of Cohesive Soils in Triaxial Compression
BS-5075	Specification for accelerating Part I Admixtures, Retarding Admixtures and Water Reducing Admixtures
CPWD	Latest CPWD specifications
ACSR MOOSE CONDUCTOR	
IS:6745 BS:443-1969	Methods for Determination of Mass of zinc coating on zinc coated Iron and Steel Articles
IS:8263	Methods for Radio Interference
IEC:437-1973 NEMA:107-1964 CISPR	Test on High Voltage Insulators
IS:209, BS:3436-1961	Zinc Ingot
IS:398 Part - V IEC:209-1966	Aluminum Conductors for Overhead Transmission Purposes
BS:215(Part-II), IEC:209-1966	Aluminium Conductors galvanized steel reinforced extra high voltage (400 kV and above)
IS:1778, BS:1559-1949	Reels and Drums for Bare Conductors
IS:1521, ISO/R89-1959	Method for Tensile Testing of steel wire
IS:2629	Recommended practice for Hot dip Galvanising on Iron and Steel
IS:2633	Method for Testing Uniformity of coating of zinc Coated Articles
IS:4826/ ASTMA-472-729	Hot dip galvanised coatings on round steel wires
GALVANISED STEEL EARTHWIRE	
IS:1521, ISO/R:89-1959	Method for Tensile Testing of Steel Wire
IS:1778	Reels and Drums for Bare Conductors
IS:2629	Recommended practice for Hot Dip Galvanising on Iron and Steel
IS:2633	Methods for testing Uniformity of Coating of Zinc Coated Articles
IS:4826/ ASTM: A 475-72a BS:443-1969	Hot dip Galvanised Coatings on Round Steel Wires
IS:6745/ BS:443-1969	Method for Determination of mass of Zinc Coating on Zinc coated Iron and Steel Articles.
IS:209/ BS:3463-1961	Zinc ingot
IS:398 (Pt. I to P5:1992)/ BS:215 (Part-II	Aluminum Conductors for overhead transmission purposes

ANNEXURE-C

CODES	TITLE
Lighting Fixtures and Accessories	
IS:1913	General and safety requirements for electric lighting fittings
IS:3528	Water proof electric lighting fittings
IS:4012	Dust proof electric lighting fittings
IS:4013	Dust tight proof electric lighting fittings
IS:10322	Industrial lighting fittings with metal reflectors
IS:10322	Industrial lighting fittings with plastic reflectors
IS:2206	Well glass lighting fittings for use under ground in mines (non-flameproof type)
IS:10322	Specification for flood light
IS:10322	Specification for decorative lighting outfits
IS:10322	Luminaries for street lighting
IS:2418	Tubular fluorescent lamps
IS:9900	High pressure mercury vapour lamps
IS:1258	Specification for Bayonet lamp fluorescent lamp
IS:3323	Bi-pin lamp holder tubular fluorescent lamps
IS:1534	Ballasts for use in fluorescent lighting fittings. (Part-I)
IS:1569	Capacitors for use in fluorescent lighting fittings
IS:2215	Starters for fluorescent lamps
IS:3324	Holders for starters for tubular fluorescent lamps
IS:418	GLS lamps
IS:3553	Water tight electric fittings
IS:2713	Tubular steel poles
IS:280	MS wire for general engg. Purposes
Conduits, Accessories and Junction Boxes	
IS:9537	Rigid steel conduits for electrical wiring
IS:3480	Flexible steel conduits for electrical wiring
IS:2667	Fittings for rigid steel conduits for electrical wiring
IS:3837	Accessories for rigid steel conduits for electrical wiring
IS:4649	Adaptors for flexible steel conduits
IS:5133	Steel and Cast Iron Boxes
IS:2629	Hot dip galvanising of Iron & Steel
Lighting Panels	
IS:13947	LV Switchgear and Control gear(Part 1 to 5)
IS:8828	Circuit breakers for over current protection for house hold and similar installations
IS:5	Ready mix paints
IS:2551	Danger notice plates
IS:2705	Current transformers

ANNEXURE-C

CODES	TITLE
IS:9224	HRC Cartridge fuse links for voltage above 650V(Part-2)
IS:5082	Wrought aluminium and Al. alloys, bars, rods, tubes and sections for electrical purposes
IS:8623	Factory built Assemblies of Switchgear and Control Gear for voltages upto and including 1000V AC and 1200V DC
IS:1248	Direct Acting electrical indicating instruments
Electrical Installation	
IS:1293	3 pin plug
IS:371	Two to three ceiling roses
IS:3854	Switches for domestic and similar purposes
IS:5216	Guide for safety procedures and practices in electrical work
IS:732	Code of practice for electrical wiring installation (system voltage not exceeding 650 Volts.)
IS:3043	Code of practice for earthing
IS:3646	Code of practice of interior illumination part II & III
IS:1944	Code of practice for lighting of public through fares
IS:5571	Guide for selection of electrical equipment for hazardous areas
IS:800	Code of practice for use of structural steel in general building construction
IS:2633	Methods of Testing uniformity of coating on zinc coated articles
IS:6005	Code of practice for phosphating iron and steel
	INDIAN ELECTRICITY ACT
	INDIAN ELECTRICITY RULES
LT SWITCHGEAR	
IS:8623 (Part-I)	Specification for low voltage switchgear and control gear assemblies
IS:13947 (Part-I)	Specification for low voltage switchgear and control gear, Part 1 General Rules
IS:13947 (part-2)	Specification for low voltage switchgear and control gear, Part 2 circuit breakers
IS:13947 (part-3)	Specification for low voltage switchgear and control gear. Part 3 Switches, Disconnectors, Switch-disconnectors and fuse combination units
IS:13947 (part-4)	Specification for low voltage switchgear and control gear. Part 4 Contactors and motors starters
IS:13947 (part-5)	Specification for low voltage switchgear and control gear. Part 5 Control-circuit devices and switching elements
IS:13947 (part-6)	Specification for low voltage switchgear and control gear. Part 6 Multiple function switching devices
IS:13947 (part-7)	Specification for low voltage switchgear and control gear. Part 7 Ancillary equipments
IS:12063	Degree of protection provided by enclosures

ANNEXURE-C

CODES	TITLE
IS:2705	Current Transformers
IS:3156	Voltage Transformers
IS:3231	Electrical relays for power system protection
IS:1248	Electrical indicating instruments
IS:722	AC Electricity meters
IS:5578	Guide for Marking of insulated conductors of apparatus terminals
IS:13703 (part 1)	Low voltage fuses for voltage not exceeding 1000V AC or 1500V DC Part 1 General Requirements
IS:13703 (part 2)	Low voltage fuses for voltage not exceeding 1000V AC or 1500V DC Part 2 Fuses for use of authorized persons
IS:6005	Code of practice of phosphating iron and steel
IS:5082	Wrought Aluminum and Aluminum alloys for electrical purposes
IS:2633	Hot dip galvanising

Note: If any standard is expired or does not exist anymore than other standard which has substituted it, shall be applicable.

ANNEXURE-D

LIST OF DRAWINGS/DOCUMENTS FOR SECOND ADVANCE

A. ELECTRICAL DRAWINGS/DOCUMENTS FOR SWITCHYARD

(1) Single Line Diagram
(2) Electrical Layout – Plan and Sections
(3) DSLP Calculation and drawing
(4) Structure Layout (Plan & Section) drawing
(5) Foundation & Cable Trench Layout
(6) Earthmat Layout
(7) Short circuit Force and Critical Span Calculations (for non-standard span)
(8) Cantilever Strength calculations (for non-standard span)

B. CIVIL DRAWINGS/DOCUMENTS

(1) Soil Investigation Report (if applicable)
(2) Structure Design, Foundation Design & Drawing, Plinth Beam Design & Drawing and column Design & Drawing up to G.F. Level of control room building
(3) Structure Design, Foundation Design & Drawing, Plinth Beam Design & Drawing and column Design & Drawing of GIS building(s)

C. DRAWINGS/DOCUMENTS OF EQUIPMENT

(1) Circuit Breaker, Isolator, CT, CVT, IVT, Surge Arrestor, Bus Post Insulator
- Drawing, GTP and Type test Reports

(2) Control and Relay Panels
- GTP and Type test Reports

(3) Substation Automation System (SAS)
- GTP and Type test Reports

D. DRAWINGS/DOCUMENTS OF POWER TRANSFORMER

(1) Design Review documents
(2) GA drawings for transformer, bushings
(3) Foundation Plan
(4) GTP
(5) RTCC -GA and schematic drawings
(6) Rating and Diagram Plate
(7) Power Transformer foundation design & drawings (if Applicable)
(8) For Single Phase Autotransformer (if Applicable)
- Single Line Diagram
- Electrical Layout & Section
- Foundation Layout including Neutral & Delta Formation

ANNEXURE-D

LIST OF DRAWINGS/DOCUMENTS FOR SECOND ADVANCE

E. DRAWINGS/DOCUMENTS OF REACTOR

(1) Design Review documents
(2) GA drawings for reactor, NGR, LA, bushings
(3) Foundation Plan
(4) GTP
(5) Rating and Diagram Plate
(6) Shunt Reactor, NGR & SA foundation design & drawings (if Applicable)
(7) For Single Phase Reactor (if Applicable)

- Single Line Diagram
- Electrical Layout & Section
- Foundation Layout including Neutral Formation

F. DRAWINGS/DOCUMENTS OF GIS

(1) GTP
(2) Gas Line Diagram
(3) GIS Layout Drawing

G. DRAWINGS/DOCUMENTS OF EHV Cable (132kV of Above)

(1) GTP
(2) Cross Section Drawing

NOTES:-

1. The list of drawings/ documents mentioned above is a standard list. Some of the items may not be applicable and need not to be referred for a particular substation package.
2. In case type tests are to be repeated/conducted, then approval of type test reports is not required at this stage.
3. Category-II approved drawings shall also be considered for release of second/engineering advance.

ANNEXURE-E

Comprehensive List of Drawing Submission Schedule

SL.NO.	DRAWINGS/DOCUMENTS TITLE	CATEGORY
1.00	**DRAWING FOR SWITCHYARD**	
1.01	Over all General Arrangement Drawing	A
1.02	Single Line Diagram	A
1.03	Electrical layout plan & section	A
1.04	Structure loading diagram cum layout arrangement	A
1.05	DSLP Calculation & layout	A
1.06	Switchyard Foundation & cable Trench Layout	A
1.07	Indoor Cable Trench Layout (As applicable for Control Room Building, GIS Hall ,Switchyard panel Room, FFPH Building)	A
1.08	Buried Cable Trench layout	A
1.09	Erection Key Diagram (plan & section) & Erection Bill of Quantity	A
1.10	Earthmat layout	A
1.11	Indoor Illumination layout (As applicable for Control Room Building, FFPH Building, Transit Camp, Switchyard panel Room, GIS Halll)	A
1.12	Out door illumination Layout	A
1.13	SLD of LT AC/DC System	A
1.14	Panel arrangement layout in Control Room Building	A
1.15	Panel arrangement layout in Switchyard panel room/LCR Room of GIS Hall	A
1.16	Fire detection and alarm system for control Room building, GIS Building and Switchyard panel room	A
1.17	Air Conditioning Layout (As applicable for Control Room Building, LCR room in GIS Hall ,Switchyard panel Room)	
1.18	LT Station Layout	A
1.19	Power and control cable schedule	A
2.00	**DESIGN CALCULATION**	
2.01	DSLP calculation	R
2.02	Lighting system design calculation (if applicable)	R
2.03	Earthing system design calculation (if applicable)	R
2.04	Battery sizing calculation (if applicable)	R
2.05	Hydrolic Calculation for Fire protection (if applicable)	R
2.06	AC and ventilation calculation for GIS Building (if applicable)	R
2.07	EOT crane sizing calculation	R
3.00	**GAS INSULATED SWITCHGEAR**	
3.01	Design Review along with all supporting documents for new design of GIS	A

Comprehensive List of Drawing Submission Schedule		
3.02	Guaranteed Technical Particular (GTP)	A
3.03	Type Test Reports of GIS	A
3.04	Drawings, GTP & Type Test Reports of SF6/Air Bushing	A
3.05	Component Drawing of Each type of GIS Equipment	R
3.06	Single Line Diagram	A
3.07	Layout for GIS Arrangement (Plan and Section View and plate form arrangement)	A
3.08	Foundation for GIS (Including Loading Data)	A
3.09	Earthing Layout including Special Earthing Requirement for GIS	R
3.10	Gas System Diagram	A
3.11	GIS support Structure layout including Details of Support Structure.	A
3.12	GIS Key Diagram	R
3.13	PD Location Layout along with sensitivity attenuation calculation	R
3.14	GA & Schematic drawings of Local Control Cabinets (LCC)	A
3.15	Type Test Reports of Local Control Cabinets (LCC)	A
3.16	Spare Parts List (Based on Contract)	A
3.17	Special Tools List (Based on Contract)	A
3.18	Name Plates	A
3.19	GA, Data Sheet and Catalogues for	
a)	SF6 gas leakage detector	R
b)	SF6 gas filling & evacuation plant	R
c)	SF6 gas Analyser	R
d)	Partial discharge monitoring system	R
e)	catalogue of UHF sensors	R
3.20	GA & Schematic drawings of overhead crane	A
4.00	**AUTOTRANSFORMER**	
4.01	Design Review	R
4.02	Guaranteed Technical Particulars	A
4.03	Outline General Arrangement Drawing with Bill of material (OGA parts list) & Shipping details	A
4.04	Foundation Plan	A
4.05	GA & schematic drawing of Cooler control cabinet/Marshalling Box and Write up	A
4.06	GA & schematic drawing of Common Marshalling Box and Write up (as applicable)	A
4.07	GA & schematic drawing of Drive Mechanism Box and Write up	A
4.08	Bushing dwg and GTP (HV, IV, LV and Neutral as applicable)	A
4.09	Radiator Details	A
4.10	Magnetising Characteristics of bushings CT	A
4.11	Rating and Diagram plate	A

Comprehensive List of Drawing Submission Schedule		
4.12	Valve Schedule plate rating	A
4.13	Twin-Bi directional roller	A
4.14	Type Test Report	A
4.15	Instruction Manual	R
5.00	**REACTOR**	
5.01	Design Review	R
5.02	Guaranteed Technical Particulars	A
5.03	Outline General Arrangement Drawing with Bill of material (OGA parts list) & Shipping details	A
5.04	Foundation Plan	A
5.05	Bushing dwg and GTP (HV and Neutral)	A
5.06	GA & schematic drawing of Marshalling Box and Write up	A
5.07	Magnetization characteristics of Reactor Core and bushing CTs	A
5.08	Rating and diagram plate	A
5.09	Twin bi-directional roller	A
5.10	Radiator Details	A
5.11	Type test Report	A
5.12	Instruction Manual	R
6.0	**NEUTRAL GROUNDING REACTOR (NGR)**	
A	**Air Core NGR**	
6.01	Design Review	R
6.02	Guaranteed Technical Particulars	A
6.03	General Arrangement Drawing with pedestal details and Bill of material (OGA parts list) & Shipping details	A
6.04	Foundation Plan	A
6.05	Rating and diagram plate	A
B	**Oil Filled Type NGR**	
6.06	Design Review	R
6.07	Guaranteed Technical Particulars	A
6.08	General Arrangement Drawing with Bill of material (OGA parts list) & Shipping details	A
6.09	Foundation Plan including Combined Foundation for NGR & LA	A
6.10	Rating and diagram plate	A
7.00	**CIRCUIT BREAKER**	
7.01	GA drg of SF6 CB	A
17.02	OGA drawing of control unit	A
7.03	OGA drawing of support insulator, interrupter insulator	R
7.04	Support structure & foundation plan drawing	A

Comprehensive List of Drawing Submission Schedule		
7.05	Electrical schematic diagram	A
7.06	Rating and name plate drawing	A
7.07	Hydraulic/SF6 gas connection diagram	R
7.08	Schematic diagram of operating mechanism	R
7.09	Wiring diagram	R
7.10	Terminal connector and corona rings	R
7.11	Sectional view of interrupter	R
7.12	GTP	A
7.13	Type Test Reports	A
7.14	Instruction Manual	R
8.00	**ISOLATOR**	
8.01	GA drawing of Isolator without earth switch	A
8.02	Contact blade assembly (main & earth switch)	R
8.03	Terminal pad & hinge contacts	R
8.04	GA of MOM – main switch	R
8.05	Schematic & wiring drg. for main switch	R
8.06	Name plate - details	A
8.07	GA of terminal connectors	A
8.08	GA of post insulator for isolator	R
8.09	GTP	A
8.10	Type Test Report	A
8.11	Instruction Manual	R
9.00	**INSTRUMENT TRANSFORMER (CT/CVT/IVT)**	
9.01	GTP	A
9.02	General Arrangement	A
9.03	Sectional view	R
9.04	Sec. terminal box GA	R
9.05	GA of Junction box	R
9.06	Data sheet of junction box	A
9.07	Wiring drg of JB incl. interpole	R
9.08	Terminal connectors	A
9.09	Schematic & rating plate	R
9.10	Porcelain insulator	R
9.11	Corona ring	R
9.12	Type Test Reports	A
9.13	Instruction Manual	R
10.00	**SURGE ARRESTER**	

Comprehensive List of Drawing Submission Schedule		
10.01	GA of Surge Arrester	A
10.02	GTP	A
10.03	Porcelain insulator	R
10.04	Cross sectional view	R
10.05	Arrestor and unit name plate	A
10.06	Grading rings	R
10.07	Insulating base / surge counter detail	R
10.08	Outline drg of surge counter	R
10.09	Circuit diagram of surge counter	R
10.10	GA of ZnO element	R
10.11	Line terminal bracket with corona rings	R
10.12	Drawing showing pressure relief arrangement.	R
10.13	Type Test Report	A
10.14	Instruction Manual	R
11.00	**BUS POST INSULATOR**	
11.01	GA drawing & GTP	A
11.02	Type Test Reports	A
12.00	**Marshaling Box, Junction Boxes**	
12.01	GA Drawings	A
12.02	Schematic Drawing	A
12.03	Type Test reports	A
13.00	**Conductor, Al Tube & GS Earth Switch**	
13.01	Type Test Reports (if applicable)	A
14.00	**DISC INSULATOR (if applicable)**	
14.01	GA drawing	A
14.02	Type Test Reports	A
15.00	**LONG ROD POLYMER INSULATOR**	
15.01	GA drawing	A
15.02	Type Test Reports	A
16.00	**INSULATOR STRINGS WITH HARDWARE ASSEMBLY**	
16.01	GA DRG	A
16.02	Component drawings	R
16.03	Type Test Reports	A

Comprehensive List of Drawing Submission Schedule		
17.00	**CLAMPS & CONNECTORS**	
17.01	Drawings	A
17.02	Type Test Reports	A
18.00	**HORN GAP FUSE**	
18.01	GA OF HG FUSE	A
18.02	Type Test Reports	A
19.00	**BATTERY AND BATTERY CHARGER**	
19.01	GTP	A
19.02	Drawings	A
19.03	Type Test Reports	A
20.00	**ILLUMINATION**	
20.01	GTP of all types of fittings/fixtures & cotrol gear	A
20.02	GA drg. of lighting poles/posts	A
20.03	Wiring drgs. of panel/LDBs to fixtures	R
20.04	GA of Junction box	A
20.05	GA street lighting panel/outdoor lighting panel	A
20.06	GA of Receptacles	A
21.00	**LT SWITCHGEAR**	
21.01	GA drg of ACDB	A
21.02	SLD of ACDB	A
21.03	GA drg of 220V DCDB	A
21.04	SLD of 220V DCDB	A
21.05	GA drg of 50V DCDB	A
21.06	SLD of 50V DCDB	A
21.07	Data sheet	A
21.08	Sch. of each type of module	R
21.09	Type Test Reports	A
21.10	Instruction Manual	R
22.00	**HT Power Cable**	
22.01	GTP & Catalogue	A
22.02	Type Test Reports	A
23.00	**POWER & CONTROL CABLE**	
23.01	Type Test Reports for Power Cable	A
23.02	**Type Test Reports for Control Cable**	**A**

Comprehensive List of Drawing Submission Schedule		
24.00	**CONTROL AND RELAY PANELS & SUBSTATION AUTOMATION SYSTEM (SAS)**	
24.01	GTP & detailed technical literature & O&M manuals of all types of relays, SAS Equipments	A/R
24.02	Type Test Reports of all relays & equipments	R
	GA and schematic drgs. for :-	
a)	Relay and protection panels for all type line(s)	A
b)	Relay and protection panels for all type autotransformer(s) including tertiary loading	A
c)	Relay and protection panels for bus/line reactor(s)	A
d)	Relay and protection panels for tie bay(s)	
e)	Relay and protection panels for TBC bay(s)	A
f)	Relay and protection panels for BC bay(s)	A
g)	Busbar protection panel (s)	A
h)	Circuit Breaker relay panel(s)	
24.03	Panel Construction Details	A
24.04	SAS Architecture	A
24.05	Relay Settings	A
25.00	**Visual Monitoring System**	
25.01	GTP/Catalogue of VMS Equipment and Camera	A
25.02	VMS Architectural Drawing	A
26.00	**PLCC EQUIPMENTS**	
26.01	GTP & technical literature	A/R
26.02	Type Test Reports of all PLCC equipment	A
26.03	GA & GTPs for wave trap	A
26.04	GA drg of PLCC terminal	R
26.05	Digital/ Analog Protection coupler	R
26.06	SNR calculation (if applicable)	R
26.07	Coupling device	R
26.08	GTP of HF cable	A
26.09	Testing & maintenance equipments	R
26.10	Frequency Planning	A
27.00	**DG SET**	
27.01	GTP	A
27.02	Drawings/manuals	A
28.00	**AIR CONDITIONING & VENTILATION SYSTEM**	

Comprehensive List of Drawing Submission Schedule		
28.01	GTP	A
28.02	Drawings	A
28.03	A/C sizing calculation	A
29.00	**LT TRANSFORMER**	
29.01	GTP	A
29.02	Drawings	A
29.03	Type Test Reports	A
30.00	**FIRE PROTECTION SYSTEM**	
30.01	Piping layout in the switchyard	A
30.02	HVW spray system drawings (plan, elevation, side view , isometric view and pylon support details)	R
30.03	Pylon support locations	R
30.04	Schematic and GA for LCP for deluge valve operation	A
30.05	Hydraulic calculations for HVW spray network	R
30.06	Drawing for deluge valve housing	A
30.07	GTP & drawings for stainers (Y type & basket strainer)	A
30.08	Drawing of valve pit details	A
30.09	System writeup with various settings	A
30.10	GTP & drgs. for gate valve, check valve, solenoid valve, outdoor hydrant valve	A
30.11	GTP & catalogue for deluge valve, spray nozzles & projectors	A
30.12	GTP & catalogue for quatrzoid bulb detector	A
30.13	GTP & drg. for pressure switch, pressure gauge	A
30.14	GTP for G.I. & M.S. pipes & pipe accessories	A
31.00	**CONTROL ROOM BUILDING / TRANSIT CAMP /FFPH BUILDING/SWITCHAYRD PANEL ROOM/INDOOR HT SWITCHGEAR ROOM/TOWNSHIP BUILDINGS (AS applicable)**	
31.01	Architectural drawing	
a)	Plan, Section & elevation	A
b)	Doors and Window Schedule	A
31.02	Building design calculation(if applicable)	A
31.03	Civil Construction Drawings	A
32.00	**DRAWING FOR GIS BUILDING (if Applicable)**	A
31.01	Architectural drawing	A
a)	Plan, section & elevation	A
b)	Doors & windows schedule	A

Comprehensive List of Drawing Submission Schedule		
31.02	GIS Building Superstructure drawings & design calculation	A
31.03	Civil Construction Drawings	A
31.04	GIS Equipment foundation inside GIS building	A
33.0	**SWITCHYARD CIVIL CONSTRUCTION DRAWING (AS APPLICABLE)**	
33.01	Tower Foundation	A
33.02	Equipment Foundation	A
33.03	Transformer Foundation	A
33.04	Reactor Foundation	A
33.05	Road Construction including culverts, rail cum roads	A
33.06	Switchyard fencing and Gate	A
33.07	Cable trench section	A
33.08	Drain Section	A
33.09	Rain water harvesting	A
33.10	Boundary wall	A
33.11	DG Set foundation	A
33.12	LT transformer foundation	A
33.13	Car parking Shed/Security Room	A
33.14	Out Door GIB foundations	A
33.15	Outdoor Sf6/Air Bushing Foundation	A
33.16	BMK/Lighting pole foundation	A
33.17	Fire wall	A
33.18	Contour layout	A
33.19	Drawing of formation level	A
33.20	Soil investigation Report	A
33.21	Any other foundation in Switchyard	A
34.00	**DESIGN, FABRICATION & PROTO CORRECTED DRAWINGS OF ALL TYPES OF TOWERS & BEAMS**	R
35.00	**DESIGN, FABRICATION DRAWINGS FOR EQUIPMENT SUPPORT STRUCTURES**	R
36.00	**MISCELLANEOUS CIVIL DRGS**	A

LEGEND:- A- for Approval; R:- for Record

Note: i) The above list of Drawing is indicative. The same shall be used for formulation of Master Drawing List (MDL) in DREAMS System.

Annexure- F

Assessment report from Contractor for proposed sub-vendor along with following enclosures (to the extent available):

1. Registration / License of the works
2. Organization chart with name and qualification of key persons
3. List of Plant and Machinery.
4. List of testing equipment with their calibration status.
5. List of Raw material, bought out items with sourcing details
6. List of out-sourced services with sourcing details.
7. List of supply in last three years.
8. Third party approval, if any (viz. ISO, BIS),
9. Pollution clearance wherever applicable
10. Energy Conservation & Efficiency report
    (Applicable to industries having contract load more than 100 KVA)
11. Formats for RM, in process and acceptance testing
12. Type test approvals conducted in last 5 years, if applicable
13. Performance Certificates from customers
14. Photographs of factory, plant and machinery & testing facilities

Annexure-G

MQP & INSPECTION LEVEL REQUIREMENT

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
A.01	LT Transformer /Power Transformer/ Reactor/ Converter Transformer/ Filter Reactor	MQP/ITP	IV
A.02	Bushing	MQP	IV
A.03	Insulating Oil	POWERGRID TS	III
A.04	Oil storage tank for transformers	MQP	III
A.05	Nitrogen injection based explosion prevention system	FAT/ITP	III
A.06	On Line oil drying system for transformers	POWERGRID TS	II**
A.07	On Line DGA and moisture monitoring system	POWERGRID TS	II**
A.08	Flow sensitive conservator isolation valve	POWERGRID TS	II**
A.09	Oil Filtration Machine	MQP	III
B.01	Circuit Breakers	MQP	IV
B.02	Current Transformers	MQP/ITP	IV
B.03	CVT/PT/IVT	MQP	IV
B.04	Isolators	MQP/ITP	IV
B.05	Surge Arrestors	MQP/ITP	III
B.06	Line Trap & Air Core Reactor	MQP/ITP	III
B.07	Point On switching device (CSD) for Circuit Breaker (wherever required)	FAT/ITP	IV
C.01	STATCOM including Valve, valve base electronics, DC capacitor, series reactor and all accessories	ITP	IV
C.02	Mechanically switched Reactor bank (3-ph) including all accessories (MSR Branches)	ITP	IV
C.03	Mechanically switched Capacitor bank (3-ph) including all accessories (MSC Branches)	ITP	IV
C.04	Harmonic Pass filters	ITP	IV
C.05	HT Capacitor	MQP	IV
D.01	Thyristor Valve	FAT/ITP	III
D.02	PLC Capacitors for HVDC	FAT/ITP	III
D.03	Valve Cooling system for	FAT/ITP	III

Annexure-G

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
	HVDC		
D.04	AC/DC Filter Resistors	ITP	III
D.05	DC Current and Voltage measuring device for HVDC	FAT/ITP	III
D.06	Maintenance platform for valve hall	POWERGRID TS	II
D.07	Optical signal column for FSC	FAT/ITP	II
E.01	GIS including spares	MQP/ITP	IV
E.02	Dew Point Meter for GIS	POWERGRID TS	I*
E.03	Portable Partial Discharge monitoring system for GIS	POWERGRID TS	I*
E.04	Partial Discharge Monitoring System (Online) for GIS	ITP	III
E.05	PEB Structure and Puf Panels	MQP	III
F.01	Substation Automation system	FAT/MQP	III
F.02	Event Logger	POWERGRID TS	III
F.03	PLCC equipment Viz PLCC Terminal ,Carrier equipment, Protection Coupler , Coupling Device but excluding EPAX / HF Cable	MQP	III
F.04	Control & Relay Panels	MQP	III
G.01	EHV Cables	MQP/ITP	III
G.02	Power Cables & Control Cables	MQP	III
G.03	Cable Joints (11 kV and above)	POWERGRID TS	II
G.04	Cable Lugs & Glands / Clamps/Terminations	POWERGRID TS	I
H.01	LT Switchgear & ACDB/DCDB/MLDB/ELDB	MQP	III
H.02	Battery	POWERGRID TS	II
H.03	Battery Charger	MQP	III
H.04	UPS & Voltage Stablizer	MQP/FAT	III
H.05	D. G. Set	FAT/ITP	III
H.06	Lighting Panel	POWERGRID TS	II
H.07	Lighting Poles	POWERGRID TS	II
H.08.1	Lighting Fixtures, Lighting Earthwire, Switches / sockets, Conduits, Lamps & fans including exhaust fans	POWERGRID TS	I
H.8.2	Solar based LEDs System including street light/pole solar panel, Inverter controller/LED fixture	FAT	III
H.09	MS/GI /PVC Pipes for cable	POWERGRID TS	I

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
	trenches and lighting		
H.10	Outdoor Receptacle	POWERGRID TS	I
H.11	Split A.C/window A.C./ precision AC/ Kiosk AC/ Cascade AC/ Tower AC	POWERGRID TS	I
H.12	Occupancy sensors for control of lighting	POWERGRID TS	I
H.13	Solar based street lighting pole including Solar Panel, Inverter, Controller, etc.	POWERGRID TS	III
H.14	Junction Box / Lighting Switch Boards / Bay MB / Portable Flood Light Panel	POWERGRID TS	II
H.15	Lighting transformer	POWERGRID TS	II
I.01	SF6 gas processing unit, SF6 gas Leakage detector, SF6 gas Analyzer	POWERGRID TS	I*
I.02	SF6 Gas	POWERGRID TS	I
I.03	Spark Gap	FAT/ITP	III
I.04	Time synchronizing Equipment (GPS Clock)	POWERGRID TS	I
I.05	Galvanized Cable trays	POWERGRID TS	II
I.06	Video Monitoring System	FAT/ITP	I
I.07	Public Address System (All Components)	POWERGRID TS	I
I.08	Building Management System (All components)	POWERGRID TS	I
I.09	Access Control System (All Components)	POWERGRID TS	I
I.10	Video Display system/ Video Projection system	POWERGRID TS	I
I.11	VESDA (smoke detector)	POWERGRID TS	I
I.12	High Mast Pole	MQP	III
J.01	Aluminium ladder	POWERGRID TS	I
J.02	Hume Pipes	POWERGRID TS	I
J.03	Castle Key	POWERGRID TS	I
J.04	Water Treatment plant (All components).	POWERGRID TS	I
J.05	Furniture	POWERGRID TS	I
J.06	DOL Starter	POWERGRID TS	I
J.07	Oil Sample Bottles and Syringe	POWERGRID TS	I
J.08	Test & Measuring Equipment, T&P	POWERGRID TS	I*
K.01	EOT Crane	POWERGRID TS	II

Annexure-G

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
K.02	Boom Crane/Golf Cart/Platform Truck/Man Lift/ Fork Lift/ Lifts	POWERGRID TS	II
L.00	Fire Protection System		
L.001	Panels, Hydro pneumatic tank for fire protection system.	POWERGRID TS	III
L.002	Deluge valve, Strainers, MS/GI pipes, Pumps, motors, air compressor, and other valves, Diesel Engines	POWERGRID TS	II
L.003	Others	POWERGRID TS	I
M.00	HVAC SYSTEM		
M.001	Air Cooled Chiller	POWERGRID TS	III
M.002	Pump	POWERGRID TS	II
M.003	Air Handling Unit	POWERGRID TS	II
M.004	Fan Filter Unit With Centrifugal Blower	POWERGRID TS	II
M.005	Axial Flow Fan	POWERGRID TS	II
M.006	Main Climate Control Unit (Dehumidifier)	POWERGRID TS	I
M.007	Dampers	POWERGRID TS	II
M.008	Fire Dampers	POWERGRID TS	II
M.009	Pressure Gauge, Thermometers, Other Instruments / Sensors	POWERGRID TS	I
M.010	Grill, Diffuser, Jet Nozzle, Louvers etc	POWERGRID TS	I
M.011	Ducting	POWERGRID TS	III
M.012	M S Pipe	POWERGRID TS	II
M.013	Pipe Insulation Material	POWERGRID TS	I
M.014	Duct Insulation Material	POWERGRID TS	I
M.015	Underdeck Insulation Material	POWERGRID TS	I
M.016	Gate Valve & Non Return valve	POWERGRID TS	I
M.017	Y Strainer	POWERGRID TS	II
M.018	Ball Valve/ Motorised Butterfly Valve/ Balancing Valve	POWERGRID TS	I
M.019	Closed Expansion Tank	POWERGRID TS	II
M.020	Air Separator	POWERGRID TS	I
M.021	MCC /PLC /Electrical Panels	POWERGRID TS	III
M.022	Propeller Fan/ Conduit	POWERGRID TS	II
M.023	Air Filter/ Mixing Valve with Thermostat	POWERGRID TS	I

Annexure-G

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
N.01	SDH Equipment	FAT/ITP	IV
N.02	Termination Equipment Primary/ DI Multiplexer	FAT/ITP	IV
N.03	DACS	FAT/ITP	IV
N.04	Optical Amplifier	FAT/ITP	IV
N.05	FODP including pigtail, Joint Box, FDMS	FAT/ITP	II
N.06	IMPS	FAT/ITP	IV
N.07	Optical bypass switch	FAT/ITP	IV
N.08	Air Purifier	FAT/ITP	I
N.09	Patch cord & connector	FAT/ITP	I
N.10	NMS	FAT/ITP	IV
N.11	OPGW Cable	MQP/ITP/FAT	III
N.12	Hardware Fittings for OPGW cable	MQP/ITP	III
N.13	DCPS	FAT/ITP	III
N.14	Radio Links	FAT/ITP	III
N.15	SMPS based DC Power Supply (DCPS) system	FAT/ITP	III
N.16	WAMS (PMU & Accessories)	FAT/ITP	III
N.17	PUF Shelter	FAT/ITP	III
N.18	Aerial OFC/UGOFC/ADSS/FO Cable	FAT/ITP	III
N.19	DWDM	FAT/ITP	III
N.20	OTN	FAT/ITP	III
N.21	MPLS-TP Equipment	FAT/ITP	III
N.22	L2 Switch	FAT/ITP	III
N.23	IP-MPLS Router	FAT/ITP	III
N.24	HDPE Pipes	POWERGRID TS	II
N.25	Equipment Cabinets	POWERGRID TS	II
N.26	Main Distribution Frame	POWERGRID TS	I
N.27	Telephone system, EPAX, Telephone wires, Telephone sockets	POWERGRID TS	I
N.28	Fibre Optic Cable	MQP	III
N.29	Hardware Fittings for Fibre Optic cable	MQP	III
O.01	Re-rollers of MS/HT Angle Section and galvanized tower parts.	MQP	IV
O.02	Conductor	MQP	IV
O.03	Hardware fittings and Conductor & Earthwire Accessories	MQP	IV
O.04	Earth wire	MQP	IV

Annexure-G

Sl. No	Item / Equipment	Reference document for inspection	Inspection Level
O.05	Insulator	MQP	IV
O.06	Bolts & Nuts of Gr 8.8 / 8	MQP	IV
O.07	Mono Pole	MQP	IV
O.08	Foundation Bolts & Anchor Bolts	POWERGRID TS	III
O.09	D-shackle/ Hanger / Links and associated Special bolt/nuts	MQP	III
O.10	Span Marker, Obstruction lights and Wind Measuring Equipment	POWERGRID TS	III
O.11	MS ROD rolled by Approved Re-roller of POWERGRID	MQP	III
O.12	MS ROD rolled by Approved steel producers of POWERGRID	POWERGRID TS	I
O.13	Spring Washers & Pack washers	POWERGRID TS	II
O.14	Bolts & Nuts Gr up to 5.6/5	POWERGRID TS	II
O.15	ACD & Barbed wire for ACD/Bird guard	POWERGRID TS	II
O.16	Danger Plate /Phase Plate / Number Plate / Circuit plate	POWERGRID TS	I
O.17	Sub Station Structure (lattice/pipe type)	MQP	III
O.18	Clamps & Connecters (including equipment connectors)	MQP	III
O.19	MS/ GI Flat, rod type, pipe type and other earthing material.	POWERGRID TS	II
O.20	Aluminium Tube & Busbar materials	POWERGRID TS	II
O.21	Pipe Type & Counter Poise Earthing	POWERGRID TS	II
O.22	DTS System	POWERGRID TS	II

For Equipment where requirement of MQP is envisaged, ITP/FAT will be followed If sourced from off shore. For items required in S/S or T/L or TELECOM/LD&C , same inspection level as specified shall be followed for all the cases.

*MICC for test and measuring equipment (inspection level I or II) shall be issued only after actual verification/ demonstration of satisfactory performance at site.

** Though level-2 items, CIP/MICC can be issued also on review of TCs and visual inspection of these item.

ANNEXURE-H

RTV Silicone high voltage insulation coating (HVIC)

1. SCOPE

The scope of work shall include supply, transportation and application of RTV-1 silicone rubber high voltage insulator coating and cleaning/removal of waste from the equipment.

a) All the required materials, tools & tackles, testing equipments including man lift etc. are in the scope of successful bidders/contractor.

b) Surface preparation:

All equipment surfaces to be coated should be made free from dust, grease, oil etc. & other foreign matter. Also the surface meant for application must be dry.

c) The RTV coating supplied for application should be properly mixed before application as per the recommendations of manufacturer. The coating should cover complete surface and should be applied in manner that prevents runs, sags, drips, spills etc. The application shall be done by certified applicant of Manufacturer.

d) Successful bidder/contractor shall submit the detailed field quality plan for approval. It is not the intention of this specification to specify completely herein all details and design requirements. However, the materials offered & work execution shall confirm in all respects to high standards of engineering and workmanship and be capable of performing in continuous commercial operation up to guarantee in a manner acceptable to purchaser.

2. CLIMATIC CONDITIONS:

The overall climate is moderate hot, humid, tropical, highly polluted and conducive to rust and fungus growth. The climatic conditions are prone to wide range of outdoor service conditions.

3. APPLICABLE CODES AND STANDARDS

The latest revision/amendments of the following Codes and Standards shall be applicable for the equipment/material covered in this Technical Specification. In case of conflict, the vendor/manufacturer may propose equipment/material conforming to one group of Industry Codes and Standards quoted hereunder without jeopardizing the requirements of this Technical Specification.

IEC 60243-1	Electric strength of insulating materials - Test methods - Part 1: Tests at power frequencies
IEC TR 62039	Selection guide for polymeric materials for outdoor use under HV stress
IEC 60250	Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical materials at power, audio and radio frequencies including meter wavelengths
IEC 60587	Electrical insulating materials used under severe ambient conditions - Test methods for evaluating resistance to tracking and erosion
IEC TS 62073	Guidance on the measurement of hydrophobicity of insulator surfaces
IEC 61621	Dry, solid insulating materials-Resistance test to high - voltage, low - current arc discharges
IEC 62217	Polymeric HV insulators for indoor and outdoor use-General definitions, test methods and acceptance criteria

RTV Silicone high voltage insulation coating (HVIC)

IEC 62631-3-2	Dielectric and resistive properties of solid insulating materials - Part 3-2: Determination of resistive properties (DC methods) - Surface resistance and surface resistivity
IEEE Std 957	IEEE Guide for Cleaning Insulators
IEEE Std 1523	IEEE Guide for the Application, Maintenance and Evaluation of Room Temperature Vulcanizing (RTV) Silicone Rubber Coatings for Outdoor Insulation Applications.
ASTM D149-09	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D150-11	Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
ASTM D257-14	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
ASTM D495-14	Standard Test Method for High - Voltage, Low - Current, Dry Arc Resistance of Solid Electrical Insulation
CEA LWIWG-02 (1996)	Line Post Composite Insulator for Overhead Distribution Lines

4. Technical Parameters

4.1 RTV Silicon compound in its liquid form shall have the following properties:

Material Properties	Requirement
Material Type	One part RTV
Appearance	Paint
Filler type	ATH, Quartz or both
Color	Gray
Percent of solids by weight	≥ 70%
Substrate Application Temperature Range °C	-4°C to 121°C
Tack free at 25°C and 50% RH	30 minutes

4.2 RTV Silicon coating after cured form shall have the following properties:

Parameters	Requirement
Application Area	Glass, Porcelain, station insulators, as well as bushing, instrument transformers and related devices
Full cure time	≥ 24 hours
Coating thickness	500 microns + 10% tolerance, dry film thickness
Dielectric Strength	≥ 20 kV/mm
Volume Resistivity	≥ 1.0*10^12 ohm.m
Tracking and Erosion test	1000 Hours
Min. Salinity Level withstood during "Artificial Pollution Test using Salt Fog Method"	≥160 kg/m^3
Hydrophobic Recovery Test	HC2 or HC1
Method of Application	Airless Spray
Dry Arc resistance	Tract ≥ 140 seconds Burn Out ≥ 420 seconds

RTV Silicone high voltage insulation coating (HVIC)

Parameters	Requirement
Tracking and Erosion (IEC 60587, Method 1: Application of constant tracking voltage)	Class 1A 4.5kV or better
Primer Required	No primer material shall be allowed
Resistant to	Marine salt fog, Water, Industrial (cement dust, fly ash, acid emission etc.), Rough Weather Conditions
Other Properties	Non Hazardous to environment, surface after full cure shall be smooth

4.3 Materials

4.3.1 The RTV Silicone high voltage insulation coating shall be ultraviolet (UV) radiation exposure resistant. The finished product shall withstand the adverse atmospheric conditions due to weather, proximity to the coast, fumes, ozone, acids (particularly nitric acid in the coastal areas and sulphuric acid in the oil field areas), bases/alkalis, and hydrocarbon components, dust or rapid changes to air temperature (temperature extremes). There shall not be significant material degradation such as development of surface cracks and unacceptable increase in surface hardness etc.

4.3.2 The RTV Silicone high voltage insulation coating shall be resistant to atmospheric and chemical degradation. Salt air, airborne pollutants, industrial pollutants such as cement dust, sulphur, rain and humidity shall not result in flashover on the coating.

4.3.3 The RTV Silicone high voltage insulation coating shall be resistant to arcing and corona. The Coating shall exhibit high tracking resistance to reduce damage during salt-storms (storms arising from the sea) or other severe contamination events. The track resistance of the RTV Silicone Rubber Insulator Coating material shall meet the requirements of IEC 60587, Method 1, Class 1A 4.5kV.

4.3.5 The RTV Silicone high voltage insulation coating shall be a single component, ready-to-use after simple mixing. It shall not require excessive mixing/shaking and thinning/dilution before use. The Coating shall be moisture curable at room temperature.

4.3.6 The RTV Silicone high voltage insulation coating shall exhibit long-term water repellency and hydrophobicity.

4.3.7 The RTV Silicone high voltage insulation coating shall not require use of any primer on the ceramic insulators for adhesion purposes.

4.3.8 The RTV Silicone high voltage insulation coating shall be easy to be reapplied. The Coating shall have excellent arc resistance, excellent unprimed adhesion, easy to apply and spray-able as well as paint-able.

4.3.9 The RTV Silicone high voltage insulation coating shall have a minimum 12 months shelf life, which shall effect from the date of manufacturing. The manufacturer shall submit the warranty to this effect. The expiry date shall be marked on the containers. The remaining shelf life of the material shall be at least six (6) months when delivered to site. The coating shall be supplied in cans weighing not more than 25kg.

4.4 Composition and Properties

4.4.1 The RTV Silicone high voltage insulation coating shall be capable of withstanding high-pressure water power washing. To prove this property, a power wash test shall be performed per requirements stated hereafter in this standard.

RTV Silicone high voltage insulation coating (HVIC)

4.4.2 The RTV Silicone high voltage insulation coating shall protect the ceramic insulators (porcelain and glass) against flashovers caused by pollution.

4.4.3 The manufacturer shall advise/recommend suitable method of application and submit written application instructions and shall suggest suitable equipment set-up (size of pump and compressors, etc.) and the compatibility of his product to be reapplied on the RTV coating from other manufacturers.

4.4.4 The warranty for RTV coating on the equipments shall be for a period of 5 years

4.5 Markings

The packing and expiry dates of coating shall be labeled on the coating cans. The expiry date shall be considered from the packaging date and not from the date of shipment of the coating.

The cans shall be marked for “flammable” or “non-flammable” depending upon the type of solvent used for the dispersion of the coating.

5.0 TESTS

All test results shall be provided for review and acceptance by customer.

5.1 **Type Tests**

5.1.1 Type tests as prescribed in relevant standards shall be performed on RTV coated sample tiles or RTV coated insulators as applicable to verify the suitability of the design, materials and method of manufacture. Testing shall include, but not limited to following. These tests shall be performed only on the new design of RTV silicone high voltage insulation coating. The test reports shall be submitted from tests done in a NABL/International accredited lab.

a) Tracking and erosion resistance test (IEC 60587, Method 1, Class 1A 4.5kV). Samples shall consist of smooth porcelain plates of 6mm (± 0.5mm) thickness coated with the thickness of the material as proposed by the manufacturer for the offered coating. Breaking of porcelain substrate shall not be allowed.

b) Salt-fog tests

The 1000 hour Tracking and erosion test outlined in IEC-62217 shall be carried out.

c) Dry arc resistance test

Dry arc resistance test shall be carried out as per ASTM D495.

d) Contact Angle Measurement Test:

Receding contact angle measurement test shall be performed in accordance with IEC TS 62073.

e) BDV testing of fully cured coating.

The test shall be carried out as per IEC:60243-1 or ASTM D149.

f) Volume Resistivity Test

The test shall be carried out as per IEC:60093. Sample thickness shall be 2mm which can be obtained by using an open mould casting technique. The minimum volume resistivity as specified shall be achieved.

g) Artificial Pollution Test in general with IEC 60507 without the pre-condition test.

h) Adhesion Test as type test:

Adhesion test shall be performed in accordance with Canadian Electric Association (CEA) specification LWIWG-02 (96) or any other equivalent standard to verify the bonding characteristics of the RTV Silicone Rubber Coating when applied to ceramic insulators. Three (3) coated insulators shall be put in water having 0.1% by weight of NaCl and boiled for 100 hours (each sample separately). At the end of boiling, allow each insulator to remain in the water until the water cools to about 50^{o}C. The coating shall not exhibit any water blisters at the interface between the insulator surface and the coating.

5.2 **Acceptance Tests (at Site or Factory)**

a) Thickness measurement:

Dry film thickness (DFT) of the coating shall be measured at site on all Equipments randomly at least at one point of the Equipment.

b) Adhesion Test as acceptance test:

Adhesion test shall be performed at site in accordance with CEA specification LWIWG-02 (96) or any other equivalent standard to verify the bonding characteristics of the RTV Silicone Rubber Coating when applied to ceramic insulators. Three (3) coated insulators shall be put in water having 0.1% by weight of NaCl and boiled for 2 hours (each sample separately). At the end of boiling, allow each insulator to remain in the water until the water cools to about 50^{o}C. The coating shall not exhibit any water blisters at the interface between the insulator surface and the coating.

c) High Pressure Water Withstand Test:

A power water wash test shall be performed at site on 5% sample in accordance with IEEE Std 957 to demonstrate that the RTV coated insulators can be power washed without any damage to RTV coating. The test shall be a water spray of a solid stream through a 6mm diameter nozzle at 3800 kPa for a period of 10 (ten) minutes. The nozzle of the spray equipment shall be at a distance of 3m from the insulator surface. There should not be any damage to the coating.

d) Hydrophobicity test :

Hydrophobicity test shall be carried out on virgin material at site on 5% sample on 1-2 coated equipment as per STRI guidelines and the results shall be HC2 class or better. Hydrophobicity test shall be carried out after completion of high pressure water withstand test.

Annexure-I

SECTION

INDICATIVE DRAWING ONLY
(SIZE SHALL BE AS PER WORK REQUIREMENT)

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

PROJECT: STANDARD DRAWING FOR OPEN PLATFORM

TITLE: INDICATIVE DRAWINGS FOR OPEN STORAGE PLATFORM

AGM(ENGG CIVIL)	CM(ENGG CIVIL)	REVD. BY AGM(ENGG CIVIL)	APPD. BY ED(ENGG CIVIL)	DATE
11/8/16				11/8/16

DRAWING NO. C-ENGG-CVL-STD-PLATFORM-01 | SCALE NTS | REV 0

ANNEXURE-J

LIST OF THE MAKES FOR WHICH TYPE TEST REPORTS NOT REQUIRED TO BE SUBMITTED

Sl. No.	ITEM DESCRIPTION	MAKE
A.	*Substation Accessories [Type Testing is not envisaged]*	
1.	Out door receptacles	CGL/B&C/BCH/Sakti, Chennai/Indo Asian/AVAIDS
2.	Trefoil clamp	Moulded Fibre Glass Products, Calcutta
3.	Diesel Engine	Cummins/Ruston & Hornsby/Greaves Cotton/Kirloskar/Mahindra/Ashok Leyland
4.	Alternator	AVK/KIRLOSKAR/STAMFORD/ Leroy Somer
5.	Motors	KEC/Siemens/NGEF/Crompton/ABB
6.	Cable Glands	Sunil & Co./Arup/ Comet/QPIE
7.	Junction Box	Sarvana/ECS/C&S/Vikas/ Maktel/Unilac/Jasper/ Amara raja/AVAIDS
8.	EPAX	MATRIX, BPL
9.	ACSR Conductor (Bersimis/Moose/Zebra)	Sterlite/Apar/HVPL/Sharavathy/Hiren Aluminium Ltd./Smita/Deepak Cables/Polycab wires/Cabcon/JSK
10.	AAC Conductor (BULL)	Sterlite/Cabcon /JSK
11.	G.S. Earthwire	Sharavathy/Bharat Wire Ropes/Ramswarup
12.	Lighting Fixtures	Phillips/CGL/Bajaj /Havels
13.	Lighting Transformer	Gujarat-Plug-In
14.	Lighting Panels	Vikas/Makel/Nitya/AVAIDS
15.	MCCB/ACB/Protective relays of LT Switchgear Boards	All approved makes as per Compendium of Vendors
16.	EOT Crane	Reva
B.	***ACCESSORIES FOR TRANSFORMER & REACTOR [Earlier approved type test reports is applicable and not required to be submitted]***	
17.	BUCHHOLZ RELAY *[Upto 765kV Transformer & Reactor]*	(i) M/S CEDESPE, ITLAY [Model Type-EE 3 (Plug & Socket type)]/ (ii) M/s VIAT INSTRUMENTS PVT. LTD.KOLKATA [Model type-GOR-3M (Plug & Socket type)]
18.	PRESSURE RELIEF DEVICE *[Upto 765kV Transformer & Reactor]*	(i) M/S SUKRUT UDYOG, Pune [Model type-T-6-MS-15-SHB-PS (Plug & Socket type)] /
19.	MAGNETIC OIL LEVEL GAUGE *[Upto 765kV Transformer & Reactor]*	(i) M/S SUKRUT UDYOG PUNE [Model type-SO-HE-10-M-ATMS-PS (Plug & Socket type)], [Model Type:- SO-6-M-P-PS (Plug & Socket type)]/
20.	AIR CELL (FLEXIBLE AIR SEPARATOR) *[Upto 765kV Transformer & Reactor]*	Type test of following makes are not to be submitted (i) M/S PRONAL FRANCE / (ii) FUJIKURA,JAPAN / (iii) PRONAL ASIA, MALAYSIYA / (iv) SHENYANG HONGDA GENERAL RUBBER FACTORY /

ANNEXURE-J

LIST OF THE MAKES FOR WHICH TYPE TEST REPORTS NOT REQUIRED TO BE SUBMITTED

Sl. No.	ITEM DESCRIPTION	MAKE
		(v) BAODING XINKE RUBBER PRODUCT INSTITUTE, CHINA / (vi) M/S ZENITH INDUSTRIAL RUBBER PRODUCTS PVT. LTD. THANE/ (vii) M/S UNIRUB TECHNO PUNE
21.	OTI & WTI *[Upto 765kV Transformer & Reactor]*	(i) M/S PRESIMEASURE BANGALORE [Model type-1005A
22.	OIL PUMP *[Upto 765kV Transformer & Reactor]*	(i) FLOWWELL PUMPS & METERS, BANGALORE [Model type-1220D, 1250D
23.	COOLING FAN AND MOTOR ASSEMBLY *[Upto 765kV Transformer & Reactor]*	(i) M/S MARATHON LTD KOLKATA [Model Type:- 36M/K75-P8, 0.7kW, 725RPM, 22J/K37-P6, 0.25kW, 940RPM,AFF 915103, 0.625kW, 550RPM]
24.	Sudden Pressure Relay *[Upto 765kV Transformer & Reactor]*	(i) Qualitrol [Model/Drawing No.900-003-02 CS-46518, 900-003-32 CS-46369] / (ii) Shenyang KEQI Electrical Equipment Co. Ltd. [Model/Drawing No.SYJ9-50-25TH]
25.	BUCHHOLZ RELAY *[Upto 400kV Transformer & Reactor]*	(i) M/S CEDASPE, ITALY [Model type-EE3 (Plug & Socket type)]/ (ii) VIAT INSTRUMENTS [Model type-GOR-3M (Plug & Socket type)]
26.	PRESSURE RELIEF DEVICE *[Upto 400kV Transformer & Reactor]*	(i) M/S SKURUT UDYOG, PUNE [Model type-T-6-MS-15-SHB-PS (Plug & Socket type)]
27.	MAGNETIC OIL LEVEL GAUGE *[Upto 400kV Transformer & Reactor]*	(i) M/S SUKRUT UDYOG PUNE [Model type-SO-HE-10-M-ATMS-PS (Plug & Socket type)], [Model Type: SO-6-M-P-PS (Plug & Socket type)]/ (ii) M/S YOGYA ENTERPRISES, JHANSI [Model type-SO-10 (Plug & Socket type)]
28.	AIR CELL (FLEXIBLE AIR SEPARATOR) *[Upto 400kV Transformer & Reactor]*	Type test of following makes are not to be submitted (i) M/S THE RUBBER PRODUCTS MUMBAI / (ii) M/S UNIRUB TECHNO PUNE / (iii) M/S PRONAL FRANCE/ (iv) M/S ZENITH INDUSTRIAL RUBBER PRODUCTS PVT. LTD. THANE / (v) SHENYANG HONGDA GENERAL RUBBER FACTORY, CHINA
29.	Sudden Pressure Relay *[Upto 400kV Transformer & Reactor]*	(i) Qualitrol [Model/Drawing No.900-003-02 CS-46518, 900-003-32 CS-46369] / (ii) VIAT INSTRUMENTS [Model/Drawing No.950 / (iii) Shenyang KEQI Electrical Equipment Co. Ltd. [Model/Drawing No.SYJ9-50-25TH]
30.	RIP Bushing (52kV, 3150A)	ABB Micafil, Switzerland [Model/Drawing No. 1ZCD073617 (Rev F)]
31.	RIP Bushing (420kV, 1250A)	ABB, SWEDEN [Model/Drawing No.1ZSC005378A0001 REV. K]
32.	RIP Bushing (245kV, 1250A)	ABB, SWEDEN [Model/Drawing No.1ZSC005416A0001 (Rev. D)]
33.	RIP Bushing (245kV, 2000A)	ABB, SWEDEN [Model/Drawing No.1ZSC005373A0001

ANNEXURE-J

LIST OF THE MAKES FOR WHICH TYPE TEST REPORTS NOT REQUIRED TO BE SUBMITTED

Sl. No.	ITEM DESCRIPTION	MAKE
		(Rev. C)]
34.	RIP Bushing (420kV, 1250A)	HSP Germany [Model/Drawing No.327470]
35.	RIP Bushing (245kV, 2000A)	HSP Germany [Model/Drawing No.329260]
36.	RIP Bushing (52kV, 3150A)	HSP Germany [Model/Drawing No.329280]
37.	RIP Bushing (420kV, 1250A)	Izolyator, Russia [Model/Drawing No.686354.603]
38.	RIP Bushing (245kV, 2000A)	Izolyator, Russia [Model/Drawing No.686353.602]
39.	RIP Bushing (52kV, 3150A)	Izolyator, Russia [Model/Drawing No.686351.601]
40.	RIP Bushing (145kV, 1250A)	Izolyator, Russia [Model/Drawing No.686352.604]
41.	RIP Bushing (420kV, 1250A)	TRENCH, CHINA [Model/Drawing No.ECT 707 (C2)]
42.	RIP Bushing (245kV, 2000A)	TRENCH, CHINA [Model/Drawing No.ECT 617 (C3)]
43.	RIP Bushing (245kV, 1250A)	TRENCH, CHINA [Model/Drawing No.ECT 616 (C3)]
44.	RIP Bushing (145kV, 1250A)	TRENCH, CHINA [Model/Drawing No.ECT 516 (C3)]
45.	RIP Bushing (52kV, 1250A)	TRENCH, CHINA [Model/Drawing No.ECT 415 (C3)]
46.	RIP Bushing (52kV, 3150A)	TRENCH, CHINA [Model/Drawing No.ECT 419 (C3)]
47.	RIP Bushing (420kV, 1250A)	Xian China [Model/Drawing No.75706 (Rev 09)]
48.	RIP Bushing (245kV,2000A)	Xian China [Model/Drawing No.75618 (Rev 09)]
49.	RIP Bushing (52kV, 3150A)	Xian China [Model/Drawing No.75366 (Rev 03)]
50.	RIP Bushing (52kV, 3150A)	Xian China [Model/Drawing No.75332 (Rev 08)]
51.	OIP Bushing (800kV, 2500A)	ABB, SWEDEN [Model / Drawing No. GOE-2550-1600-2500-0.6-B, 1ZSC026186-AAM REV. H]
52.	OIP Bushing (420kV, 2500A)	ABB, SWEDEN [Model / Drawing No.GOE-1425-1150-2500-0.6, 1ZSC026186-AAL REV. F]
53.	OIP Bushing (800kV, 2500A)	TBEA, CHINA [Model / Drawing No.TBEA-500-765T-A0035-01, REV. 02]
54.	OIP Bushing (420kV, 2500A)	TBEA, CHINA [Model / Drawing No.TBEA-500-765T-A0035-02, REV. 02]
55.	OIP Bushing (420kV, 2500A)	TRENCH, CHINA [Model / Drawing No.OT-738-1 (C 5)]
56.	OLTC (500MVA, 765kV ICT)	MR Germany [Model/Drawing No. MI 1503 72.5/RC- 12231WR]
57.	OLTC (500MVA, 400kV ICT)	Easun MR, Chennai [Model/Drawing No. 3 x MI 1200 300/D 10.19.3W]
58.	OLTC (220kV & below rating transformer)	BHEL, Bhopal [Model/Drawing No.MIII 600 110/C 10.19.3W]
C.	***TESTING EQUIPMENT FOR TRANSFORMER & REACTOR***	
59.	Oil BDV Test Kit	Baur [Model/Drawing No.DTA 100C]
60.	Oil BDV Test Kit	Megger [Model/Drawing No.OTS 100AF]

ANNEXURE-J

LIST OF THE MAKES FOR WHICH TYPE TEST REPORTS NOT REQUIRED TO BE SUBMITTED

Sl. No.	ITEM DESCRIPTION	MAKE
61.	Online Dissolved Gas (Multi-gas) and Moisture Analyser	A Eberle GmbH & Co. KG [Model/Drawing No.HYDROCAL 1008]
62.	Online Dissolved Gas (Multi-gas) and Moisture Analyser	Ningbo Ligong Online Monitoring Technology Co. LTD [Model/Drawing No.MGA2000]
63.	Online Dissolved Gas (Multi-gas) and Moisture Analyser	GE Energy [Model/Drawing No.KELMAN TRANSFIX]
64.	Online Dissolved Gas (Multi-gas) and Moisture Analyser	Qualitrol Company LLC [Model/Drawing No.SERVERON TM 8]
65.	On line Insulating Oil Drying System	CEE DEE Vacuum Equipment Pvt. Ltd. [Model/Drawing No.TRANSDRY CD-002]
66.	On line Insulating Oil Drying System	PTSS [Model/Drawing No.PTSS-TDS1GA6XS]
67.	Portable Dissolved Gas Analysis of Insulating Oil	GE Energy [Model/Drawing No. KELMAN TRANSPORT X]

NOTES:-

1. For sub-station accessories mentioned at Sr. No. A above, model specific separate approval of type test report is not required.

2. For Transformer/Reactor accessories & testing equipment mentioned at Sr. No. B & C above, wherever, model/drawing no. is specified separate approval of type test report and drawing/documents is not required, thus requirement of type test report validity of 10 years is not applicable.

ANNEXURE-K

SL.NO.	Power System Equipment
A	**Power System Equipment**
1	Transformers and Reactors (66 kV to 765 kV AC)
2	Air Insulated Switchgear (Circuit Breakers, Disconnectors), Surge Arrester, Wave trap (66 kV to 765 kV AC)
3	Gas Insulated Switchgear (66 kV to 400 kV AC)
4	Instrument Transformers (66 kV to 765 kV AC)
5	Bus Post Insulators
6	Substation structure material
7	Transmission line tower material
8	Conventional conductors and accessories
9	Porcelain Insulators and hardware fittings
10	Control & power cables
11	High Voltage Cables (upto 220 kV AC)
12	Control and Protection System including Substation Automation System
13	DG set
14	DC system (DC Battery & Battery Charger) in a substation
15	AC & DC Distribution Board for substation
16	Material for Grounding system
17	Items for illumination system
B	**Telecom Products, Services and Works**
1	Encryption/UTM platforms (TDM and IP)
2	IP/MPLS Core routers/ Edge/ Enterprise Router
3	Managed Leased line Network equipment
4	Ethernet Switches (L2 and L3), Hubs
5	IP based Soft Switches, IMS, Unified Communication Systems

6	Wireless/Wireline PABXs / IP PBX & / Media Gateways
7	CPE (including Wi-Fi Access points and Routers, Media Converters), 2G/3G/4G/LTE Modems, Leased-line Modems, NFV/SDN CPE
8	Set-Top Boxes
9	SDH/Carricr-Ethernct/MPLS- TP/Packet Optical Transport equipment/PTN/OTN systems
10	DWDM/CWDM systems
11	GPON/XGS-PON, NG-PON2 equipment (including ONT and OLT)
12	Optical/SDH/PDH Cross Connects/OTN Cross-connects and optical MUX, OADM
13	Small size 2 G/3 G GSM based Base Station Systems, with its various derivatives including rural & disaster response, Macro & Micro BTS, Small Cells, NIB, C-RAN BBU and RRH
14	2 G/3 G GSM based Base Station Systems, with its various derivatives including rural & disaster response, Macro & Micro BTS, Small Cells, NIB, C-RAN BBU and RRH
15	Small Size LTE/LTE-R Based Mobile Systems, with its various derivatives including rural & disaster communications, Macro & Micro eNodeB, Small Cells, EPC, NIB C-RAN BBU and RRH, LTE/LTE-R/4.5 G/ 5 G based broadband wireless access systems (eNodeB, gNB, EPC, etc.)
16	LTE/LTE-R Based Mobile Systems, with its various derivatives including rural & disaster communications, Macro & Micro eNode B, Small Cells, EPC, NIB C-RAN BBU and RRH, LTE/LTE-R/4.5 G/ 5 G based broadband wireless access systems (eNodeB, gNB, EPC, etc.)
17	Wi-Fi based broadband wireless access systems (Including Access Point, Aggregation Block, Core Block), Integrated Broadband system
18	Microwave Radio systems (IP/Hybrid), Mobile Front haul BBU and RRH (CPRI, eCPRI, FlexE, RoE, NGFI)
19	Software Defined Radio, Cognitive Radio systems
20	Repeaters (RF/RF-over-Optical), IBS, and Distributed Antenna system
21	Satellite based systems-Hubs, VSAT Disaster Communication Systems etc.
22	Copper access systems (DSL/DSLAM), high-speed xDSL (G.fast)
23	Network Management systems (NMS) with its various derivatives

24	Security and Surveillance Communication Systems (video and sensors based) including Perimeter Security Systems
25	Optical Fiber
26	Optical Fiber Cable
27	Telecom Power System (Including Solar Power)
28	Telecom Batteries (Lead Acid & Li-ion)
29	IP audio phones / IP video Phones / Analog adaptor
30	SDN Software Controllers, NVF and CNF software
31	Telecom Cloud infrastructure, Telecom Data centers
32	2 way Analog/Digital radio including Walkie-Talkie & Mobile Radio
33	Batteries of 2 way Analog/Digital radio including Walkie-Talkie
34	Fiber Monitoring System
35	M2M/IOT Subsystems
36	Telecom Services/Works

ANNEXURE-L

Major Changes in Section GTR (Rev 15)

S.No	Clause ref	Existing Clause	Proposed Text	Reason/Background for proposed changes
1.	**Clause2.1 a)**		All equipment/materials/items, as per Annexure-K, as applicable under present scope of works, shall be procured and supplied from domestic manufacturers only Any imported equipment/material/item/parts/component (comprising of embedded systems) to be supplied under the contract shall be tested in the certified laboratories to check for any kind of embedded malware/trojans/cyber threats and for adherence to Indian Standards as per the directions issued by Ministry of Power/Govt. of India from time to time. In case of such import from specified "prior reference" countries, the requirement of prior permission from the Govt. of India including protocol for testing in certified and designated laboratories by Ministry of Power/Govt. of India shall also be complied with by the contractor. The bidder/contractor shall list out the products and components producing Toxic e-waste under the contract and shall furnish to the Employer the procedure of safe disposal at the time of closing of the contract	New Clause Added..
2.	**Clause 2.6**	The bidder shall be responsible for safety of human and equipment during the working…..	The **contractor** shall be responsible for safety of human and equipment during the working.	
3.	**Clause 3.2**	The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the originally scheduled date of bid opening) of standard specified under Annexure-C of this section, unless specifically mentioned in the specification.	The equipment offered by the contractor shall at least conform to the requirements specified under relevant IS standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. The Contractor shall also note that the list of standards presented in this specification at Annex-C is not complete. Whenever necessary, the list of standards shall be considered in conjunction with specific IS. If the IS standard is not available for an equipment/material, then other applicable International standard	Changes incorporated In line with recent Guidelines from GOI.

			(IEC/Equivalent), as per the specification, shall be accepted.	
4.	**Clause 3.3**	The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.	The Contractor shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.	
5.	**Clause 3.4**	The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IS/IEC.	**The equipment offered by the contractor shall confirm to relevant IS standard. The list of such IS standards are given at Annexure-C. In case There is discrepancy between IS and other international standard then provision in IS shall prevail.** The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific **IS. If the IS standard is not available for relevant equipment's/ Material is supplied from foreign country, then other internationally standard (IEC/Equivalent) will be accepted.**	Changes incorporated In line with recent Guidelines from GOI
6.	**Clause 4.1**	The 800kV and 420kV system is being designed to limit the switching surge over voltage of 1.9 p.u. and 2.5 p.u., respectively and the power frequency over voltage of 1.4 p.u. and 1.5 p.u., respectively. In case of the 420kV system, the initial value of the temporary overvoltages could be 2.0 p.u. for 1-2 cycles. The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.	**Switching surge over voltage and power frequency over voltage is specified in the system parameters below**. In case of the 420kV system, the initial value of the temporary over voltages could be 2.0 p.u. for 1-2 cycles. The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.	To avoid repetition.
7.	**Clause 4.4**	The bidder shall design terminal connectors of the equipment taking into account various forces that are required to withstand.	The ~~bidder~~ Contractor shall design terminal connectors of the equipment taking into account various forces as mentioned at Sl.No.4.3 that are required to withstand.	

Major Changes in Section GTR (Rev 15)

<table>
<tr><td>8.</td><td>Clause 4.6</td><td>4.6 System parameters
132kV,66kV,33kV & 11kV System<table><tr><td>S.No</td><td>Description of parameters</td><td>66kV System</td></tr><tr><td>9</td><td>Rated Short circuit current</td><td>31.5kA</td></tr></table></td><td>4.6 System parameters
132kV,52kV 66kV,33kV & 11kV System<table><tr><td>S.No</td><td>Description of parameters</td><td>66kV System</td></tr><tr><td>9</td><td>Rated Short circuit current</td><td>31.5kA/25kA* for 3 Sec/</td></tr><tr><td colspan="3">* For Tertiary loading Equipment's fault level shall be 25kA for 3 Sec. For Other Switchyards shall be as specified in Section Project

• Further Parameters of 52 kV System is also added
• Sectional Clearance of 66kV System is updated in line with Safety regulation of CEA</td></tr></table></td><td></td></tr>
<tr><td>9.</td><td>Clause 5.2</td><td>The Contractor shall submit 4 (four) sets of drawings/ design documents /data detailed bill of quantity and 1 (one) set of test reports for the approval of the Employer. The contractor shall also submit the softcopy of the above documents in addition to
hardcopy.</td><td>The Contractor shall submit ~~4 (four) sets of~~ All Engineering Documents (drawings/ design documents /data / detailed bill of quantity and 1 (one) set of test reports) through Online Document Review and Engineering Approval Management System(Herein after DREAMS) for the approval of the Employer. ~~The contractor shall also submit the softcopy of the above documents in addition to hardcopy~~</td><td></td></tr>
<tr><td>10.</td><td>Clause 5.7</td><td>Approval Procedure
Note (2)
All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also</td><td>Approval Procedure
Note (2) All drawings should be submitted in ~~softcopy form~~ DREAMS, ~~however~~ further substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version as supporting documents in DREAMS. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

For Civil drawings, associated documents shall be submitted in</td><td></td></tr>
</table>

Major Changes in Section GTR (Rev 15)

			STAAD/Excel format as supporting document in DREAMS.	
11.	**Clause 6.1.7**	All oil, grease and other consumables used in the Works/Equipment shall be purchased in India unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in India. If such is the case, he shall declare in the proposal, where such oil or grease is available. He shall help Employer in establishing equivalent Indian make and Indian Contractor. The same shall be applicable to other consumables too.	All oil, grease and other consumables used in the Works/Equipment shall be purchased in India unless the Contractor has any special requirement for the specific application of a type of oil or grease not available in India. If such is the case, he shall declare source of oil/grease /other consumables in the ~~proposal~~ GTP/Drawings, where such oil or grease is available. He shall help Employer in establishing equivalent Indian make and Indian Contractor. The same shall be applicable to other consumables too.	
12.	**Clause 6.2.4**	Degree of Protection The degree of protection shall be in accordance with IS:13947(Part-I)/IEC-60947 (Part-I)/IS 12063/IEC-60529. Type test report for IP-55 or higher degree of protection shall be submitted for approval.	Degree of Protection The degree of protection shall be in accordance with IS/IEC60947; IS/IEC60529. Type test report of relevant Degree of Protection test, shall be submitted for approval.	IS 13947 is superseded by IS/IEC 60947 IS 12063 is superseded by IS/IEC 60529
13.	**Clause 6.3.1**	Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, , year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IEC requirement.	Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, Customer Name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IS/ IEC requirement.	
14.	**Clause 9.2**	The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. However, type test reports of similar equipments/ material already accepted in POWERGRID shall	The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. However, type test reports of similar equipments/ material already accepted in POWERGRID shall be applicable for all projects with similar requirement. The type tests conducted earlier should have	In line with CEA Guidelines for Validity of Type tests

		be applicable for all projects with similar requirement. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID or representative authorized by POWERGRID or Utility or representative of accredited test lab. Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted within last 10 (ten) years from the date of NOA. In case the test reports are of the test conducted earlier than 10 (ten) years from the date of NOA, the contractor shall repeat these test(s) at no extra cost to the Employer	either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID/representative authorized by POWERGRID/representative of Utility /representative of accredited test lab/ representative of NABCB certified agency shall also be acceptable. Unless otherwise specified elsewhere, the type test reports submitted shall be of the tests conducted within the years specified below from the date of NOA. In case the test reports are of the test conducted earlier than the years specified below from the date of NOA, the contractor shall repeat these test(s) at no extra cost to the Employer.	

S. No	Name of Equipment	Validity of type test(in years)
1	Power Transformer	5
2	LT Transformer	5
3	Shunt Reactor	5
4	OLTC	10
5	Bushing of Power Transformers/Reactors	7
6	Fittings and accessories for Power transformers & Reactors	10
7	Circuit Breaker	10
8	Isolator	10
9	Lighting Arrester	10
10	Wave Trap	10
11	Instrument transformer	7
12	GIS & Hybrid GIS	10

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<tr>
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<table>
<tr><td>13</td><td>LT Switchgear</td><td>10</td></tr>
<tr><td>14</td><td>Cable and associated accessories</td><td>10</td></tr>
<tr><td>15</td><td>Relays</td><td>7</td></tr>
<tr><td>16</td><td>Capacitors</td><td>10</td></tr>
<tr><td>17</td><td>Battery & Battery Charger</td><td>7</td></tr>
<tr><td>18</td><td>Conductor & Earth wire</td><td>10</td></tr>
<tr><td>19</td><td>Insulators (Porcelain/Glass)</td><td>10</td></tr>
<tr><td>20</td><td>Composite Insulators</td><td>5</td></tr>
<tr><td>21</td><td>PLCC</td><td>5</td></tr>
</table>
Note
For all other equipment’s validity of type test shall be 10 years from date of NOA

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the type tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies
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<tr>
<td>15.</td>
<td>Clause no. 9.5</td>
<td>The list of makes of various items, for which Type test reports are not required to be submitted are specified in Compendium of Vendors (COV).</td>
<td>The list of makes of various items, for which Type test reports are not required to be submitted are specified <s>in Compendium of Vendor (COV)</s> at Annex-J</td>
<td></td>
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<tr>
<td>16.</td>
<td>Clause 12.2</td>
<td>The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above and 900 gm/sq.m for coastal area (30km from sea shore approximately) or as specified in Section-</td>
<td>The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above and 900 gm/sq.m for coastal area (<s>30km from sea shore approximately</s> if defined in Section Project) <s>or as specified in Section-Project</s>. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For</td>
<td></td>
</tr>
</table>

<table>
<tr><td></td><td></td><td>Project. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq.m minimum and 900 gm/sq.m for coastal area as specified in Section-Project</td><td>surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq.m minimum and 900 gm/sq.m for coastal area as specified in Section-Project</td><td></td></tr>
<tr><td>17.</td><td>Clause 12.3.2</td><td>After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved</td><td>Hot Phosphating shall be done for phosphating process under pretreatment of sheets After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved</td><td></td></tr>
<tr><td>18.</td><td>Clause 12.3.6</td><td><table><tr><td>S.No</td><td>PIPE LINE</td><td>BASE COLOUR</td><td>BAND COLOUR</td></tr><tr><td>1</td><td>Hydrant and Emulsifier system pipeline</td><td>Fire red</td><td></td></tr></table></td><td><table><tr><td>S.No</td><td>PIPE LINE</td><td>BASE COLOUR</td><td>BAND COLOUR</td></tr><tr><td>1</td><td>Hydrant and Emulsifier system pipeline /NIFPS</td><td>Fire red</td><td></td></tr></table></td><td></td></tr>
<tr><td>19.</td><td>Clause no. 12.3.8</td><td></td><td>Band colour is required for Emulsifier system detection line only if both water and air detection lines are present at the same substation. Further, band colour shall be applied at an interval of 2 meters approx. along the length and minimum width of band shall be 25mm.</td><td>New Clause added</td></tr>
<tr><td>20.</td><td>Clause No. 13.14</td><td></td><td>Erection, testing and commissioning of Transformers, Reactors, Circuit breakers, Isolators, Substation automation system, Control & protection panels, PLCC, PMU, Telecommunication Equipments, NIFPS System ,</td><td>New Clause added</td></tr>
</table>

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<tr><td></td><td></td><td></td><td>etc. shall be done by the contractor under the supervision of respective equipment manufacturers. Charges for the above supervision shall be included by the bidder in the erection charges for the respective equipment in the BPS.</td><td></td></tr>
<tr><td>21.</td><td>Clause no. 15.2</td><td></td><td>Pickup value of binary input modules of Intelligent Electronic Devices, Digital protection couplers, Analog protection couplers shall not be less than 50% of the specified rated station auxiliary DC supply voltage level.</td><td>New Clause added</td></tr>
<tr><td>22.</td><td>Clause no. 16.2</td><td>The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.</td><td>The minimum vertical distance from the bottom of the lowest porcelain/polymer part of the bushing, porcelain/polymer enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.</td><td></td></tr>
<tr><td>23.</td><td>Clause 17.1</td><td><table>
<tr><td>S.No</td><td>Description</td><td>Material</td></tr>
<tr><td>a</td><td>For connecting ACSR conductors/AAC conductors/ Aluminium tube</td><td>Aluminum alloy casting, conforming to designation A6 of IS:617 and all test shall conform to IS:617</td></tr>
<tr><td>b</td><td>For connecting equipment terminals mad of</td><td>Bimetallic connectors made from aluminum alloy casting, conforming</td></tr>
</table></td><td><table>
<tr><td>Sl. No.</td><td>Description</td><td>Materials</td></tr>
<tr><td>a)</td><td>For connecting ACSR conductors/AAC conductors/ Aluminium tube</td><td>Aluminum alloy casting, conforming to designation ~~A6~~ 4600 of IS:617 and all test shall conform to IS:617</td></tr>
</table></td><td></td></tr>
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		(cont.) copper with ACSR conductors/AAC conductors/ Aluminium tube — to designation A6 of IS:617 with 2mm thick bimetallic liner/strip and all test shall conform to IS:617	b) For connecting equipment terminals mad of copper with ACSR conductors/AAC conductors/ Aluminium tube — Bimetallic connectors made from aluminum alloy casting, conforming to designation ~~A6~~4600 of IS:617 with 2mm thick bimetallic liner/strip and all test shall conform to IS:617	
24.	**Clause 17.11**	Clamps and connectors should be type tested on as per IS:5561 and shall also be subjected to routine tests as per IS:5561. Following type test reports shall be submitted for approval. Type test once conducted shall hold good. The requirement of test conducted within last ten years, shall not be applicable i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient) ii) Short time current test iii) Corona (dry) [for 400kV and above] and RIV (dry) test [for 132kV and above voltage level clamps]	Clamps and connectors should be type tested on minimum three samples as per IS:5561 and shall also be subjected to routine tests as per IS:5561. Following type test reports shall be submitted for approval. Type test once conducted shall hold good. The requirement of test conducted within last ten years, shall not be applicable i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient) ii) Short time current test iii) Corona (dry) ~~[for 400kV and above]~~ and RIV (dry) test [for 132kV and above voltage level clamps] iv) Resistance test and ~~tensile test~~ Pullout strength test v) Cantilever strength test on bus support clamps & connectors	

		iv) Resistance test and tensile test		
25.	**Clause 18.1**	All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:	All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with ~~IS 5039/IS 8623, IEC 60439~~ IS/IEC 61439-0, as applicable, and the clauses given below:	
26.	**Clause 18.2**	Control cabinets, junction boxes, Marshalling boxes, & terminal boxes shall be made of stainless steel of atleast 1.5 mm thick or aluminum enclosure of atleast 1.6 mm thick and shall be dust, water and vermin proof. Stainless steel used shall be of grade SS304 (SS316 for coastal area) or better. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.	Control cabinets, junction boxes, Marshalling boxes & terminal boxes, Out door ACDB cum DCDB panels shall be made of stainless steel of atleast 1.5 mm thick or aluminum enclosure of atleast 1.6 mm thick and shall be dust, water and vermin proof. Stainless steel used shall be of grade SS304 (SS316 for coastal area) or better. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness. Control cabinets, junction boxes, marshalling boxes & terminal boxes, out-door ACDB cum DCDB panels shall have adequate space/clearance as per guidelines/technical specifications to access/replace any component. Necessary component labelling to be also done on non-conducting sheet. For CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES MARSHALLING BOXES FOR OUTDOOR EQUIPMENT Junction Box, wire should be as per IS or equivalent IEC with FRLS grade Machine laid PU Foam gasket may be permitted for use in Control Cabinets etc.	

27.	**Clause 18.4**	Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere	Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. Cabinet boxes with width more than 700 mm shall be double door double hinged with padlocking type.	
28.	**Clause 18.13**	The enclosure of bay marshalling kiosk, junction box, terminal box and control cabinets shall conform to IP-55 as per IS:13947 including application of 2KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test	The enclosure of bay marshalling kiosk, junction box, terminal box and control cabinets shall conform to IP-55 as per **IS/IEC60947** including application of minimum 1KV rms for 1 (one) minute, ~~insulation resistance and functional test~~ after IP-55 test	
29.	**Clause 20.13**	The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. **For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge over voltages either transferred through the equipment or due to transients induced from the EHV circuits.**	The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. ~~For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge over voltages either transferred through the equipment or due to transients induced from the EHV circuits~~.	
30.	**Clause 20.14**	All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.	**-**	Clause deleted
31.	**Clause 21.3.2**	All fuses shall be of HRC cartridge type	All fuses shall be of HRC cartridge type conforming to relevant IS	

		conforming to IS:9228 mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage	mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage	
32.	**Clause 22.8**	**Tests** In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS:2099 & IS:2544 & IS:5621.	**-**	Clause deleted
33.	**Clause No. 22.10**		All switchgear/equipments, insulator strings, bushings, bus post insulators shall be designed for minimum creepage distance of 31mm/kV or 25mm/kV as mentioned against each substation in section project under "PHYSICAL AND OTHER PARAMETERS" Zinc coating for galvanized lattice and pipe structures, all ferrous parts of composite long rod insulators and earthing conductors shall not be less than 900 gm/sq-m irrespective of other values mentioned elsewhere in technical specification/drawings at substations where creepage distance is considered as 31mm/kV. In case, different designs of lattice and pipe structures other than Employer supplied structures are required to be adopted in view of higher creepage (31mm/kV) of the switchgear/equipments, insulator strings, bushings & bus post insulators etc., Design, supply & erection of such structures shall be in the scope of contractor against respective standard structure. However dimensional details (except height) shall not be less than that specified in standard structure drawing of respective equipments. **Silicon RTV coating**:- Equipment/insulators (except equipments with polymer insulator) including mandatory spares being supplied at	New Clause added

			substations where creepage distance is considered as 31mm/kV shall be with Silicon RTV coating. The price of RTV coating shall be included in the installation cost of respective equipment.	
34.	**Clause No. 24**	**TECHNICAL REQUIREMENT OF EQUIPMENTS** Following equipment shall be offered from the manufacturer(s) who meets the technical requirements as stipulated here, provided the same equipment are not covered under the Bidder's Qualifying requirement of the Bidding Documents.	**24. TECHNICAL REQUIREMENT OF EQUIPMENTS** **24.1** Following equipment shall be offered from the Indian Manufacturing Facilities of manufacturer(s) who meets the technical requirements as stipulated here, provided the same equipment are not covered under the Bidder's Qualifying requirement of the Bidding Documents.	
35.	**Clause 24.1**	**24.1 Technical requirements for 765/400/220/132/110kV* Air Insulated Switchgear (AIS) Equipment* (i.e Circuit Breaker, Isolator, Current Transformer, Capacitive Voltage transformer, Inductive Voltage transformer, Surge Arrester and Wave Trap)** (i) The manufacturer(s) whose 765/400/220/132/110kV* equipment(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715/345/220/132/110kV* or higher voltage class equipment(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA.	**24.1 Technical requirements for 765/400/220/132/110kV* Air Insulated Switchgear (AIS) Equipment* (i.e Circuit Breaker, Isolator, Current Transformer, Capacitive Voltage transformer, Inductive Voltage transformer, Surge Arrester and Wave Trap)** (i) The manufacturer(s) whose 765/400/220/132/110kV* equipment(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715/345/220/132/110kV* or higher voltage class equipment(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered equipment and not meeting the requirement stipulated in (i) above, can also be considered provided that	

		(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered equipment and not meeting the requirement stipulated in (i) above, can also be considered provided that a) 715/345/220/132/110kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA. Contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.	a) 715/345/220/132/110kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA. In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor.	
25.	**Clause No. 24.2**	**Technical Requirement for 765kV class Transformer** (i) The Manufacturer whose 765kV Transformer(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number three phase Transformer of atleast 500 MVA capacity (or equivalent capacity in a bank of three (3) numbers single phase units). These transformer(s) must have been in satisfactory operation# for atleast two	**Technical Requirement for 765kV class Transformer** (i) The Manufacturer whose 765kV Transformer(s) are offered must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA, and the same transformer (s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA.	

		(2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) 715kV or higher voltage class one (1) number three phase Transformer of atleast 500 MVA capacity (or equivalent capacity in a bank of three (3)numbers single phase units) must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA. b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 765kV transformer in India, shall be submitted. c) the collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) 715 kV or higher voltage class either One (1) no. 1-phase Transformer of at least 166 MVA capacity or One (1) no. 1-phase Reactor of at least 80 MVAR capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA. b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 765kV transformer in India, shall be submitted. c) the collaborator shall furnish performance guarantee for an amount of ~~10~~ 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor	
26.	**Clause No. 24.3**	~~24.3 Technical Requirement for 765kV class Reactor~~	**24.3 Technical Requirement for 765kV class Reactor** (i) The Manufacturer whose 765kV Reactor(s) are offered must have designed, manufactured, tested & supplied 715 kV or	

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		~~(i) The Manufacturer whose 765kV Reactor(s) are offered must have designed, manufactured, tested & supplied 715kV or higher voltage class one (1) number three phase Reactor of atleast 240 MVAR capacity (or equivalent capacity in a bank of three (3) numbers single phase units). These Reactor(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.~~ ~~OR~~ ~~(ii) The Manufacturer must have designed, manufactured, tested & supplied 715kV or higher voltage class one (1) number three phase Transformer of atleast 500MVA capacity (or equivalent capacity in a bank of three (3) numbers single phase units). These Transformer(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA. And the manufacturer must have designed, manufactured, tested & supplied 345kV or higher voltage class one (1) number three phase Reactor of atleast 50MVAR capacity (or equivalent capacity in a bank of three (3) numbers single phase units). These Reactors must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.~~ ~~(iii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that~~	higher voltage class one (1) number 1-phase Reactor of at least 110 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 36.7 MVAR and the same Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA. OR The Manufacturer must have designed, manufactured, tested & supplied 715 kV or higher voltage class one (1) number 1-phase Transformer of at least 500 MVA capacity or at least three (3) numbers 1-phase Transformers each having a capacity of at least 166 MVA and the bidder should have designed, manufactured, tested & supplied 345 kV or higher voltage class one (1) number 3-phase Reactor of at least 50 MVAR capacity or at least three (3) numbers 1-phase Reactors each having a capacity of at least 16.7 MVAR and the same Transformer(s) & Reactor(s) should have been in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) 715 kV or higher voltage class either One (1) no. 1-phase Reactor of at least 80 MVAR capacity or One (1) no. 1-phase Transformer of at least 166 MVA capacity must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and same should have been supplied as on the date of NOA. b) The collaborator meets the requirements stipulated in (i)	

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		~~(iv) 715kV or higher voltage class one (1) number three phase Reactor of atleast 240MVAR capacity (or equivalent capacity in a bank of three (3) numbers single phase units) must have been manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.~~ ~~(v) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 765kV Reactor in India, shall be submitted.~~ ~~(vi) the collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.~~	above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 765kV Reactor in India, shall be submitted. c) the collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	
27.	**Clause 24.4**	**24.4 Technical Requirement for 400kV, 220kV, 132kV and 110kV class Transformer** (i) The manufacturer whose transformer(s) are offered must have designed, manufactured, tested and supplied 400kV/220kV/132kV/110kV* or	**24.4 Technical Requirement for 400kV, 220kV, 132kV ~~and 110kV~~ class Transformer** (i) The manufacturer whose transformer(s) are offered must have designed, manufactured, tested and supplied transformers as per table below:	

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higher voltage class transformers. These Transformer(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) 220kV (applicable for supply of 400kV and 220kV class Transformer)/ 132kV (applicable for supply of 132kV & 110kV class Transformer) or higher voltage class transformers must have been designed, manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply
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<table>
<tr><td>345kV or above class 3-phase transformers of at least 200 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 66.7 MVA</td><td>applicable for supply of 400kV class Transformer</td></tr>
<tr><td>220kV or above class 3-phase transformers of at least 50 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 16.7 MVA</td><td>applicable for supply of 220kV class Transformer</td></tr>
<tr><td>commissioned 132kV or above class 3-phase transformers of at least 20 MVA or at least three (3) nos. 1-phase Transformers each having capacity of at least 6.7 MVA</td><td>applicable for supply of 132kV class Transformer</td></tr>
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These Transformer(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the
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		400kV/220kV/132kV/110kV* transformer in India, shall be submitted. the collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	requirement stipulated in (i) above, can also be considered provided that a) 220kV (applicable for supply of 400kV ~~and 220kV~~ class Transformer)/ 132kV (applicable for supply of 220kV class Transformer)/ 66kV (applicable for supply of 132kVclass Transformer)or higher voltage class transformers must have been designed, manufactured in the above Indian works based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied as on the date of NOA. b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV/220kV/132kV/~~110kV~~* transformer in India, shall be submitted. the collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	
28.	**Clause 24.5**	**24.5 Technical Requirement for 400kV, 220kV and 132kV class Reactor** (i) The Manufacturer whose 400kV/220kV/132kV* Reactor(s) are offered must have designed, manufactured, tested & supplied	**24.5 Technical Requirement for 400kV, 220kV and 132kV class Reactor** (i) The Manufacturer whose 400kV/220kV/132kV* Reactor(s) are offered must have designed, manufactured, tested & supplied Reactor as per table below:	

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<td>400kV/220kV/132kV* or higher voltage class. These Reactor(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Such manufacturer has designed, manufactured based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied 400kV class transformer or 220kV or above class shunt reactors as on the date of NOA.

b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply the</td>
<td><table>
<tr><td>345kVor above class 3-phase shunt reactor of at least 50 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors, each having capacity of at least 16.7 MVAR</td><td>applicable for supply of 400kV class Reactors</td></tr>
<tr><td>220kV or above class 3-phase shunt reactor of at least 20 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 6.67 MVAR</td><td>applicable for supply of 220kV class Transformer</td></tr>
<tr><td>132kV or above class 3-phase shunt reactor of at least 15 MVAR capacity or at least three (3) nos. 1-phase Shunt Reactors each having capacity of at least 5 MVAR</td><td>applicable for supply of 132kV class Transformer</td></tr>
</table>
These Reactor(s) must have been in satisfactory operation# for atleast two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated</td>
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		Reactor in India, shall be submitted. the collaborator shall furnish performance guarantee for an amount of 10% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	in (i) above, can also be considered provided that a) Such manufacturer has designed, manufactured based on technological support of collaborator, type tested (as per IEC/IS standard) and supplied 400kV class transformer or 220kV or above class shunt reactors (applicable for supply of 400kV class Reactors) / 220kV class transformer or 132kV or above class shunt reactors (applicable for supply of 220kV class Reactors)/ 132kV class transformer or 66kV or above class shunt reactors (applicable for supply of 132kV class Reactors) as on the date of NOA. b) The collaborator meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply the Reactor in India, shall be submitted. the collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	
29.	**Clause 24.6**	**24.6 Technical Requirement for 400 kV Grade XLPE Power Cables** (i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and	**24.6 Technical Requirement for 400 kV Grade XLPE Power Cables** (i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 400kV grade	

		supplied in a single contract atleast 5 (five) km of single core, 400kV grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) The manufacturer must have designed, manufactured, type tested and supplied 400kV grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA. OR b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 400kV grade XLPE insulated Cable as on the date of NOA.	XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) The manufacturer must have designed, manufactured, type tested and supplied 400kV grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA. OR b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 400kV grade XLPE insulated Cable as on the date of NOA. Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.	
30.	**Clause 24.7**	**24.7 Technical Requirement for 220KV Grade XLPE Power Cables**	**24.7 Technical Requirement for 220KV, 132KV,110KV Grade XLPE Power Cables**	

			(i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 220kV/132kV/110kV* or higher grade XLPE insulated cable which must be in operation for atleast 2 (two) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) The manufacturer must have designed, manufactured, type tested and supplied 220kV/132kV/110kV* or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA. OR b) The manufacturer must have designed, manufactured, type tested and completed Pre-qualification (PQ) tests as per IEC for 220kV/132kV/110kV* or higher grade XLPE insulated Cable as on the date of NOA. Note: In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the	

			entire quantity of cable to supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.	
31.	**Clause 24.8**	**24.8 Technical Requirement for 132KV, 110kV, 66kV Grade XLPE Power Cables** (i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, 132KV/110kV/66kV* or higher grade XLPE insulated cable which must be in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i)above, can also be considered provided that	**24.8 Technical Requirement for ~~132KV, 110kV~~, 66kV Grade XLPE Power Cables** (i) The manufacturer(s) whose XLPE Power Cables are offered must have designed, manufactured, type tested and supplied in a single contract atleast 5 (five) km of single core, ~~132KV/110kV/~~66kV* or higher grade XLPE insulated cable which must be in satisfactory operation# for atleast two (2) years as on the date of NOA. Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i)above, can also be considered provided that the manufacturer must have designed, manufactured, type tested and supplied ~~132KV/110kV/~~66kV* or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.	

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		a) The manufacturer must have designed, manufactured, type tested and supplied 132KV/110kV/66kV* or higher grade XLPE insulated cable and which must be in satisfactory operation# for atleast one (1) year as on the date of NOA.		
32.	**Clause No. 24.9**	**Technical Requirement for 1.1 KV Grade PVC Control Cable** The manufacturer(s), whose PVC control cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV grade PVC insulated control cables as on the originally scheduled date of bid opening. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 27C x 2.5 Sq.mm or higher size as on the date of NOA	**Technical Requirement for 1.1 KV Grade PVC Control Cable** The manufacturer(s), whose PVC control cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV grade PVC insulated control cables as on ~~the originally scheduled~~ ~~date of bid opening~~ the date of NOA. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 27C x 2.5 Sq.mm or higher size as on the date of NOA	
33.	**Clause No. 24.10**	**Technical Requirement for 1.1 KV Grade PVC Power Cable** The manufacturer(s), whose PVC Power Cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV orhigher grade PVC insulated power cables as on the date of NOA/award. Further themanufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 150 Sq. mm or higher size as on the date of NOA.	**Technical Requirement for 1.1 KV Grade PVC Power Cable** The manufacturer(s), whose PVC Power Cables are offered, must have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1kV or higher grade PVC insulated power cables as on the date of NOA~~/award~~. Further the manufacturer must also have designed, manufactured, tested and supplied atleast 1 km of 1C x 150 Sq. mm or higher size as on the date of NOA.	
34.	**Clause 24.15**	**24.15 Technical Requirements for LT**	**24.15 Technical Requirements for LT Transformer**	

		Transformer i) The manufacturer, whose LT transformer(s) are offered, must have designed,manufactured, type tested including short circuit test as per IEC/IS or equivalent standards and supplied transformer(s) of atleast 33kV class of 630kVA or higher. The transformer must have been in satisfactory operation# for atleast two (2) years as on the date of NOA. ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can alsobe considered provided that a) At least 33kV class of 630 kVA or higher rating LT transformer(s) must have been designed, manufactured in the above Indian works, type tested (as perIEC/IS standard) including short circuit test and supplied as on the date of NOA. b) the contractor shall furnish performance guarantee for an amount of 10% of the ex-works cost of the equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor.	i) The manufacturer, whose LT transformer(s) are offered, must have designed, manufactured, type tested including short circuit test as per IEC/IS or equivalent standards and supplied transformer(s) of atleast 33kV class of ~~630kVA~~ 315kVA or higher. The transformer must have been in satisfactory operation# for atleast two (2) years as on the date of NOA. ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that At least 33kV class ~~of 630 kVA~~ 315kVA or higher ~~rating~~ LT transformer(s) must have been designed, manufactured in the above Indian works, type tested (as perIEC/IS standard) including short circuit test and supplied as on the date of NOA. In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor	
35.	**Clause 24.16**	**24.16 Technical Requirements for Composite Long Rod Polymer Insulator (765kV & 400kV)** (i) The manufacturer whose Composite Long rod Insulator are	**24.16 Technical Requirements for Composite Long Rod Polymer Insulator (765kV & 400kV)** (i) The manufacturer whose Composite Long rod Insulator are offered, must have designed, manufactured, tested and supplied Composite Long	

		offered, must have designed, manufactured, tested and supplied Composite Long rod Insulator of 120KN or higher electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) The manufacturer must have designed, manufactured, type tested and supplied Composite Long rod Insulator of 120KN or above electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# as on the date of NOA.	rod Insulator of 120KN or higher electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) The manufacturer must have designed, manufactured, type tested and supplied Composite Long rod Insulator of 120KN or above electro-mechanical strength for 765kV/400kV* or higher voltage class and the same must have been in satisfactory operation# as on the date of NOA. In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two(2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipments(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor.	

		Contractor shall furnish performance guarantee for an amount of 10% of the exworks cost of the equipments(s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor		
36.	**Clause 24.19**	**24.19 Technical Requirement of Communication Equipment** ~~The SDH equipment shall be offered from a manufacturer(s) who has been manufacturing SDH equipments for the last three (3) years and SDH equipment manufactured by such manufacturer(s) shall have been satisfactory operation in 110kV or higher voltage Power Substations for at least two (2) years as on the date of NOA.~~	**24.19 Technical Requirement of Communication Equipment** The SDH equipment shall be offered from a manufacturer(s) who is a **"Local Supplier"** as per DPIIT PP notification & has been Manufacturing SDH equipments for the last three (3) years and SDH equipment Manufactured by such manufacturer(s) shall have been satisfactory operation in 110kV or higher voltage Power Substations for at least two (2) years as on the date of NOA	
37.	**Clause 24.20**	**24.20 Technical Requirement of "Indian Associate" for execution of on shore supply and services for 765 kV Transformer & Reactor package** Indian associate must have erected at least two (2) or more circuit breaker equipped bays of 345 kV or above voltage level or at least two (2) nos. of 345 kV or above voltage class transformer/reactor; during last seven (7) years and above bays/transformer/reactors must be in satisfactory operation# as on the date of NOA	.	Clause Deleted
38.	**Clause 24.20**		**24.20 <u>Technical Requirement for 400kV GIS Equipment</u>**	New Clause added

			(i) The manufacturer whose 400kV GIS bays are offered must have designed, manufactured, type tested** (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 345kV or above voltage class in one (1) Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that a) Atleast one no. 345kV or above voltage class GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above CB bay (as per IEC or equivalent standard) as on the date of NOA. b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply 400kV or above voltage level GIS equipment in India, shall be submitted. **c)** The Collaborator(s) shall furnish performance guarantee for an amount of 3 % of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.	

			Note :- (**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable	
39.	**Clause 25.0**		**25.0 Technical Requirement of Sub-contractors:** The sub-contractor must have either of the following experience of having successfully completed similar works during last 7 years as on the last day of month previous to the one in which the sub-contractor is proposed to be engaged: a) Three similar works costing not less than the amount equal to 40% of the cost of the work to be sub-contracted. **OR** b) Two similar works costing not less than the amount equal to 50% of the cost of the work to be sub-contracted. **OR** c) One similar work costing not less than the amount equal to 80% of the cost of the work to be sub-contracted. 1. Minimum Average Annual Turnover **(MAAT)	New Clause added

			for best three years i.e. 36 months out of last five financial years of the sub-contractor should be……….: **Annual Gross Revenue from operations/ Gross operating income as incorporated in the profit & loss account excluding Other Income. **Note:** a) Similar work shall mean the work which are of similar in nature to the work to be sub-contracted e.g. for the scope of civil work to be sub-contracted, the experience should be of civil work. b) The aforesaid qualifying requirement shall however, not be applicable for engaging labour as per extant policy. c) The cost of the work to be sub-contracted shall be considered as available in the Contract Agreement. However, if the value is not available in the Contract Agreement, the same shall be the estimated value for such work. d) The above criteria is in addition to extant policy on selection of sub-contractor as per WPPP, Vol-II. e) The MAAT requirement shall be worked out basis the following formula:	

			Minimum Average Annual Turnover (MAAT) = Cost of the work to be sul contractedx1.5/Completion period years** **The completion period shall be considered as 1 year even if the same is less than 1 year.	
40.			26.0 **Technical Requirement of Sub-contractors of GIS Packages** In case of GIS is supplied from Indian GIS manufacturer, the erection, testing & commissioning of GIS shall be executed either by the bidder himself or by the Subcontractor meeting the following technical requirement: The bidder/Subcontractor must have erected, tested and commissioned at least two (2) nos. GIS/AIS Circuit breaker equipped bays@ of voltage class** as specified below or higher in one (1) substation or switchyard during the last seven (7) years and these bays must be in satisfactory operation# as on the date of NOA.	New Clause added

S. no	Voltage class of GIS Package	Minimum Voltage class Circuit Breaker Equipped of Bay(**)
1	765kV & 400kV GIS	345kV
2	220kV	220kV
3	132kV	110kV
4	66kV	66kV

			Further, the sub-contractor shall also meet the requirement specified at Clause No. 25.0 of this section. **Note:** *1.* (@) For the purpose of technical requirement, one no. of circuit breaker bay shall be considered as a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs. GIS means SF6 Gas insulated Switchgear. AIS Means Air Insulated Switchgear. 2. # satisfactory operation means certificate issued by the Owner/Utility certifying the operation without any adverse remark.	
41.	**Section GTR Rev 14 Annexure-A**	Annex-A: Corona and Radio Interface Voltage(RIV) Test		Annexure updated
42.	**Section GTR Rev 14 Para-1 at Annexure-B**		“The seismic withstanding test on the complete equipment (**for 400kV and above**) shall be carried out along with supporting structure. **Seismic Withstand Test carried out using either lattice or pipe structure is acceptable**.” **Seismic Calculations certified by NABL Labs shall also be acceptable**	Annexure updated
43.	**Annexure-D**	List of General Standard/Document for second advance		The Annexure is updated with incorporation of requirement for GIS & EHV cables (

Major Changes in Section GTR (Rev 15)

				above 132kV)
44.	**Annexure F**	Assessment report from main Contractor for proposed sub vendors list of enclosure		The Annexure is updated
45.	**Annexure-G**	MOP & Inspection Level Requirement		The Annexure is updated
46.	**Section GTR Rev 14 Annexure-H**	Annex-H:RTV Silicon high voltage insulation coating(HVIC)		Annexure updated
47.	**Annexure J**		List of make for which type test reports are not required	The New Annexure is added
48.	**Annexure K**		List of Equipment's to be supplied from domestic manufacture only	The New annexure added

Note: The details mentioned in this annexure are only for the purpose of identification of changes in this revision of Technical Specification only, how ever details mentioned at respective clause shall be referred for execution purpose.

TECHNICAL SPECIFICATION
SECTION-SWITCHYARD ERECTION

पावर ग्रिड कार्पोरेशन आफ इन्डिया लिमिटेड

(भारत सरकार का उद्यम)

Power Grid Corporation of India Limited

(A Government of India Enterprises)

Document No.: C/ENGG/SPEC/SE (Rev.10) **April 2016**

TECHNICAL SPECIFICATION

SECTION- SWITCHYARD ERECTION
REVISION - 10

SECTION-(SE)
SWITCHYARD ERECTION

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SECTION-(SE)
SWITCHYARD ERECTION

1.0 **GENERAL**

This section covers erection of all equipment such as circuit breakers, isolators, current transformers, voltage transformers, surge arresters etc. This section also covers design, engineering, manufacture, testing at works, supply, insurance, handling, storage, erection, testing and commissioning of supply & erection of following items.

- String insulators and hardware
- AAC / ACSR conductor
- Galvanised Steel Earthwire
- Aluminium Tube
- Spacers
- Bus post insulators
- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

2.0 **String Insulators & Hardware**

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to IS:2486**.** Composite long rod polymer insulator shall conform to IEC:61109. Further, the contractor shall supply insulators as per details mentioned below:

A. <u>Tension Insulator String</u>

Sl. No.	System Voltage	Type
1.	765kV, 400kV, 220kV & 132kV (for all substations in coastal, pollution affected areas as identified in Section-Project and for all substations in Northern Region)	Composite Long Rod Polymer with 31mm/kV Creepage
2.	765kV, 400kV, 220kV & 132kV (for substations not covered in 1. above)	Composite Long Rod Polymer/Porcelain/Glass with 31mm/kV Creepage

B. <u>Suspension Insulator String</u>

Sl. No.	System Voltage	Type
1.	765kV, 400kV, 220kV & 132kV (for all substations)	Composite Long Rod Polymer with 31mm/kV Creepage

SECTION - (SE)
SWITCHYARD ERECTION

2.1 Construction Features (Porcelain & Glass Insulators)

2.1.1 **Porcelain insulators**

a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength, manufacturer’s logo, month & year of manufacturing markings on porcelain printed and applied before firing.

b) Porcelain used in insulator manufacturing shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

c) Glazing of the porcelain shall be of uniform brown colour, free from blisters, burrs and other similar defects.

2.1.2 **Glass insulators**

It **shall** be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

2.1.2.1 When operating at normal rated voltage, there shall be no electric discharge between conductor and insulator which would cause corrosion or **damage** to conductors or insulators by the formation of substances due to chemical action.

2.1.2.2 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized in accordance with the latest edition of IS: 2629. The zinc used for galvanizing shall be of grade Zn-99.95 as per IS-209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.

2.1.2.3 Contractor shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

2.1.3 Hardware Fittings

2.1.3.1 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

2.1.3.2 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

2.1.3.3 The tension Insulator hardware assembly shall be designed for minimum 21000 kg tensile load for 765kV and minimum 12000 kg tensile load for hardware assembly below 765kV. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

2.1.3.4 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

2.1.3.5 All hardware shall be bolted type.

2.2 Tests

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

2.2.1 Type Tests on Insulator Strings: The test reports for following type tests shall be submitted for approval as per clause 9.0 of Section - GTR.

a) Power frequency voltage withstand test with corona control rings **(if applicable)** under wet condition as per IEC- 60383.

b) Switching surge voltage withstand test [400 kV and above class only] under wet condition as per IEC-60383.

c) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383

d) Voltage distribution test (Dry) **[applicable for disc insulator string only]**

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 6.5% for 765 kV suspension and tension insulator strings, 9% and 10% for 400KV suspension string and tension insulator string respectively, 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

e) Corona Extinction Voltage test (Dry) [**220kV** and above class only]

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage **as specified at clause 2.3.2**. There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

f) RIV Test (Dry) [**220kV** and above class only]

Under the conditions as specified under (e) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage as **specified in clause 2.3.2 of this section.** The test procedure shall be in accordance with IS 8263/IEC 60437.

g) Mechanical strength test: The test shall be carried out as per following procedure.

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.2.2 Type Tests on String Insulator Units

Type test report for Thermal Mechanical Performance tests **(applicable for porcelain type insulators)** as per IEC-60575, Clause 3 shall be submitted for approval as per clause 9.2 of Section - GTR.

2.2.3 Acceptance Tests for Insulators:

a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

b) Verification of Dimensions as per IEC- 60383.

c) Temperature cycle test as per IEC- 60383.

d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).

e) Galvanizing Test as per IEC- 60383.

f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).

g) Test on locking device for ball and socket coupling as per IEC-60372(2).

h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).

i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

2.2.4 Acceptance Test on Hardware Fitting

a) Visual Examination as per Cl. 5.10 of IS: 2486 (Part-I).

b) Verification of Dimensions as per Cl. 5.8 of IS:2486 (Part-I)

c) Galvanising/Electroplating tests as per Cl. 5.9 of IS:2486 (Part-I).

d) Slip strength test as per Cl 5.4 of IS-2486 (part-I)

e) Shore hardness test **by** the Elastometer

f) Mechanical strength test for each component (including corona control rings and arcing horns).

The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in 2.2.1.(g) above should be followed.

g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

2.2.5 Routine Test on Insulator

a) Visual Inspection as per IEC-60383

b) Mechanical Routine Test as per IEC-60383

c) Electrical Routine Test as per IEC-60383

2.2.6 Routine Test on hardware Fittings

a) Visual examination as per Cl 5.10 of IS:2486 (Part-I)

b) Mechanical strength Test as per Cl. 5.11 of IS:2486 (Part-I)

2.2.7 Test during manufacture on all Components as applicable on insulator

a) Chemical analysis of zinc used for galvanising: Samples taken from the zinc ingot shall be chemically analyzed as per IS: 209. The purity of zinc shall not be less than 99.95%.

b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Program.

2.2.8 Test during manufacture on all components as applicable on hardware fittings:

a) Chemical analysis of zinc used for galvanising:

Samples taken from the zinc ingot shall be chemically analyzed as per IS:209. The purity of zinc shall not be less than 99.95%

b) Chemical analysis, hardness tests and magnetic particle for Forgings/ **fabricated hardware:**

The chemical analysis, hardness tests and magnetic particle inspection for forgings/fabricated hardware will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

2.3 Guaranteed technical Particular For

2.3.1 Disc Insulators

Sl. No.	Description	For 765kV	For 400/220/132kV
a)	Type of insulators	Anti Fog type	Anti Fog type
b)	Physical Size of insulator units		
(i)	Diameter of Disc	As per IEC	As per IEC
(ii)	Ball to ball spacing between discs	170 mm	145 mm
c)	Electro mechanical strength	210 kN	120 kN
d)	Minimum Creepage distance of individual insulator units	460 mm	430 mm
e)	Markings		
i)	For Porcelain insulators	Markings on porcelain	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the actual wet flashover voltage	1.3 times the actual wet flashover voltage

2.3.2 INSULATOR STRING

Sl. No.	Description	765 kV	400kV	220kV	132kV
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	870	680	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 2100	± 1550	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	± 1550	± 1050	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) - kV rms	508	320	156	NA
e)	Maximum RIV level in micro volts of string with Corona Control rings across 300 Ohms resistor at 1 MHz	1000 (Max) at 508 kV	1000 (Max) at 320 kV	1000 (Max) at 156 kV	NA
f)	**Minimum total creepage distance of the insulator string (mm)**	**24800**	**13020**	**7595**	**4495**
g)	**Minimum no. of discs per string (for tension string if applicable)**	**54**	**31**	**18**	**11**

h)	Electromechanical strength of Insulator Unit. (KN)	210	120	120	120

For tension application:-

Double insulator strings for 765kV, 400kV, 220kV and single insulator strings for 132 kV systems shall be used.

For suspension application:-

V-type polymer insulator string shall be used for 765kV system and single suspension polymer insulator string shall be used for 400kV, 220kV & 132 kV systems.

2.4 COMPOSITE LONG ROD POLYMER INSULATOR

Bidder shall offer composite long rod polymer insulators with suitable hardware fittings.

2.4.1 Details of Composite Long Rod Insulators

2.4.1.1 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

2.4.1.2 Ball and socket shall be 20mm designation for 120kN & 24mm designation for 210kN Insulators in accordance with the standard dimensions stated in IEC:60120/ IS:2486 (Part-II). Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have laser markings on housings for manufacturer’s name, month & year of manufacturing, rated strength markings on each composite insulator rod unit. No negative tolerance shall be applicable to creepage distance of composite insulators

2.4.1.3 **All ferrous parts shall be hot dip galvanized as per Section-GTR with minimum weight of zinc coating as 610 gm/sq.m for normal area and 900 gm/sq.m for coastal area as specified in Section-Project.**

2.4.2 Material

2.4.2.1 **Core**

It shall be a glass-fiber reinforced (FRP) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. The rod shall be of electrical grade corrosion resistant (ECR), boron free glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

2.4.2.2 **Housing & Weathersheds**

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum **5mm**. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core.

The weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

2.4.2.3 **End Fittings**

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The gap between fitting and sheath shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

2.4.2.4 **Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material. The insulator supplier shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona **rings**. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design & supply of grading rings shall be in the scope of the composite insulator supplier.

2.4.3 Tests

2.4.3.1 **Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Section - GTR.

2.4.3.1.1 **On the complete composite Long Rod Polymer Insulator String with Hardware Fittings**:-

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993.

b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.

c) Impulse voltage withstand test under dry condition as per IEC:60383-1993

d) Corona and RIV test under dry condition. [132kV and above class only]

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage as specified in clause 2.3.2 of this section There shall be no evidence of Corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC 60383.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level **as** specified at specified in clause 2.3.2 of this section. The test procedure shall be in accordance with IS 8263/IEC-60437.

e) Mechanical Strength test: The test shall be carried out as per following procedure.

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m3 NaCl.

2.4.3.1.2 **On Composite Polymer Insulator Units**

a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.

b) Assembled core load time test as per IEC: 61109-2008.

c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008

d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, the washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be done by 1 minute wet power frequency withstand test at 680kV r.m.s for 400KV.

e) Brittle fracture resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

f) Dye penetration test as per IEC: 61109-2008

g) Water diffusion test as per IEC: 61109-2008

h) Tracking and erosion test as per IEC: 61109-2008.

i) Hardness test as per IEC: 61109-2008.

j) Accelerated weathering test as per IEC: 61109-2008.

k) Flammability test as per IEC: 61109-2008.

l) Silicone content test

Minimum content of silicone shall be 30% and the same shall be verified through FT-IR spectroscopy & TGA analysis or any other approved/ acceptable method.

m) Recovery of Hydrophobicity test

1. The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

2. Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1” x 1”. Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

3. Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

4. Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

n) Torsion test

Three complete insulators of each electrical and mechanical rating shall be subjected to a torsional load of 55Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex-B of IEC - 62217

2.4.3.2 **Acceptance Tests:**

For Composite Long Rod Polymer Insulators

a.	Verification of dimensions	IEC : 61109-2008
b.	Galvanizing test	IEC : 60383
c.	Verification of end fittings	IEC : 61109-2008
d.	Recovery of Hydrophobicity	As per **Cl. 2.4.3.1.2.m)** above
e.	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109-2008
f.	Silicone content test	As per **Cl. 2.4.3.1.2.l)** above
g.	Brittle fracture resistance test	As per **Cl. 2.4.3.1.2.e)** above
h.	Dye penetration test	IEC : 61109-2008
i.	Water diffusion test	IEC : 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in **2.4.3.2** above, the **re-test** procedure shall be as per IEC 61109.

2.4.3.3 **Routine Tests**

For Composite Long Rod Polymer Insulator Units

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

2.4.4 **Guaranteed Technical Particulars for Composite Long Rod Polymer Insulators**

The technical parameters for composite long rod polymer insulator string shall be same of the insulator string specified in clause 2.3.2 of this section.

3.0 AAC / ACSR CONDUCTOR

3.1 Details of AAC Conductor

3.1.1 The Conductor shall conform to IEC: 61089/IS: 398 (Part V) - 1992 except where otherwise specified herein.

The contractor shall supply the conductor as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Section – Switchyard Erection and separate approval for **guaranteed technical particulars** is not required during detailed engineering.

3.2 Details of ACSR Conductor

3.2.1 The Conductor shall conform to IEC: 61089/IS: 398 (Part V) - 1992 except where otherwise specified herein.

3.2.2 The details of the ACSR Bersimis, ACSR Moose, ACSR Zebra and ACSR Panther conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Section – Switchyard Erection and separate approval for **guaranteed technical particulars** is not required during detailed engineering.

3.3 Workmanship

3.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (**protrusion** of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

3.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

3.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating as indicated in the guaranteed technical particulars. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 60888.

3.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

3.4 Joints in Wires

3.4.1 Aluminium Wires

3.4.1.1 During stranding, no aluminium wire welds shall be made for the purpose of achieving the required conductor length.

3.4.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

3.4.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

3.4.2 Steel Wires

There shall be no joint of any kind in the finished wire **used for** the **manufacturing** of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

3.5 Tolerances

The manufacturing tolerances to the extent indicated in the guaranteed technical particulars shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor.

3.6 Materials

3.6.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. They shall have the same properties and characteristics as prescribed in IEC:60889.

3.6.2 **Steel**

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the guaranteed technical particulars.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 60888.

3.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS:209 -1979.

3.7 **Standard Length**

3.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

3.8 Tests:

3.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

3.8.1.1 Type Tests

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Section -GTR.

a)	UTS test on stranded conductor.	As per Annexure-A
b)	Corona extinction voltage test (dry)	
(c)	Radio Interference voltage test (dry)	
(d)	DC resistance test on stranded conductor	

3.8.1.2 Acceptance Tests

a)	Visual check for joints, scratches etc. and lengths of conductor	As per Annexure - A
b)	Dimensional check on steel and aluminium strands	-do-
c)	Check for lay ratios of various layers	
d)	Galvanising test on steel strands	
e)	Torsion and Elongation test on steel strands	
f)	Breaking load test on steel and aluminium strands	As per IEC:60888 & 60889
g)	Wrap test on steel and aluminium strands	
h)	DC resistance test on aluminium strands	As per IEC:60889
i)	UTS test on welded joint of aluminium strands	As per Annexure - A

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

3.8.1.3 **Routine Tests**

a) Check to ensure that the joints are as per specification.

b) Check that there are no cuts, fins etc. on the strands.

c) All acceptance tests as mentioned above to be carried out on each coil/drum (as applicable).

3.8.1.4 **Tests During Manufacture**

a)	Chemical analysis of zinc used for galvanising	As per Annexure - A
b)	Chemical analysis of aluminium used for making aluminium strands	
c)	Chemical analysis of steel used for making steel strands	

4.0 Galvanised Steel Earth wire

4.1 Details of Earth wire

4.1.1 The galvanised steel earth wire shall generally conform to the specification of ACSR core wire as mentioned in IEC:60888/IS: 398 (Part-II)-1976 except where otherwise specified herein.

The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Section – Switchyard Erection and separate approval **for guaranteed technical particulars** is not required during detailed engineering.

4.2 Workmanship

4.2.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.

4.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

4.2.3 The steel strands shall be hot dip qalvanised and shall have minimum Zinc coating after stranding, as stipulated in guaranteed technical particulars attached with. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-74.

4.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

4.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

4.3 Joints in Wires

There shall be no joints of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

4.4 Tolerances

The manufacturing tolerance to the extent of the limits as stipulated in guaranteed Technical Particulars attached with this specification shall only be permitted in the diameter of the individual steel strands and lay length of the earth wire.

4.5 **Materials**

4.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and the chemical composition shall conform to the requirements as stipulated in Guaranteed Technical Particulars attached with.

4.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc. It shall conform to and satisfy all the requirements of IS: 209 -1979.

4.6 Standard Length

4.6.1 The standard length of the earth wire shall be as stipulated in Guaranteed Technical Particulars attached with, with the specified tolerance on standard length.

4.8 **TESTS**

4.8.1 The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earthwire.

4.8.2 **TYPE TESTS**

In accordance with the stipulation of specification, the following type tests reports of the earthwire shall be submitted for approval as per clause 9.2 of Section - GTR.

a)	UTS test	As per Annexure - B
b)	DC resistance test	

4.8.3 **ACCEPTANCE TESTS**

a)	Visual check for joints, scratches etc. and length of Earthwire	As per Annexure - B
b)	Dimensional check	
c)	Galvanising test	
d)	Lay length check	

e)	Torsion test	)	
f)	Elongation test	)	
g)	Wrap test	)	
h)	DC resistance test	)	IS:398 (Part-III) - 1976
i)	Breaking load test	)	
j)	Chemical Analysis of steel	)	

4.8.4 **ROUTINE TESTS**

a) Check that there are no cuts, fins etc. on the strands.

b) Check for correctness of stranding.

4.8.5 **TESTS DURING MANUFACTURE**

a)	Chemical analysis of zinc used for galvanising	)	As per Annexure - B
b)	Chemical analysis of steel	)	

5.0 **ALUMINIUM TUBE**

5.1 **General**

Aluminium used shall be grade 63401 WP (range 2) conforming to IS:5082.

The contractor shall supply the aluminium tubes as per the standard guaranteed technical particulars enclosed in Annexure-E of **this section** and separate approval **for guaranteed technical particulars** is not required during detailed engineering.

5.2 **Constructional Features**

5.2.1 For outer diameter (OD) & thickness of the tube there shall **not** be **any negative** tolerance, other requirements being as per IS: 2678 and IS: 2673.

5.2.2 The welding of aluminium tube shall be done by the qualified welders duly approved by the Employer.

5.3 **Tests**

In accordance with stipulations of the specification, Routine tests shall be conducted on tubular bus conductors as per IS:5082. Also the wall thickness and ovality of the tube shall be measured.

5.4 **Technical Parameters**

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE	4.5" AL. TUBE	5" AL. TUBE
1.	Type	3" IPS	4" IPS	4.5" IPS	5" IPS

		(EH Type)	(EH Type)	(EH Type)	(H Type)
2.	Outer diameter	88.9 mm	114.2 mm	120.00 mm	141.30 mm
3.	Thickness	7.62 mm	8.51 mm	12.00 mm	9.53 mm
4.	Cross-sectional area of aluminium	1945.76 sq.mm	2825.61 sq.mm	4071.50 sq.mm	3945.11 sq.mm
5.	Weight	5.25 kg/m	7.7 kg/m	11.034 kg/m	10.652 kg/m

Sl. No.	Description	6" AL. TUBE	8" AL. TUBE	10" AL. TUBE
1.	Type	6" IPS (H Type)	8" IPS (H Type)	10" IPS (H Type)
2.	Outer diameter	150 mm	202 mm	252 mm
3.	Thickness	10 mm	16 mm	17 mm
4.	Cross-sectional area of aluminium	4398.2 Sq mm	9349.3 sq.mm	12550.6 sq.mm
5.	Weight	11.875 kg/m	25.243 kg/m	33.887 kg/m

6.0 EARTHING CONDUCTORS

6.1 General

All conductors burried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanised steel, except for cable trench earthing. The minimum sizes of earthing conductor to be used are as indicated in clause 9.4 of this Section.

6.2 Constructional Features

6.2.1 Galvanised Steel

a) Steel conductors above ground level shall be galvanised according to IS:2629.

b) The minimum weight of the zinc coating shall be **610** gm/sq.m **for normal area and 900 gm/sq.m for coastal area as specified in Section-Project** and minimum thickness shall be 85 microns.

c) The galvanised surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

6.3 Tests

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per IS : 2633.

7.0 SPACERS

7.1 General

Spacers shall conform to IS: 10162. The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 765kV, 400 kV, 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per Annexure-D. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used. All quad/twin conductors between equipments/ bus shall be provided with at least one spacer.

Wherever Employer's 765kV, 400 kV, 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

7.2 Constructional Features

7.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

7.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.

7.2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

7.3 Tests

Each type of spacers shall be subjected to the following type tests, acceptance tests and routine tests:

7.3.1 **Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Section - GTR.**

a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

b) Fault current test as per Cl 5.14.2 of IS: 10162. Alternately, the same can be carried by simulated short circuit method for which compressive forces shall be based on IEC-60865.

c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 765 kV, 400 kV and 220 kV spacers as per procedure mentioned at Annexure - C, Minimum Corona Extinction voltage shall be as per clause 2.3.2.

d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Annexure - C, Maximum RIV levels shall be as per clause 2.3.2.

e) Resilience test (if applicable)

f) Tension Test

g) Log decremant test (if applicable)

h) Compression test

i) Galvanising test

7.3.2 **Acceptance Test (As per IS:10162)**

a) Visual examination

b) Dimensional verification

c) Movement test

d) Clamp slip test

e) Clamp bolt torque test (if applicable)

f) Assembly torque test

g) Compression test

h) Tension test

i) Galvanising test

j) Hardness test for neoprene (if applicable)

The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 to 80.

k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

7.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

8.0 **BUS POST INSULATORS**

The post insulators shall conform in general to latest IS: 2544, IEC-60168, IEC 60273 and IEC-60815.

SECTION - (SE)
SWITCHYARD ERECTION

8.1 **Constructional Features**

8.1.1 Bus Post insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators will be acceptable.

8.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

8.1.3 Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.

8.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile, The shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.

8.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or damage to conductors or insulators by the formation of substance produced by chemical action.

8.1.6 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

8.1.7 All ferrous parts shall be hot dip galvanised in accordance with the latest edition of IS: 2633, & IS: 2629. The zinc used for galvanising shall be grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.

8.1.8
a) Every bolt shall be provided with a hop dip galvanised steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

c) All bolts and nuts shall be of steel with well formed hexagonal heads forged from the solid and shall be hot dip galvanised. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

8.1.9 Bidder shall furnish drawings for the essential design features of assembly of shells and metal parts, and number of shells per insulator.

8.2 **Tests**

In accordance with the stipulations of the specification, the post insulators shall be subjected to type, acceptance, sample and routine tests as per IEC-60168.

8.2.1 In accordance with the stipulation of specification, the following **type tests** reports of the post insulators shall be submitted for approval as per clause 9.2 of Section - GTR.

a) Power frequency withstand test (dry & wet)

b) Lightning impulse test (dry)

c) Switching impulse test (wet) (For 420 kV and above class Insulator only)

d) Measurement of R.I.V (Dry) (As per Annexure – C)

e) Corona extinction voltage test (Dry) (As per Annexure – C)

.

f) Test for deflection under load

g) Test for mechanical strength.

8.**2.2** In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

a) Soundness test, metallurgical tests and magnetic particle Inspection **(MPI)** test on MCI/SGI caps as acceptance test.

b) All hot dip galvanised components shall be subjected to check for uniformity of thickness and weight of zinc coating on sample basis as an acceptance test.

c) The bending test shall be carried out at 50% minimum cantilever strength load in four directions as a routine test and at 100% minimum cantilever strength load in four directions as an acceptance test.

d) Acceptance norms for visual defects allowed at site and also at works shall be agreed in the Quality plan.

8.3 **Technical Parameters of Bus Post Insulators.**

Sl. No.	**Description**	**800 kV**	**420 kV**	**245 kV**	**145 kV**
a)	Type	Solid Core	Solid Core	Solid Core	Solid Core
b)	Voltage Class (kV)	800	420	245	145
c)	Dry and wet one minute power frequency withstand voltage (kV rms)	830	680	460	275
d)	Dry lightning impulse withstand Voltage (kVp)	±2100	±1425	±1050	±650
e)	Wet switching surge withstand voltage (kVp)	±1550	±1050	—-	—-
f)	Max. radio interference voltage (in microvolts) - **Dry**	1000 at 508 kV	500 at 305 kV	500 at 156 kV	500 at 105 kV
g)	Corona extinction voltage (kV rms) (min.)	508	320	156	105

h)	Cantilever Strength				
(i)	Total minimum cantilever strength (Kg)	800	800	800	600
i)	Minimum torsional moment	As per IEC-60273	As per IEC-60273	As per IEC-60273	As per IEC-60273
j)	Total height of insulator (mm)	5700	3650	2300	1500
k)	P.C.D Top (mm)	225	127	127	127
	Bottom (mm)	325	300	254	254
l)	No. of bolts				
	Top	4	4	4	4
	Bottom	8	8	8	8
m)	Diameter of bolt/holes (mm)				
	Top	M16	M16	M16	M16
	Bottom dia	18	18	18	18
n)	Pollution level as per IEC-60815	Heavy(III)	Heavy(III)	Heavy(III)	Heavy(III)
o)	Minimum total creepage distance for Heavy Pollution (mm)	20000	10500	6125	3165

8.3.1 If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the Contractor. Aluminium used for corona ring shall be of grade 63401 or 19501 conforming to IS:5082.

9.0 EARTHING

9.1 The earthing shall be done in accordance with requirements given hereunder and drawing titled 'Earthing Details' enclosed with the specification. The spacing for the main earthmat shall be provided by the Employer and the earthmat layout drawings shall be prepared by the contractor based on the spacing provided by the Employer. The resistivity of the stone for spreading over the ground shall be considered as 3000 ohm-m under wet condition. The resistivity measurement of stone (to be used for stone spreading) shall also be done by the Contractor to confirm the minimum resistivity value of stone considered in earth mat design. For measurement purpose, one sample of stones from each source (in case stones are supplied from more than one source) shall be used. The main earthmat shall be laid in the switchyard area in accordance with the approved earthmat layout.

9.2 Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.

9.3 Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

a) Code of practice for Earthing IS: 3043

b) Code of practice for the protection of Building and allied structures against lightning IS: 2309.

c) CEA Safety Regulations 2010 & Indian Electricity Act 2003 with latest amendments.

d) National Electricity Safety code IEEE-80.

9.4 **Details of Earthing System**

Sl. No.	Item	Size	Material
a)	Main Earthing Conductor to be buried in ground	40mm dia	Mild Steel rod as per IS:2062/ SAE1018
b)	Conductor above ground& earthing leads (for equipment)	75x12mm G.S. flat	Galvanised Steel
c)	Conductor above ground& earthing leads(for columns & aux. structures)	75x12mm G.S. flat	Galvanised Steel
d)	Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, Junction boxes& Lighting Panels etc.	50x6 mm G.S. flat	Galvanised Steel
e)	Rod Earth Electrode	40mm dia, 3000mm long	Mild Steel as per IS:2062/ SAE1018
f)	Pipe Earth Electrode (in treated earth pit) as per IS.	40mm dia, 3000mm long	Galvanised steel
g)	Earthing for motors	25x3mm GS flat	Galvanised steel
h)	Earthing conductor along outdoor cable trenches	50x6mm MS flat	Mild steel as per IS:2062/ SAE1018
I)	Earthing of Lighting Poles (for lighting poles outside switchyard)	40 mm dia 3000 mm long	Mild steel rod as per IS:2062/ SAE1018
j)	Isolator MOM Box	75X12 mm GS flat & Flexible copper braid	Galvanised steel and copper braid

The sizes of the earthing conductor indicated above are the minimum sizes.

9.5 **Earthing Conductor Layout**

9.5.1 Earthing conductors in outdoor areas shall be buried at least 600 mm below finished ground level unless stated otherwise.

9.5.2 Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

9.5.3 Tap-connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as per “Standard Earthing Details – Drg No. **C/ENG/STD/EARTHINGS/09**” enclosed**.**

9.5.4 Earthing conductors or leads along their run on cable trench, ladder, walls etc. shall be supported by suitable welding/cleating at intervals of 750 mm. Wherever it passes through walls, floors etc., PVC sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

9.5.5 Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building.

9.5.6 Earthing conductors crossing the road shall be laid 300mm below road or at greater depth to suit the site conditions.

9.5.7 Earthing conductors embeded in the concrete shall have approximately 50mm concrete cover.

9.**6** **ELECTRO-MAGNETIC FIELD CONTROL**

The contractor shall provide galvanised steel earth wire at 8m level in the area where three interconnection levels (equipment interconnection, bus & jack bus interconnection) are present at 765kV switchyard to limit electric and magnetic field within permissible limit.

9.7 **Equipment and Structure Earthing**

9.7.1 Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with Employer.

9.7.2 Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.

9.7.3 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.

9.7.4 Metallic conduits shall not be used as earth continuity conductor.

9.7.5 Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.

9.7.6 Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running alongwith the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.

9.7.7 Railway tracks within switchyard area shall be earthed at a spacing of 30m and also at both ends.

9.7.8 Earthing conductor shall be buried 2000 mm outside the switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid.

The stone spreading shall also be done 2000 mm outside switchyard fence. The criterian for stone spreading shall be followed in line with requirement specified elsewhere in the specification

9.7.9 Flexible earthing connectors shall be provided for the moving parts.

9.7.10 All lighting panels, junction boxes, receptacles fixtures, conduits etc. shall be grounded in compliance with the provision of I.E. rules

9.7.11 A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, switches, lighting fixtures etc. shall be connected to this 16 SWG ground conductor.

9.7.12 50mm x 6mm MS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 30 mtrs. The M.S. flat shall be finally painted with two coats of Red oxide primer and two coats of Zinc riched enamel paint.

9.7.13 One number 40 mm dia, 3000 mm long MS earth electrode with test link, CI frame and cover shall be provided to connect each down conductor of surge arresters, capacitive voltage transformers, lightning masts and towers with peak.

9.8 **Jointing**

9.8.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti corrosive paint/compound.

9.8.2 Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protections, the welds should be treated with red oxide primer and afterwards coated with two layers bitumen compound to prevent corrosion.

9.8.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

9.8.4 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

9.8.5 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.

9.8.6 All arc welding with large dia. conductors shall be done with low hydrogen content electrodes.

9.8.7 The 75x12mm GS flat shall be clamped with the equipment support structures at 1000mm interval.

9.9 **Power Cable Earthing**

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

9.10 **Specific Requirement for Earthing Systems**

9.10.1 Each earthing lead from the neutral of the power transformer/Reactor shall be directly connected to two numbers pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in Cement Concrete pit with a ISI marked cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer/reactor like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points.

9.10.2 Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode which in turn, shall be connected to station earthing grid.

9.10.3 Auxiliary earthing mat comprising of 40mm dia M.S. rods closely spaced (300 mm x 300 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the M.O.M. Box of the isolators. M.O.M. boxes shall be directly connected to the auxiliary earthing mat. Flexible copper braid connection to be provided between MOM box and GI flat to take care of soil sagging. The size of auxiliary earthing mat shall be of 1500mmx1500mm size for 220kV and above voltage class isolators and 900mmx900mm size for 132kV and below voltage class isolators. Factory welded auxiliary earthmat is preferable.

9.11 **Insulating mats**

9.11.1 The scope covers supply and laying of insulating mats of “class A” conforming to IS: 15652-2006.

9.11.2 These insulating mats shall be laid in front of all floor mounted AC and DC switchboards and control & relay panels located in control room building/ Switchyard panel room.

9.11.3 The insulating mats shall be made of elastomer material free from any insertions leading to deterioration of insulating properties. It shall be resistant to acid, oil and low temperature.

9.11.4 Upper surface of the insulating mats shall have small aberration (rough surface without edges) to avoid slippery effects while the lower surface shall be plain or could be finished slip resistant without affecting adversely the dielectric property of the mat.

9.11.5 Insulating mat **(wherever applicable)** shall be of pastable type, to be fixed permanently on the front of the panels except for the chequered plate area which shall not be pasted as per requirement. The insulating mats shall generally be fixed and joints shall be welded as per recommendations in Annexure-A of IS: 15652.

9.11.6 Width of insulating mats shall generally be of 1.5 meters or as per site requirements. Length shall be supplied as per site requirements.

9.11.7 The insulating mats offered shall conform to IS: 15652-2006.

10.0 **Bus Bars**

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated elsewhere in the specification. The bus bar arrangements are shown in electrical layout drawings enclosed with the bid documents.

10.1 The Contractor shall furnish supporting calculations where the design is to be done by the contractor for the bus bars/conductors to show adequacy of design parameters for:

a) Fibre-stress (applicable for aluminum tube)

b) Cantilever strength of post insulators (applicable for aluminum tube)

c) Aeolain vibrations (applicable for aluminum tube)

d) Vertical deflection of bus bars (applicable for aluminum tube)

e) Short circuit forces in bundle conductor and spacer location for each span of ACSR conductor stringing as per layout drawings.

10.1.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to Employer's approval. Material for welding sleeve shall be same as that of Aluminium tube. Welding sleeve shall be of 600mm length

10.1.2 Corona bells shall be provided wherever the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electrostatic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of Corona bell shall be Aluminium alloy similar to that of clamps & connectors.

10.1.3 To minimise the vibrations in the aluminium tubes, damping conductor shall be provided inside the aluminium tubes. For this purpose, the cut pieces of ACSR conductor which otherwise are considered wastages, shall be used as damping conductor.

10.1.4 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electrical and mechanical characteristics shall also be furnished **to Employer**. Welding at site shall be done by adopting a qualified procedure and employing qualified welders as per ASME-Section IX.

10.1.5 Joints shall be avoided in strung bus to avoid joint failure / hot spots and hardwares to be designed accordingly.

11.0 **BAY EQUIPMENT**

11.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

11.2 Bay Marshalling Kiosk:-

Bay marshalling kiosk shall be fabricated from 304 grade stainless steel of minimum thickness of 1.6mm. For other constructional details, technical specification of section-GTR shall be referred. Further, for stainless steel type bay marshaling kiosk, no painting is envisaged.

One no. of bay marshalling kiosk shall be provided for each 765 kV, 400 kV, 220 kV and 132 kV bay under present scope. For one and half breaker scheme, one number bay marshalling kiosk shall be provided for each controlling feeder (Line/ transformer/ bus reactor etc) of the diameter and no bay marshalling kiosks are required to be provided for the tie bays. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose:-

A. For 765kV , 400 kV & 220 kV Bays

(i) To receive two incoming 415V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum nine (9) numbers outgoing 415V, 3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum two numbers outgoing 415V, 63Amps three phase supplies to be controlled by MCB to be drawn from above 3 phase incomers for supply to switchyard panel rooms.

(iii) To distribute minimum ten numbers outgoing 240V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and necessary heating circuits.

B. For 132kV & 66 kV Bays

(i) To receive two incoming 415V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum four (4) number outgoing 415V, 3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum six (6) numbers outgoing 240V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iii) 100 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and necessary heating circuits.

11.**3** Further, all Bay Marshalling Kiosks shall be erected such that a minimum height of 1000mm is maintained between FGL & bottom of the marshalling box. Size of Marshalling box shall be such that cables are properly terminated and wires are dressed with provision of loop.

11.4 **BAY AND PHASE IDENTIFICATION**

11.4.1 The name plate for the bays shall be provided by the contractor as per standard drawing (Drawing no. C/ENG/STD/BAY NAME PLATE) enclosed in this technical specification.

11.4.2 All the phases are to be identified by painting the structures Red, Yellow and Blue by reflecting colour as per as built condition. Phase identification colour is to be provided around the top of the structure with colour band of 100 mm width at a height of approximately 2000mm from the finished ground level.

12.0 **LIGHTNING PROTECTION**

12.1 Direct stroke lightning protection (DSLP) shall be provided in the EHV switchyard by lightning masts and shield wires**.** The layout drawings enclosed indicate the tentative arrangement. The final arrangement shall be decided after approval of the DSLP calculations.

12.2 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

12.3 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

12.4 Down conductors shall be cleated on the structures at 2000 mm interval.

12.5 Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earthmat.

12.6 Lightning conductors shall not pass through or run inside G.I. conduits.

12.7 Lightning protection shall also be provided for various buildings like control building, FFPH, Township buildings as per relevant standard.

13.0 **EQUIPMENT ERECTION DETAILS**

13.1 All circuit breaker and isolator erection shall be done under the supervision of equipment manufacturer and erection of all switchyard equipments shall be done as per POWERGRID approved Field Quality Plan (FQP) and as per provision of Technical Specification.

13.2 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

13.3 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

13.4 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

13.5 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.

All welding done at site for equipment and structures, shall be painted with zinc rich paint immediately to avoid corrosion.

13.6 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

13.7 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

13.8 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

13.9 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

14.0 **STORAGE**

14.1 The Contractor shall provide and construct adequate storage shed as per the Filed Quality Plan for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Employer shall be strictly adhered to. POWERGRID approved Field Quality Plan shall be followed alongwith the provision of Technical Specification for storage.

15.0 **CABLING MATERIAL**

15.1 **CABLE TAGS AND MARKERS**

15.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

15.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS:280. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

15.1.3 Location of cables laid directly underground shall be clearly indicated with cable route marker made of galvanised iron plate.

15.1.4 Location of underground cable joints shall be indicated with cable **route** marker with an additional inscription “Cable joints”.

15.1.5 The **cable route** marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings as per relevant standard.

15.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

15.2 **Cable Supports and Cable Tray Mounting Arrangements**

15.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

15.2.2 The supports shall be fabricated from standard structural steel members.

15.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.

15.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

15.3 **Cable Termination and Connections**

15.3.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Employer.

15.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

15.3.3 Supply of all consumable material shall be in the scope of Contractor.

15.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

15.3.5 Control cable inside control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

15.3.6 The Contractor shall use printed ferrules for control cable cores at all terminations, as instructed by the Employer. Each cable wire shall be identified with a number and detailed cable schedule may be prepared indicating the wire numbers.

15.3.7 Spare cores shall be similarly encaped & tagged with cable numbers and coiled up with end cap.

15.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

15.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.

15.3.10 The cable glands shall conform to BIS:6121. They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

15.3.11 The cable glands shall also be suitable for dust proof and weather proof termination.

15.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Employer.

15.3.13 Crimping tool used shall be of approved design and make.

15.3.14 Control Cable lugs shall be tinned copper solderless crimping type conforming to

IS-8309 & 8394. Aluminium Bimetallic lugs for power cables as required shall be used depending upon type of cables and terminations.

15.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

15. 4 **Storage and handling of Cable Drums**

15.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

16.0 **DIRECTLY BURIED CABLES**

16.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers.

16.2 The cable (power and control) between LT station, DG set location and fire lighting pump house and control room shall be laid in the burried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.

16.3 Power cables from Main Switchboard to colony shall be laid in burried cable trench. Location of cable termination point at colony shall be as per site condition and shall be decided in consultation with Employer's site-in-charge. Power Cables for oil filtration plant shall be laid in open cable trench or burried trench upto transformer/reactor area and can be looped from adjacent receptacles provided for power supply of oil filtration plant.

16.4 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker. Cable markers shall be grounded in a concrete base.

17.0 **INSTALLATION OF CABLES**

17.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.

17.2 All cables from bay cable trench to equipments including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter of class 4 as per IS 4985 which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required. **For vertical runs on equipments, perforated cable trays shall be provided for all equipments under scope of the contract or any equipment to be provided by the owner (including for owner supplied circuit breakers)**.

17.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained. Embedded pipes shall be dressed properly at the equipment termination points.

17.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint. The red oxide and zinc chromate shall conform to IS:2074.

17.5 Suitable arrangement should be used between fixed pipe/cable trays and equipment terminal boxes, where vibration is anticipated.

17.6 Power and control cables in the cable trench shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.

a) Power cables preferably on top tiers.
b) Control instrumentation and other service cables in bottom tiers.
c) For cabling from control room to switchyard in main cable trench, cable shall be laid such that bottom tiers are preferably filled first and top tiers are kept for filling future cables as per the instructions of Engineer-In-Charge.

17.7 For Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. Further, for horizontal cables a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables shall be maintained.

17.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon-6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.

17.9 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with de-interlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

17.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Table of Cable and	Minimum bending radius
Power cable	12 D
Control cable	10 D

D is overall diameter of cable

17.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth. The size of hume/steel pipe shall be such that approximately 70% area is only occupied. For meeting future requirement, additional hume/steel pipe shall be laid for future bay provision.

17.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/ two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.

17.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Employer. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

17.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

17.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Employer.

17.16 Rollers shall be used at intervals of about two metres while pulling cables to avoid damage.

17.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

17.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

17.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with IS:1255 and other Indian Standard Codes of practices.

17.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.

17.21 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Employer. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Employer, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.

17.22 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

17.23 **Cable trays**

i) The cable trays shall be of G.S Sheet and minimum thickness of sheet shall be 2mm.

ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)
The test shall be done as per approved standards.

17.24 **Conduits, Pipes and Duct Installation**

17.24.1 Contractor shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as required. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

17.24.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

17.24.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

17.24.4 Installation of optical cables/ special cables:

GI pipe (light grade) of suitable size (minimum 25 mm) along with required bends, joints etc. shall be used for special cables such as cables for visual monitoring system (VMS), substation automation system (SAS). Further, single pipe can be used for laying multiple cables.

17.24.5 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

17.24.6 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

17.24.7 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

17.24.8 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

17.24.9 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

17.24.10 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

17.24.11 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

17.24.12 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

17.24.13 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

17.24.14 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

17.24.15 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

17.24.16 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

17.24.17 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.

17.24.18 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

17.24.19 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

17.24.20 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

17.24.21 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

17.24.22 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

17.24.23 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

17.24.24 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

17.25 **Cable Sealing System**

Modular multi-diameter cable sealing system consisting of frames, blocks and accessories shall be installed where the underground and over ground cables enter or leave concrete bay kiosks/switchyard panel room & control rooms in the substations. Cable sealing system shall consist of multi-diameter type peel-able or adjustable blocks of different sizes to suit the various cables. It should be simple, easy and quick to assemble & re-assemble the cable sealing system. Solid blocks shall not be used on frame. Frames & stay-plate material shall be of galvanized steel and for compression, single piece wedge with galvanized steel bolts shall be used. 30% spare blocks on the frame shall be provided for expansion in future. Cable sealing system should have been tested for fire/water/smoke tightness.

Cable sealing system having earthing strip can alternately be used in place of cable gland arrangement for indoor panels such as LCC, C&R, PLCC panels etc.

18.0 LIGHTING JUNCTION BOX

The Contractor shall supply and install ISI marked junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.

19.0 **TESTING AND COMMISSIONING**

19.1 **All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with Employer's "Pre- Commissioning procedures for Switchyard Equipments (Doc. No. D-2-01-03-01-03)" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage. Test results in the prescribed formats shall be duly filled by the contractor and shall be submitted to the Owner in soft form (CD or Pen Drive)**

The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates.

19.2 **GENERAL CHECKS**

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

19.3 **STATION EARTHING**

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanised surfaces.

e) Dip test on earth conductor prior to use.

19.4 **AAC/ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

a) Physical check for finish

b) Electrical clearance check

c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

19.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

c) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

19.**6** **INSULATOR**

Visual examination for finish, damage, creepage distance etc.

ANNEXURE "A"

(Testing Procedure for ACSR/AAC Conductor)

1.0 **UTS Test on Stranded Conductor**

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate upto 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to Relative movement of strands. Thereafter the load shall be increased at a steady rate to 100% of minimum specified UTS and held for one minute. The conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.0 **Corona Extinction Voltage Test**

Two samples of conductor of 5m length shall be strung with a spacing of 450 mm between them at a height not exceeding 8.0 m above ground. This assembly shall be tested as per Annexure-C, Corona extinction voltage shall not be less than 510 kV (rms) & 320 KV (RMS) Line to ground for 765 kV & 400 kV respectively.

3.0 **Radio Interference Voltage Test**

Under the conditions as specified under (2.0) above, the conductor samples shall have radio interference voltage as indicated in the guaranteed technical particulars enclosed with. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-60437.

4.0 **D.C Resistance Test on Stranded Conductor**

On a conductor sample of minimum 5 m length two contact clamps shall be fixed with a pre-determined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C as per clause no. 12.8 of IS:398 (Part V)-1982. The resistance corrected at 20°C shall conform to the requirements of this specification.

5.0 **Chemical Analysis of Zinc**

Samples taken from the zinc ingots shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

6.0 **Chemical Analysis of Aluminium and Steel**

Samples taken from the Aluminium ingots/coils/strands shall be chemically/ spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

7.0 **Visual Check for Joints, Scratches etc.**

Conductor drums shall be rewound in the presence of the inspector. The inspector shall visually check for scratches, joints, etc. and that the conductor generally conform to the requirements of this specification. The length of conductor wound on the drum shall be measured with the help of counter meter during rewinding.

8.0 **Dimensional Check for Steel and Aluminium Strands.**

The individual strands shall be dimensionally checked to ensure that they conform to the requirements of this specification.

9.0 **Check for Lay-ratios of various Layers.**

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this Specification.

10.0 **Galvanising Test**

The test procedure shall be as specified in IEC:60888. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

11.0 **Torsion and Elongation Tests on Steel Strands**

The test procedures shall be as per clause No. 10.3 of IEC:60888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the GTP. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

12.0 **Procedure Qualification test on welded Aluminium strands**

Two Aluminium wires shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of individual strands.

ANNEXURE "B"

(Testing procedure for Galvanised Steel Earthwire)

1. **UTS TEST**

Circles perpendicular to the axis of the earthwire shall be marked at two places on a sample of earthwire of minimum 5m length suitably compressed with dead end clamps at either end. The load shall be increased at steady rate upto 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter, the load shall be increased at a steady rate to 100% of UTS and held for one minute. The earthwire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and value recorded.

2. **D.C. RESISTANCE TEST**

On an earthwire sample of minimum 5m length, two contact clamps shall be fixed with a predetermined Bolt torque. The resistance shall be measured by a Kelvin double-bridge by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C shall conform to the requirements of this specification.

3. **Visual check for joints, scratches etc. and length of earthwire**

Earthwire drums shall be rewound in the presence of the inspector. The inspector shall visually check for joints, scratches etc. and see that the earthwire generally conforms to the requirements of this specification. The length of earthwire wound on the drum shall be measured with the help of counter meter during rewinding.

4. **TORSION TEST**

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case the test sample length is less or more than 100 times the standard diameter of the strand, the minimum number of twists will be proportionate to the length and if number comes in the fraction then it will be rounded off to next higher whole number.

5. **DIMENSIONAL CHECK**

The individual strands shall be dimensionally checked to ensure that they conform to the requirements of this specification.

6. **LAY LENGTH CHECK**

The lay length shall be checked to ensure that they conform to the requirements of this specification.

7. **GALVANISING TEST**

The test procedure shall as specified in IS:4826-1968. The material shall conform to the requirements of this specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

8. **CHEMICAL ANALYSIS OF ZINC USED FOR GALVANIZING**

Samples taken from zinc ingots shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

9. **CHEMICAL ANALYSIS OF STEEL**

Samples taken from steel ingots/coils/strands shall be chemically/ spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

ANNEXURE-C

CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV).

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100% and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 765kV, 400kV, 220kV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noisel meter.

4. Test Methods for Visible Corona [applicable for 400kV and above]

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 110% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

In case corona inception does not take place at 110%, voltage shall not be increased further and corona extinction voltage shall be considered adequate.

4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.

4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.

4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.

b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.

d) Results and observations with regard to location and type of interference sources detected at each step.

e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.

f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

ANNEXURE – D

A. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 765kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40kA/50 kA for 1 sec.**					
1.	54.0 mtr	QUAD AAC BULL	15 mtr	3.96 T	5.98 T	3.5 mtr
2.	56.0 mtr	QUAD AAC BULL	15 mtr	4.52 T	6.77 T	4.0 mtr
3.	87.9 mtr	QUAD AAC BULL	15 mtr	8.35 T	11.22 T	6.5 mtr
4.	104.0 mtr	QUAD AAC BULL	15 mtr	9.00 T	12.72 T	7.5 mtr
5.	108.61 mtr	QUAD AAC BULL	15 mtr	9.00 T	12.72 T	8.0 mtr

B. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 400kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	7 mtr	4 T	5.64 T	6 mtr
2.	70 mtr	TWIN ACSR	7 mtr	4 T	5.64 T	5 mtr
3.	54 mtr	QUAD ACSR	6 mtr	4 T	5.10 T	5 mtr
4.	70 mtr	TWIN ACSR	6 mtr	4 T	5.10 T	5 mtr
5.	48 mtr	QUAD ACSR	6 mtr	4 T	4.82T	5 mtr
6.	52.5 mtr	QUAD ACSR	6 mtr	4 T	4.85T	5 mtr
7.	56.5 mtr	QUAD ACSR	6 mtr	4 T	4.88T	5 mtr
8.	52.5 mtr	TWIN ACSR	6 mtr	4 T	4.97T	5 mtr
9.	56.5 mtr	TWIN ACSR	6 mtr	4 T	5.00 T	5 mtr
II.	**For Fault Level of 50 kA for 1 sec.**					
1.	48 mtr	QUAD AAC BULL	6 mtr	4 T	5.10 T	4 mtr
2.	52.5 mtr	QUAD ACSR	6 mtr	4 T	5.18 T	4 mtr
3.	56.5 mtr	QUAD ACSR	6 mtr	4 T	5.20 T	4 mtr
III.	**For Fault Level of 63 kA for 1 sec.**					
1.	48 mtr	QUAD AAC BULL	6 mtr	4 T	6.00 T	4 mtr
2.	52.5 mtr	QUAD ACSR	6 mtr	4 T	6.33 T	4 mtr
3.	56.5 mtr	QUAD ACSR	6 mtr	4 T	6.37 T	4 mtr

ANNEXURE – D

C. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 220 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 40 kA for 1 sec.**					
1.	54 mtr	QUAD ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
2.	54 mtr	TWIN ACSR	4.5 mtr	2 T	3.50 T	2.5 mtr
3.	74 mtr	TWIN ACSR	4.5 mtr	4 T	5.00 T	2.5 mtr
4.	54 mtr	QUAD ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
5.	54 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.5 mtr
6.	74 mtr	TWIN ACSR	4.0 mtr	4 T	5.70 T	2.5 mtr
7.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.30 T	2.5 mtr
8.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.35 T	2.5 mtr
9.	68 mtr	TWIN ACSR	4.0 mtr	4 T	5.20 T	2.5 mtr
10.	56 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.5 mtr
11.	72 mtr	TWIN ACSR	4.0 mtr	4 T	5.27 T	2.5 mtr
II.	**For Fault Level of 50 kA for 1 sec.**					
1.	48 mtr	QUAD ACSR	4.0 mtr	4 T	5.41 T	2.0 mtr
2.	52 mtr	QUAD ACSR	4.0 mtr	4 T	5.50 T	2.0 mtr
3.	36 mtr	TWIN ACSR	4.0 mtr	2 T	3.50 T	2.0 mtr

NOTE: ACSR conductor as mentioned above indicates that it is suitable for both ACSR MOOSE as well as ACSR BERSIMIS conductor.

D. SHORT CIRCUIT FORCES AND SPACER SPAN FOR 132 kV GANTRY STRUCTURE

Sl. No.	Max. Span	Conductor Configuration	Ph-Ph Spacing	Normal Tension	SCF per Phase	Spacer span
I.	**For Fault Level of 31.5kA for 1 sec.**					
1.	36 mtr	Twin Moose/ Zebra ACSR	3 mtr	1 T	2.15 T	2.5 mtr
2.	31.5 mtr	Twin Moose/ Zebra ACSR	2.7mtr	1 T	2.15 T	2.5 mtr
3.	48 mtr	Single Moose/ Zebra ACSR	3 mtr	1 T	2.05 T	NA
4.	42 mtr	Single Moose/ Zebra ACSR	2.7 mtr	1 T	2.03 T	NA

ANNEXURE-E

STANDARD TECHNICAL DATA SHEETS FOR AAC/ACSR CONDUCTORS, GS EARTHWIRE AND ALUMINIUM TUBE

1.0 GENERAL

Employer has stardardised the guaranteed technical particulars for the following AAC/ACSR conductors, Galvanised steel earthwire and aluminum tube. The contractor shall supply the conductors as per the standard GTP mentioned below. Any deviation to the following GTP shall be clearly brought out by the bidder in their bid.

1.1 Guaranteed Technical Particulars (GTP) for conductors:

A. **GTP of AAC BULL and AAC TARANTULA conductor:**

Sl.	Description	Unit	AAC BULL	AAC TARANTULA
1.0	**Applicable Standard**		IS:398	
2.0	**Raw Materials**			
2.1	Steel Wire / Rods			
2.1.1	Aluminium			
a)	Minimum purity of Aluminium	%	99.50	99.50
b)	Maximum copper content	%	0.04	0.04
3.0	**Aluminum strands after stranding**			
3.1	Diameter			
a)	Nominal	mm	4.25	5.23
b)	Maximum	mm	4.29	5.28
c)	Minimum	mm	4.21	5.18
3.2	Minimum breaking load of strand			
a)	Before stranding	KN	2.23	3.44
b)	After stranding	KN	2.12	3.27
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm /KM	3.651	3.627
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.00203	0.001341
4.0	**AAC Conductor**			
4.1. a)	Stranding		Al – 61/4.25 mm	Al – 37/ 5.23 mm
b)	Number of Strands			
i.	1st Aluminium Layer	Nos.	1	1
ii.	2nd Aluminium Layer	Nos.	6	6

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Sl.	Description	Unit	AAC BULL		AAC TARANTULA	
iii.	3rd Aluminium Layer	Nos.	12		12	
iv.	4th Aluminium Layer	Nos.	18		18	
v.	5th Aluminium Layer	Nos.	24		-	
4.2	Sectional Area of aluminium	Sq. mm	865.36		794.80	
4.3	Total sectional area	Sq. mm	865.36		794.80	
4.4	Approximate Weight	Kg/m	2.4		2.191	
4.5	Diameter of the conductor	mm	38.25		36.60	
4.6	UTS of the conductor	kN	139 (Min.)		120 (Min.)	
4.7	Lay ratio of the conductor	mm	Max	Min	Max	Min
a)	6 wire Aluminium layer	mm	16	10	16	10
b)	12 wire Aluminium layer	mm	16	10	16	10
c)	18 wire Aluminium layer	mm	16	10	14	10
d)	24 wire Aluminium layer	mm	14	10	-	-
4.8	DC resistance of the conductor at 20°C	ohm/ km	0.03340		0.03628	
4.9	Standard length of the conductor	m	1000		1000	
4.10	Tolerance on Standard length	%	(+/-) 5		(+/-) 5	
4.11	Direction of lay of outer layer		Right Hand		Right Hand	
4.12	Linear mass of the conductor					
a)	Standard	kg/ km	2400		2192	
b)	Minimum	kg/ km	2355		2150	
c)	Maximum	kg/ km	2445		2234	
4.13	Modulus of Elasticity	Kg/sq .mm	4709 (Initial) 5869 (Final)		4709 (Initial) 5869 (Final)	
4.14	Co-efficient of Linear Expansion	Per Deg. C	$23.0\text{x}10^{-6}$		$23.0\text{x}10^{-6}$	
4.15	Minimum Corona Extinction Voltage	KV (rms)	508		320	
4.16	RIV at 1 Mhz	Micro volts	Less than 1000 at 508 kV (rms)		Less than 1000 at 320 kV (rms)	
5.0	**Drum Dimensions**		Generally conforms to IS:1778			

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Sl.	Description	Unit	AAC BULL	AAC TARANTULA
a)	Flange Diameter	mm	1855	1855
b)	Traverse width	mm	925	925
c)	Barrel Diameter	mm	850	850
d)	Flange thickness	mm	50x50	50x50

B. GTP of ACSR BERSIMIS and ACSR MOOSE conductor:

Sl.	Description	Unit	ACSR BERSIMIS	ACSR MOOSE
1.0	**Applicable Standard**		IS:398 / IEC - 61089	
2.0	**Raw Materials**			
2.1	Aluminium			
a)	Minimum purity of Aluminium	%	99.50	99.50
b)	Maximum copper content	%	0.04	0.04
2.2	Steel wires/ rods			
a)	Carbon	%	0.50 to 0.85	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035	Not more than 0.035
d)	Sulphur	%	Not more than 0.045	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)	0.10 to 0.35 (Max.)
2.3	Zinc			
a)	Minimum purity of Zinc	%	99.95	99.95
3.0	**Aluminum strands after stranding**			
3.1	Diameter			
a)	Nominal	mm	4.57	3.53
b)	Maximum	mm	4.61	3.55
c)	Minimum	mm	4.53	3.51
3.2	Minimum breaking load of strand			
a)	Before stranding	KN	2.64	1.57
b)	After stranding	KN	2.51	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm/ KM	1.738	2.921
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.001738	0.002921

ANNEXURE-E

Sl.	Description	Unit	ACSR BERSIMIS	ACSR MOOSE
4.0	**Steel strand after stranding**			
4.1	Diameter			
a)	Nominal	mm	2.54	3.53
b)	Maximum	mm	2.57	3.60
c)	Minimum	mm	2.51	3.46
4.2	Minimum breaking load of strand			
a)	Before stranding	KN	6.87	12.86
b)	After stranding	KN	6.53	12.22
4.3	Galvanising			
a)	Minimum weight of zinc coating per sq.m.	gm	260	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute	2 dips of one minute & 1 dip of half minute
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)	16 (After stranding) 18 (Before stranding)
5.0	**ACSR Conductor**			
5.1.a)	Stranding		Al -42/4.57 mm+ Steel-7/2.54 mm	Al -54/3.53 mm+ Steel-7/3.53 mm
b)	Number of Strands			
i.	Steel centre	Nos.	1	1
ii.	1st Steel Layer	Nos.	6	6
iii.	1st Aluminium Layer	Nos.	8	12
iv.	2nd Aluminium Layer	Nos.	14	18
v.	3rd Aluminium Layer	Nos.	20	24
5.2	Sectional Area of aluminium	Sq. mm	689.50	528.50
5.3	Total sectional area	Sq. mm	725.00	597.00
5.4	Approximate Weight	Kg/m	2.181	2.004
5.5	Diameter of the conductor	mm	35.05	31.77
5.6	UTS of the conductor	kN	154 (Min.)	161.20 (Min.)
5.7	Lay ratio of the conductor	mm	Max Min	Max Min

ANNEXURE-E

Sl.	Description	Unit	ACSR BERSIMIS		ACSR MOOSE	
a)	Outer Steel layer	mm	24	16	18	16
b)	8/12 wire Aluminium layer	mm	17	10	14	12
c)	14/ 18 wire Aluminium layer	mm	16	10	13	11
d)	20/24 wire Aluminium layer	mm	13	10	12	10
5.8	DC resistance of the conductor at 20°C	ohm/ km	0.04242		0.05552	
5.9	Standard length of the conductor	m	1800		1800	
5.10	Tolerance on Standard length	%	(+/-) 5		(+/-) 5	
5.11	Direction of lay of outer layer	-	Right Hand		Right Hand	
5.12	Linear mass of the conductor					
a)	Standard	kg/ km	2181		2004	
b)	Minimum	kg/ km	2142		1965	
c)	Maximum	kg/ km	2221		2045	
5.13	Modulus of Elasticity (Final State)	Kg/sq .mm			6860	
5.14	Co-efficient of Linear Expansion	Per Deg. C	21.5×10^{-6}		19.3×10^{-6}	
5.15	Minimum Corona Extinction Voltage	KV (rms)	320		320	
5.16	RIV at 1 Mhz under dry condition	Micro volts	Max. 1000 at 320 kV (rms)		Max. 1000 at 320 kV (rms)	
6.0	**Drum Dimensions**		Generally conforms to IS:1778			
a)	Flange Diameter	mm	1800		1800	
b)	Traverse width	mm	950		950	
c)	Barrel Diameter	mm	650		650	
d)	Flange thickness	mm	50x50		50x50	

C. B. GTP of ACSR ZEBRA and ACSR PANTHER conductor:

Sl.	Description	Unit	ACSR ZEBRA	ACSR PANTHER
1.0	**Applicable Standard**		IS:398 / IEC-61089	
2.0	**Raw Materials**			
2.1	Aluminium			
a)	Minimum purity of Aluminium	%	99.50	99.50

ANNEXURE-E

Sl.	Description	Unit	ACSR ZEBRA	ACSR PANTHER
b)	Maximum copper content	%	0.04	0.04
2.2	Steel wires/ rods			
a)	Carbon	%	0.50 to 0.85	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035	Not more than 0.035
d)	Sulphur	%	Not more than 0.045	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (Max.)	0.10 to 0.35 (Max.)
2.3	Zinc			
a)	Minimum purity of Zinc	%	99.95	99.95
3.0	**Aluminum strands after stranding**			
3.1	Diameter			
a)	Nominal	mm	3.18	3.00
b)	Maximum	mm	3.21	3.03
c)	Minimum	mm	3.15	2.97
3.2	Minimum breaking load of strand			
a)	Before stranding	KN	1.29	1.17
b)	After stranding	KN	1.23	1.11
3.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.003626	0.004107
4.0	**Steel strand after stranding**			
4.1	Diameter			
a)	Nominal	mm	3.18	3.00
b)	Maximum	mm	3.24	3.06
c)	Minimum	mm	3.12	2.94
4.2	Minimum breaking load of strand			
a)	Before stranding	KN	10.43	9.29
b)	After stranding	KN	9.91	8.85
4.3	Galvanising			
a)	Minimum weight of zinc coating per sq.m.	gm	260	260
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	2 dips of one minute & 1 dip of half minute	2 dips of one minute & 1 dip of half minute

ANNEXURE-E

Sl.	Description	Unit	ACSR ZEBRA	ACSR PANTHER
c)	Min. No. of twists in guage length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16 (After stranding) 18 (Before stranding)	16 (After stranding) 18 (Before stranding)
5.0	**ACSR Conductor**			
5.1.a)	Stranding		Al -54/3.18 mm+ Steel-7/3.18 mm	Al -30/3.00 mm+ Steel-7/3.00 mm
b)	Number of Strands			
i.	Steel centre	Nos.	1	1
ii.	1st Steel Layer	Nos.	6	6
iii.	1st Aluminium Layer	Nos.	12	12
iv.	2nd Aluminium Layer	Nos.	18	18
v.	3rd Aluminium Layer	Nos.	24	NA
5.2	Sectional Area of aluminium	Sq. mm	428.9	212.10
5.3	Total sectional area	Sq. mm	484.5	261.50
5.4	Approximate Weight	Kg/m	1.621	0.974
5.5	Diameter of the conductor	Mm	28.62	21.00
5.6	UTS of the conductor	kN	130.32 (Min.)	89.67 (Min.)
5.7	Lay ratio of the conductor	mm	Max Min	Max Min
a)	Outer Steel layer	mm	28 13	28 16
b)	12 wire Aluminium layer	mm	17 10	16 10
c)	18 wire Aluminium layer	mm	16 10	14 10
d)	24 wire Aluminium layer	mm	14 10	NA NA
5.8	DC resistance of the conductor at 20°C	ohm/ km	0.06868	0.140
5.9	Standard length of the conductor	m	1800	1800
5.10	Tolerance on Standard length	%	(+/-) 5	(+/-) 5
5.11	Direction of lay of outer layer		Right Hand	Right Hand
5.12	Linear mass of the conductor			
a)	Standard	kg/ km	1621	974
b)	Minimum	kg/	1589	954

ANNEXURE-E

Sl.	Description	Unit	ACSR ZEBRA	ACSR PANTHER
		km		
c)	Maximum	kg/ km	1653	993
5.13	Modulus of Elasticity	Kg/sq .mm		8158
5.14	Co-efficient of Linear Expansion	Per Deg. C	$19.3x10^{-6}$	$17.8x10^{-6}$
5.15	Minimum Corona Extinction Voltage	KV (rms)	154	92
5.16	RIV at 1 Mhz	Micro volts	Less than 1000 at 154 kV (rms)	Less than 500 at 92 kV (rms)
6.0	**Drum Dimensions**		Generally conforms to IS:1778	
a)	Flange Diameter	mm	1850	1850
b)	Traverse width	mm	925	925
c)	Barrel Diameter	mm	650	650
d)	Flange thickness	mm	50x50	50x50

1.2 Guaranteed technical particulars of Galvanised Steel Earthwire

	Description	Unit	Standard Values
1.0	**Raw Materials**		
1.1	**Steel wires / rods**		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04
e)	Silicon	%	0.15 to 0.35
1.2	**Zinc**		
a)	Minimum purity of Zinc	%	99.95
2.0	**Steel strands**		
2.1	**Diameter**		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.74
c)	Minimum	mm	3.58
2.2.	**Minimum breaking load of strand**		
a)	After stranding	KN	10.58
2.3	**Galvanising**		
a)	Minimum weight of zinc coating per sq.m. after stranding	gms.	275
b)	Minimum number of dips that the galvanized strand can withstand	Nos.	3 dips of 1 minute and

	in the standard preece test		one dip of ½ minute
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	Nos.	18
3.0	**Stranded Earth wire**		
3.1	**UTS of Earth wire**	KN	68.4 (min.)
3.2	**Lay length of outer steel layer**		
a)	Standard	mm	181
b)	Maximum	mm	198
c)	Minimum	mm	165
3.3	**Maximum DC resistance of earth wire at 20^0 C**	Ohm/km	3.375
3.4	**Standard length of earth wire**	M	2000 or actual quantity whichever is less.
3.5	**Tolerance on standard length**	%	±5
3.6	**Direction of lay for outside layer**		Right hand
3.7	**Linear mass**		
a)	Standard	Kg/km	583
b)	Maximum	Kg/km	552
c)	Minimum	Kg/km	600
3.8	**Overall diameter**	mm	10.98

1.3 Guaranteed Technical Parameters of Aluminum Tube

A. GTP for 3" IPS & 4" IPS AL. TUBE

Sl. No.	Description	3" AL. TUBE	4" AL. TUBE
1.	Size	3" IPS (EH Type)	4" IPS (EH Type)
2.	Material	Aluminium Alloy 6101 T6 confirms to 63401 WP (range 2) of IS 5082 : 1998	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	88.90 mm	114.2 mm
5.	Tolerance on outer diameter	+2.2 mm, - 0.0 mm	+2.2 mm, - 0.0 mm
6.	Thickness	7.62 mm	8.51 mm
7.	Tolerance on thickness	+2.2 mm, - 0.0 mm	+2.2 mm, - 0.0 mm
8.	Cross-sectional area	1945.76 sq.mm	2825.61 sq.mm
9.	Weight	5.25 kg/m	7.7 kg/m
10.	Moment of Inertia	1621589.99 mm^4	3972577.97 mm^4
11.	Section Modulus	36481.21 mm^3	69572.29 mm^3

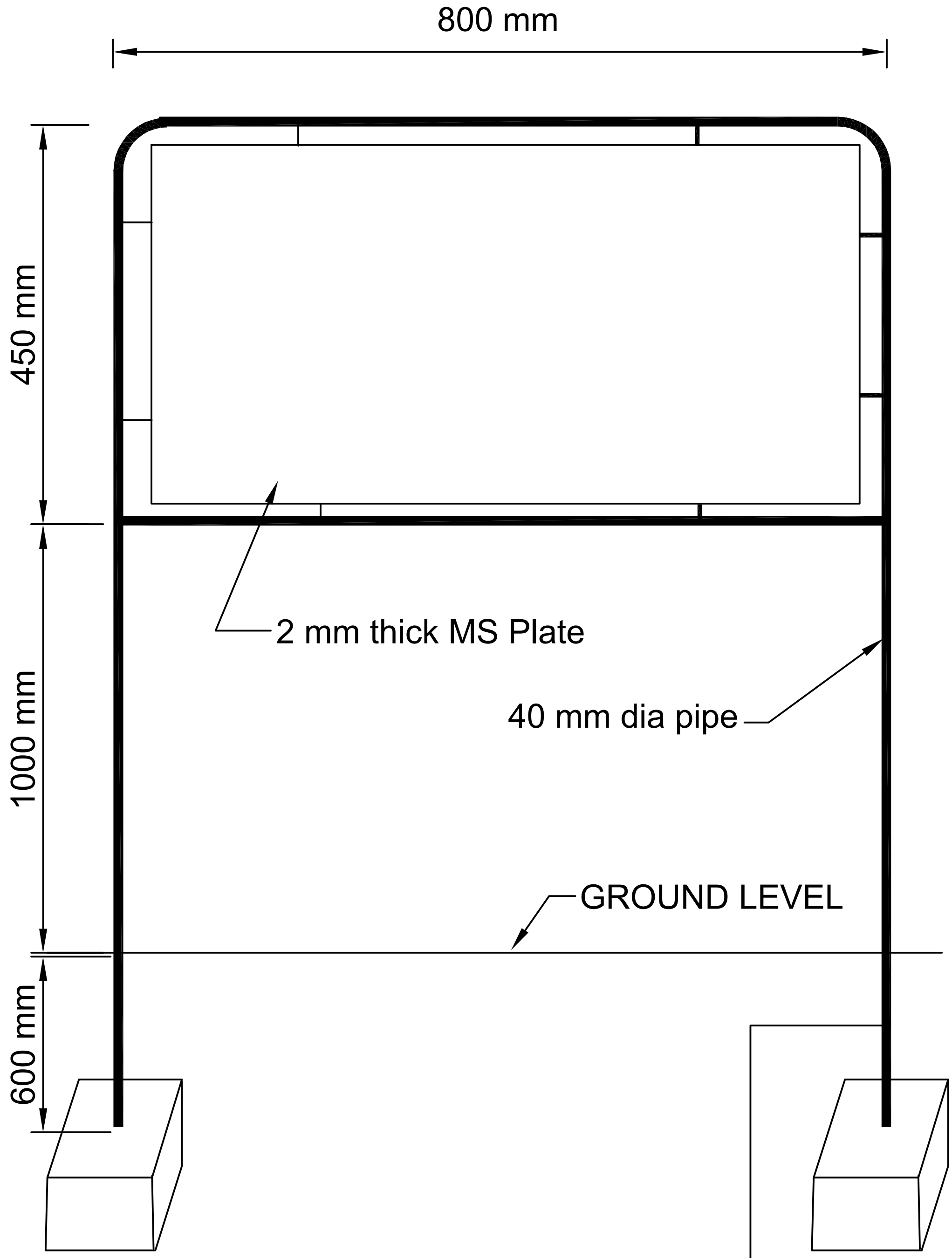
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50 mm	10%	
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	17.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	20.42 Kg/sq.mm	20.42 Kg/sq.mm

B. GTP for 4.5” IPS & 5” IPS AL. TUBE

Sl. No.	Description	4.5” AL. TUBE	5” AL. TUBE
1.	Size	4.5" IPS (EH Type)	5" IPS
2.	Material	Aluminium Alloy 6101 T6 confirms to 63401 WP (range 2) of IS 5082 : 1998	
3.	Chemical Composition		
i)	Cu	0.05 Max	
ii)	Mg	0.4 to 0.9	
iii)	Si	0.3 to 0.7	
iv)	Fe	0.5 Max	
v)	Mn	0.03 Max	
Vi)	Al	Remainder	
4.	Outer diameter	120.0 mm	141.3 mm
5.	Tolerance on outer diameter	+1.5 mm, - 0.0 mm	+2.8 mm, - 0.0 mm
6.	Thickness	12.0 mm	9.53 mm
7.	Tolerance on thickness	+1.0 mm, - 0.0 mm	+0.8 mm, - 0.0 mm
8.	Cross-sectional area	4071.50 sq.mm	3945.11 sq.mm
9.	Weight	10.993 kg/m	10.652 kg/m
10.	Moment of Inertia	6011958.58 mm^4	8610787.65 mm^4
11.	Section Modulus	100199.31 mm^3	121879.51 mm^3
12.	Minimum Ultimate Tensile Strength	20.5 Kg/sq.mm	
13.	Temperature co-efficient of resistance	0.00364 per Deg.C	
14.	Minimum Electrical Conductivity at 20 deg.C	55% of IACS	
15.	Linear Temperature Co-efficient of Expansion (20 Deg.C -200 Deg.C)	0.000023	
16.	Modulus of Elasticity	6700 Kg/sq.mm	
17.	Minimum Elongation on 50	10%	

ANNEXURE-E

	mm		
18.	Thermal Conductivity at 100 Deg.C	0.43 Calories/sec/sq.mm/cm/deg.C	
19.	Minimum 0.2% proof stress	17.34 Kg/sq.mm	
20	Minimum Yield point	14.50 Kg/sq.mm	17.50 Kg/sq.mm
21	Minimum Breaking Strength	17.50 Kg/sq.mm	20.42 Kg/sq.mm



NOTE : DIMENSIONS ARE INDICATIVE ONLY.
IT MAY VARY AS PER SITE REQUIREMENT.

POWER GRID CORPORATION
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PROJECT :- STANDARD

TITLE:- STANDARD BAY NAME PLATE

K.K.Parkar	K.K.Parkar	18/ 02/ 2008	Drawing No.: C/ ENG/ STD/ BAY NAME PLATE	Rev. 00
CKD BY	PRPD BY	Date		

GENERAL INSTRUCTION FOR EARTHING:

1. Location of earthing conductors / risers shown in the earthing drawing may change to suit the site condition.
2. Two different risers of one structure/equipment shall be connected to different conductors of main earthmat.
3. Earthing conductor around the building shall be burried at a minimum distance of 1500 mm from the outer boundary of the building.
4. Minimum distance of 6000 mm shall be maintained between two treated (pipe) electrode.
5. For surge arrester, earthing lead from surge counter to to main earthmat shall be shortest in length as pratically as possible. Earthing lead from surge arrester shall not be passed through any pipe.
6. No welding is allowed in the over ground earthing leads/risers if the length is less than 6m .

RELEASED FOR CONTRUCTION

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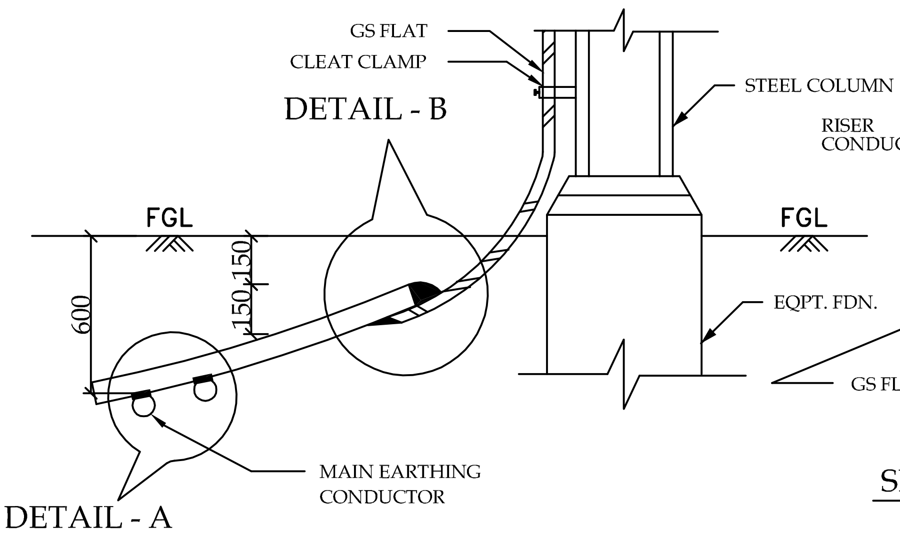
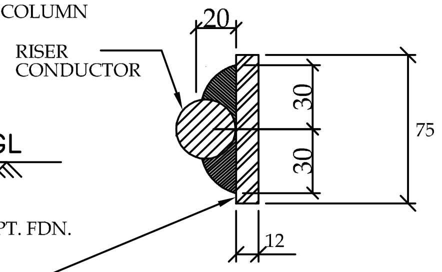
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

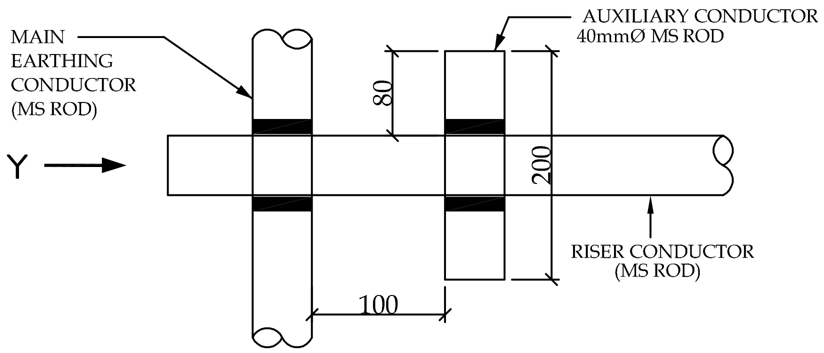
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 1



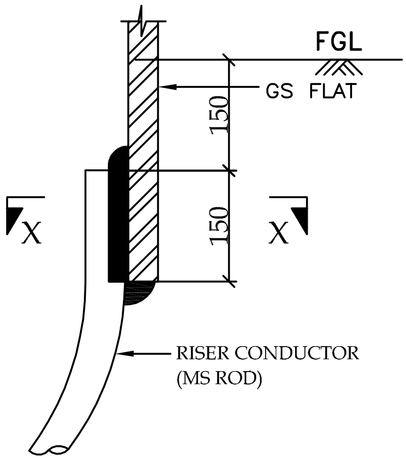


SECTION X - X

TYPICAL DETAILS OF RISER

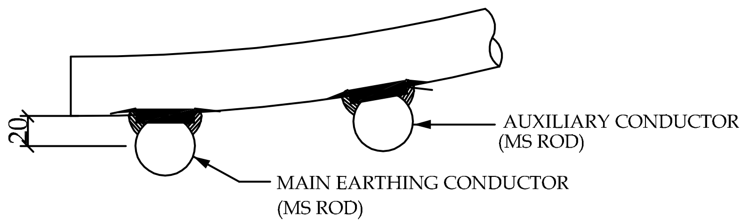


PLAN



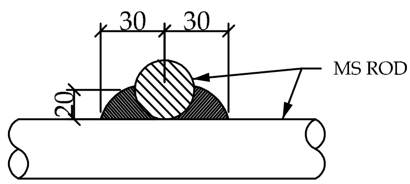
ELEVATION

DETAIL - B



ELEVATION

DETAIL - A



VIEW - Y

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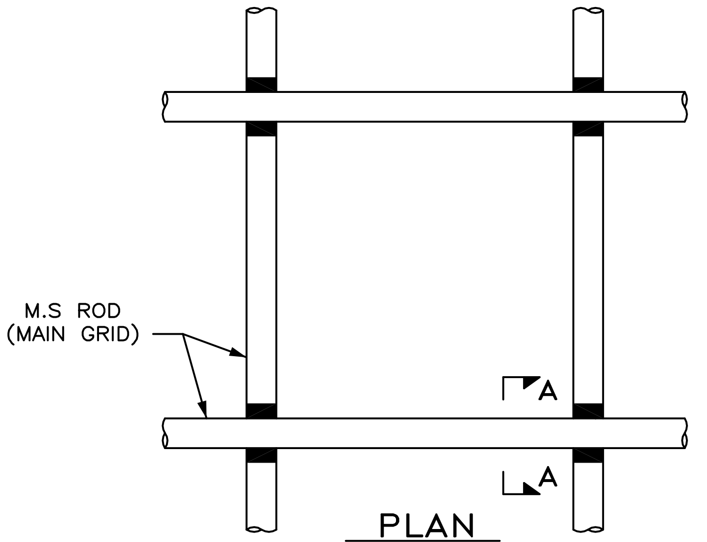
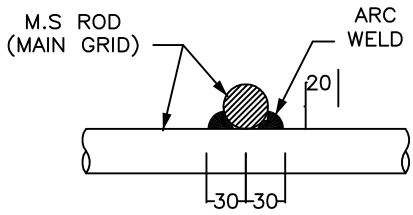
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 2
CKD BY	PRPD BY	Date	

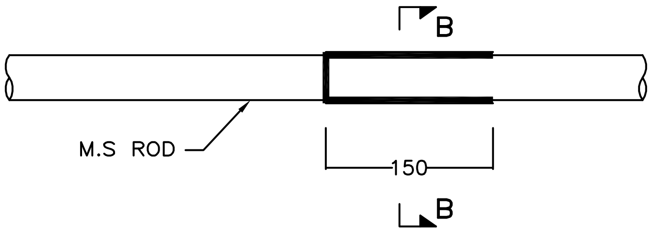


PLAN



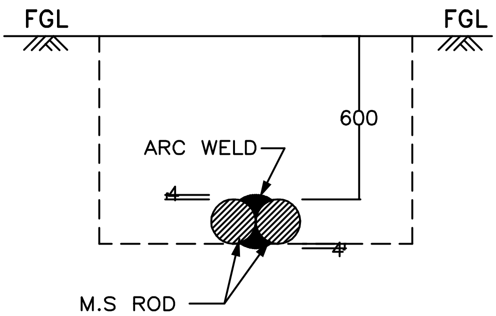
SECTION A – A

DETAIL OF CROSS JOINT

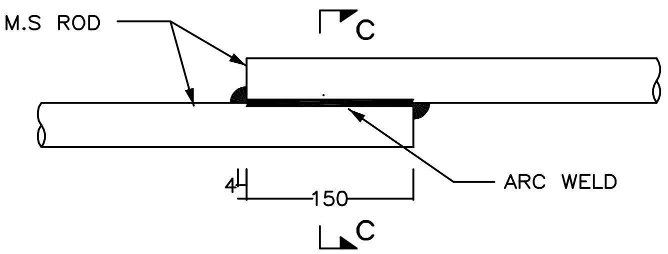


ELEVATION

(CONDUCTORS KEPT ON SIDES)

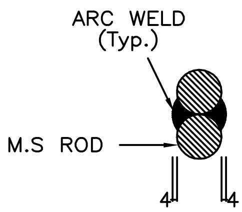


SECTION B – B



ELEVATION

(CONDUCTORS ONE ABOVE THE OTHER)



SECTION C – C

DETAIL OF LAP JOINT

RELEASED FOR CONTRUCTION

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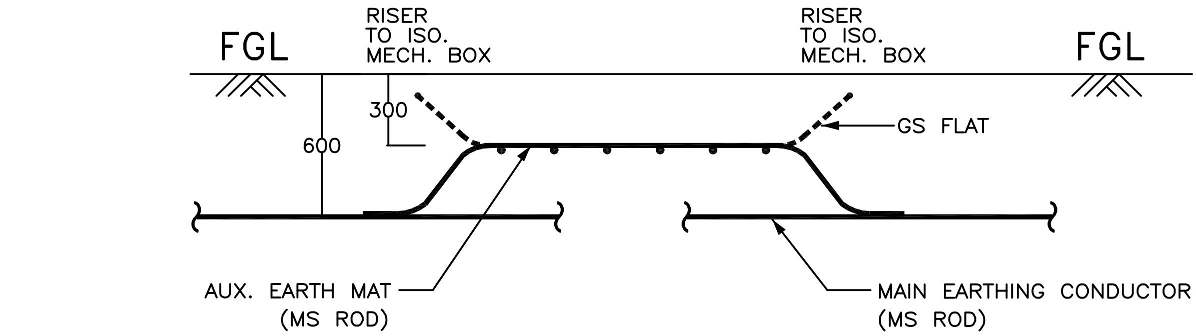
पावरग्रिड

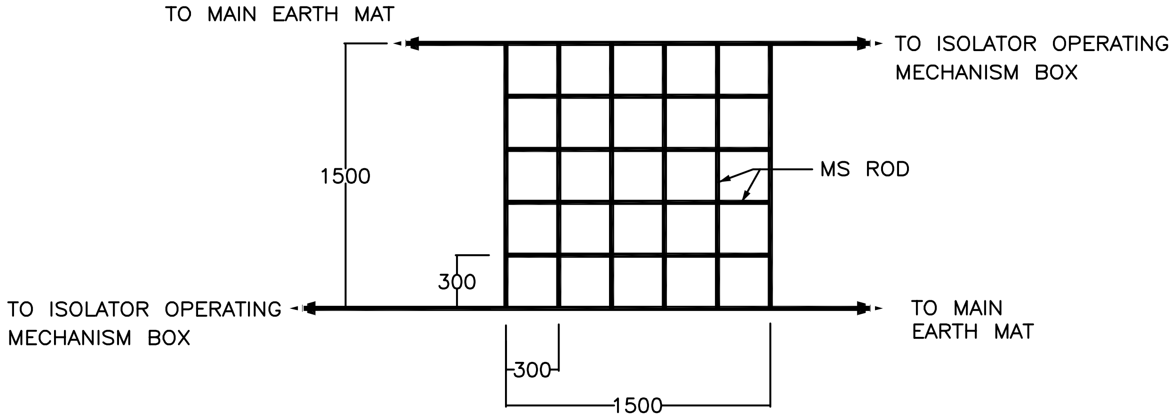
PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

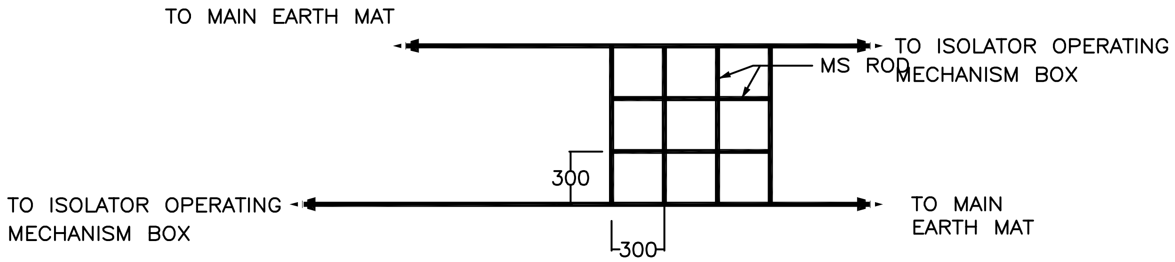
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 3
CKD BY	PRPD BY	Date	



ELEVATION



PLAN (For 220kV & above class isolators)



PLAN (For 132kV & below class isolators)

RELEASED FOR CONTRUCTION

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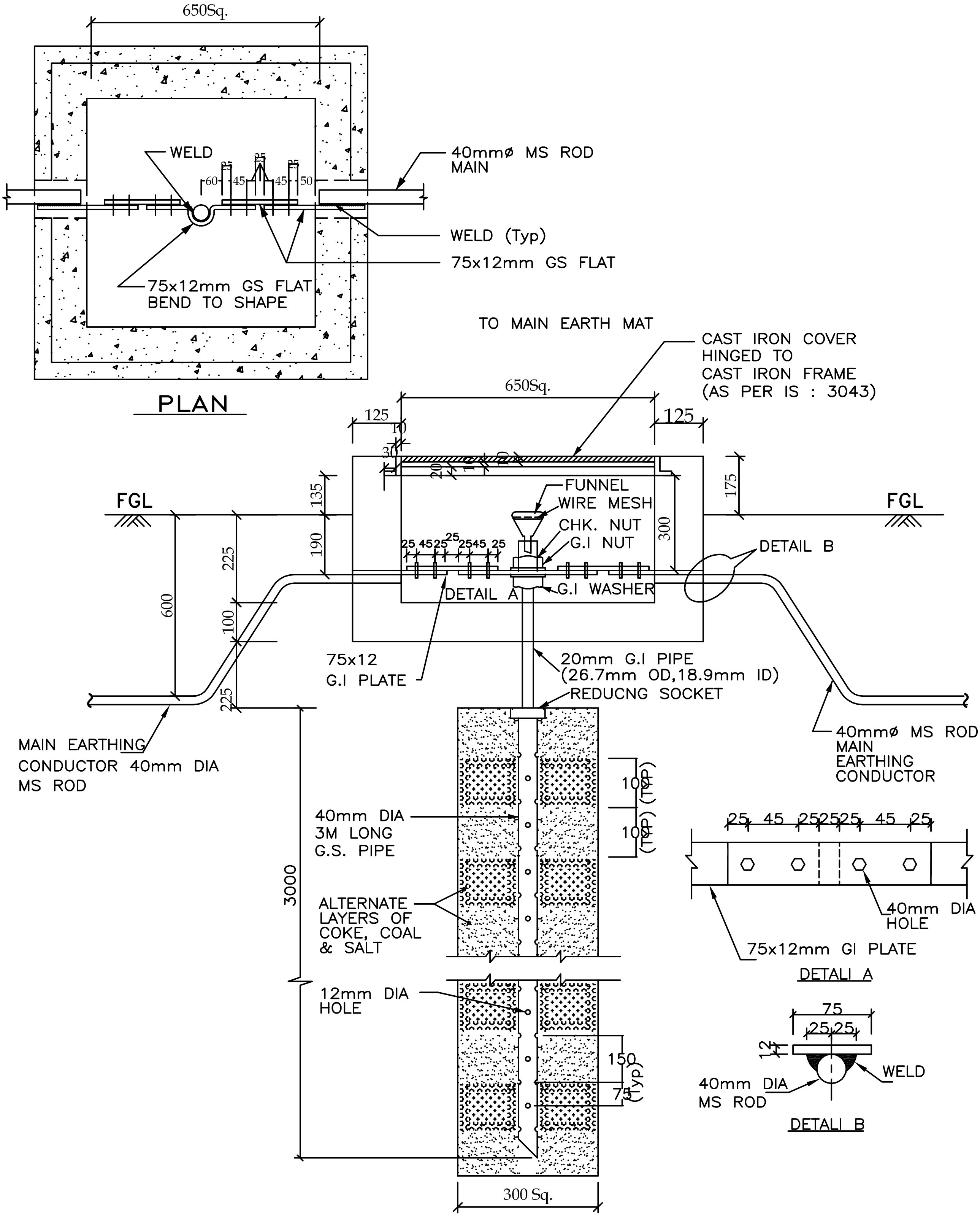
PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 4
CKD BY	PRPD BY	Date	



RELEASED FOR CONTRUCTION

POWER GRID CORPORATION
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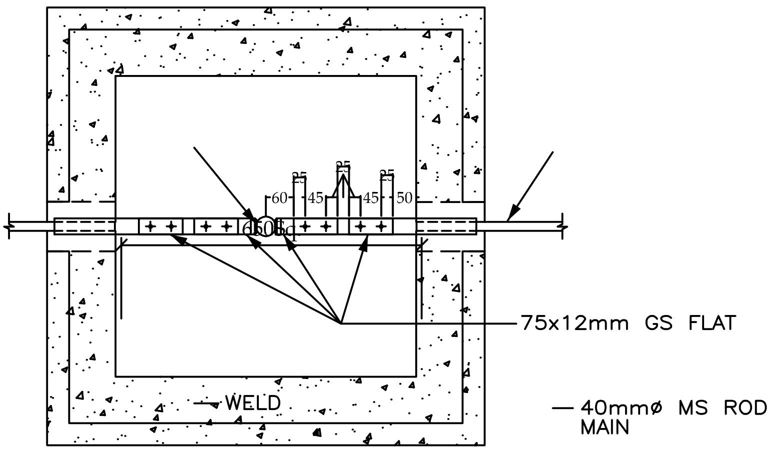
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

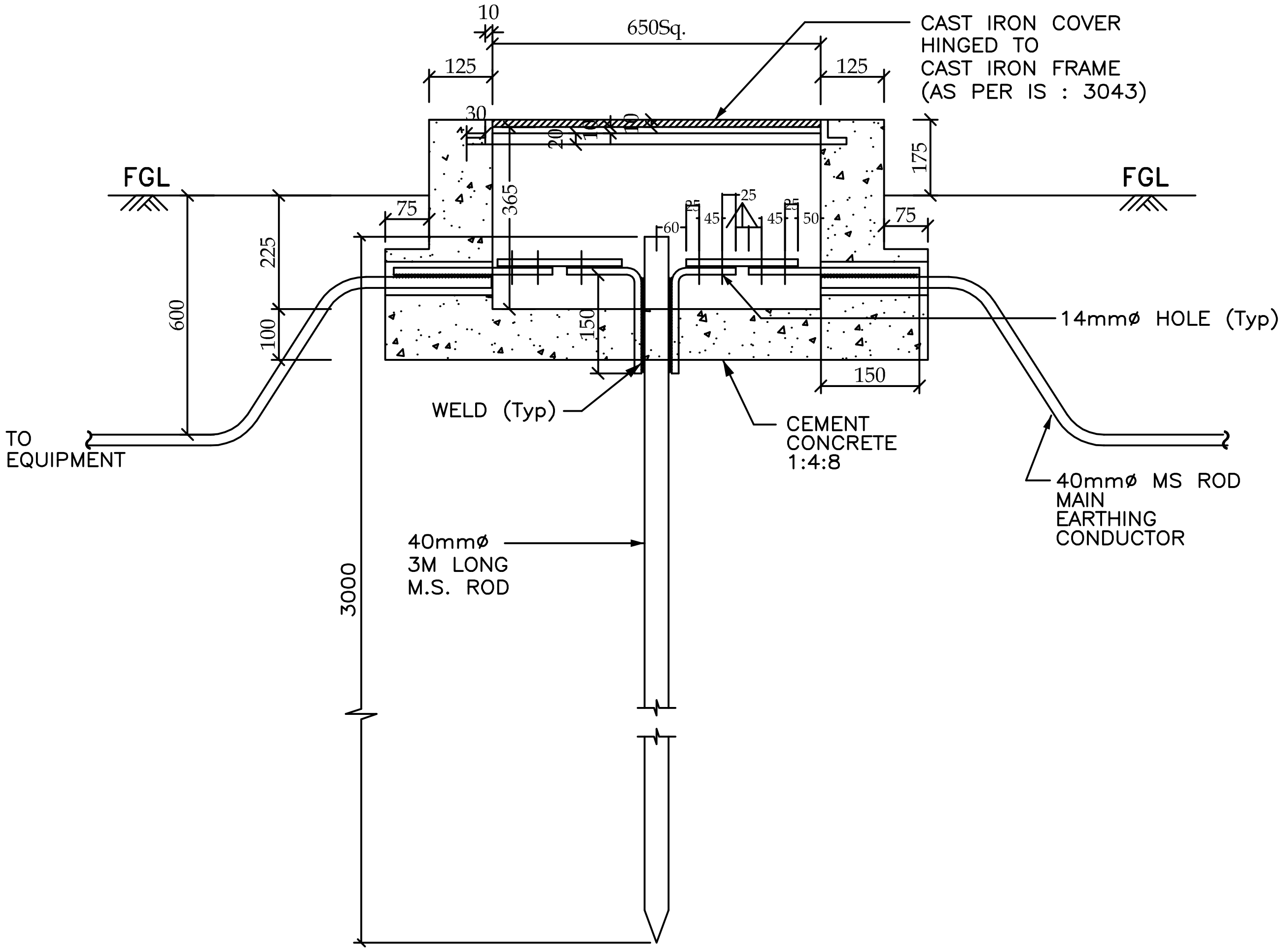
TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 5

ROD ELECTRODE WITH TEST LINK FOR LM, TOWER WITH PEAK, CVT, LA



PLAN



ELEVATION

RELEASED FOR CONTRUCTION

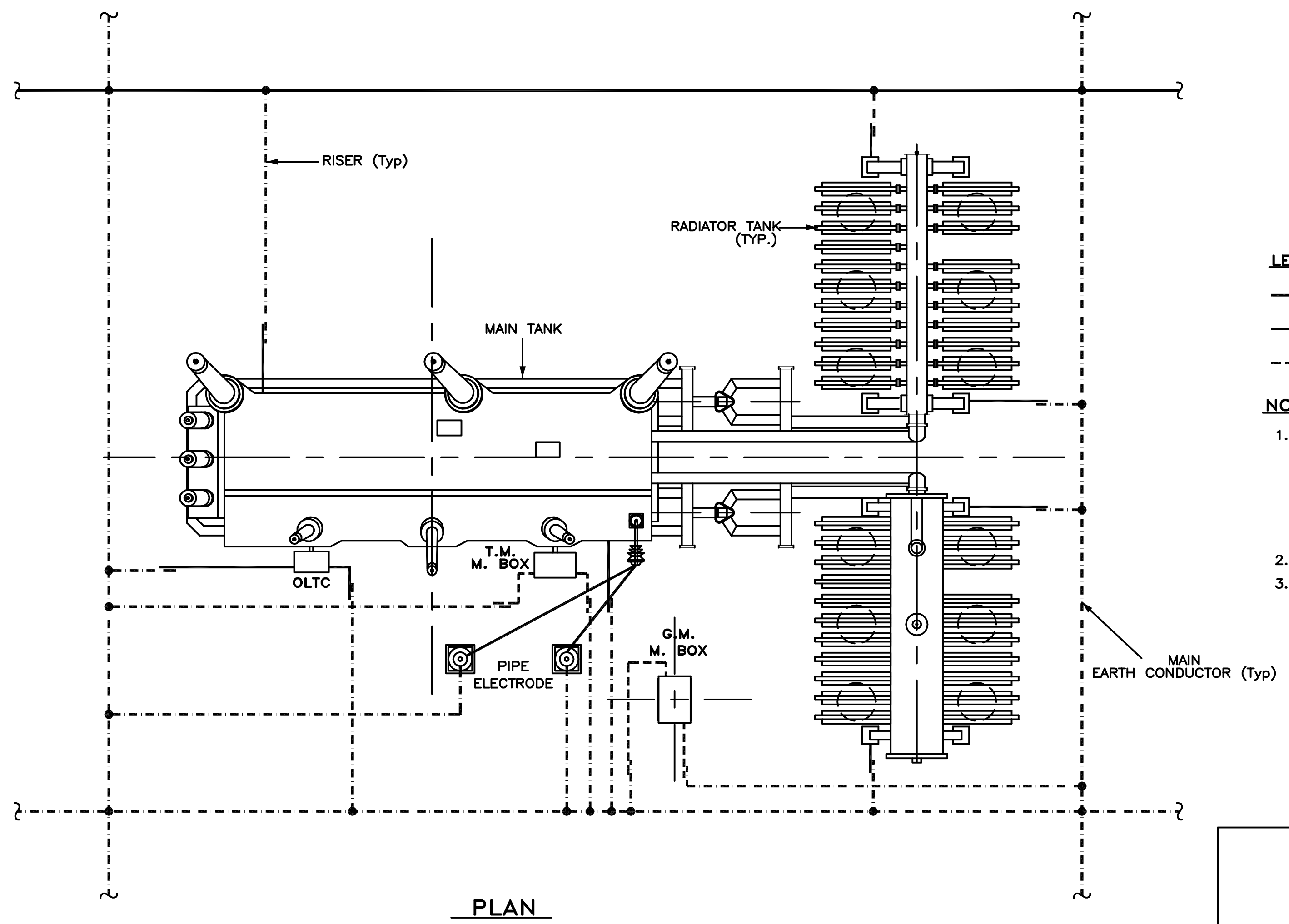
POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 6

EARTHING OF TRANSFORMER/ REACTOR



LEGEND

— · — · —	40mmø MS ROD
————	75 x 12 mm GS FLAT
- - - - - -	50 x 6 mm GS FLAT

NOTES :–

1. No. OF RISERS :–

MAIN TANK	–	2 Nos.
RADIATOR TANK	–	4 Nos.
OLTC	–	2 Nos. (ICT only)
M. BOX	–	2 Nos./M. BOX
NEUTRAL EARTH ELECTRODE	–	2 Nos.

2. No. OF PIPE ELECTRODE REQUIRED = 2 Nos.
3. PYLON SUPPORTS SHALL BE EARTHED TO THE MAIN EARTHING CONDUCTOR BY GS FLAT.

RELEASED FOR CONTRUCTION

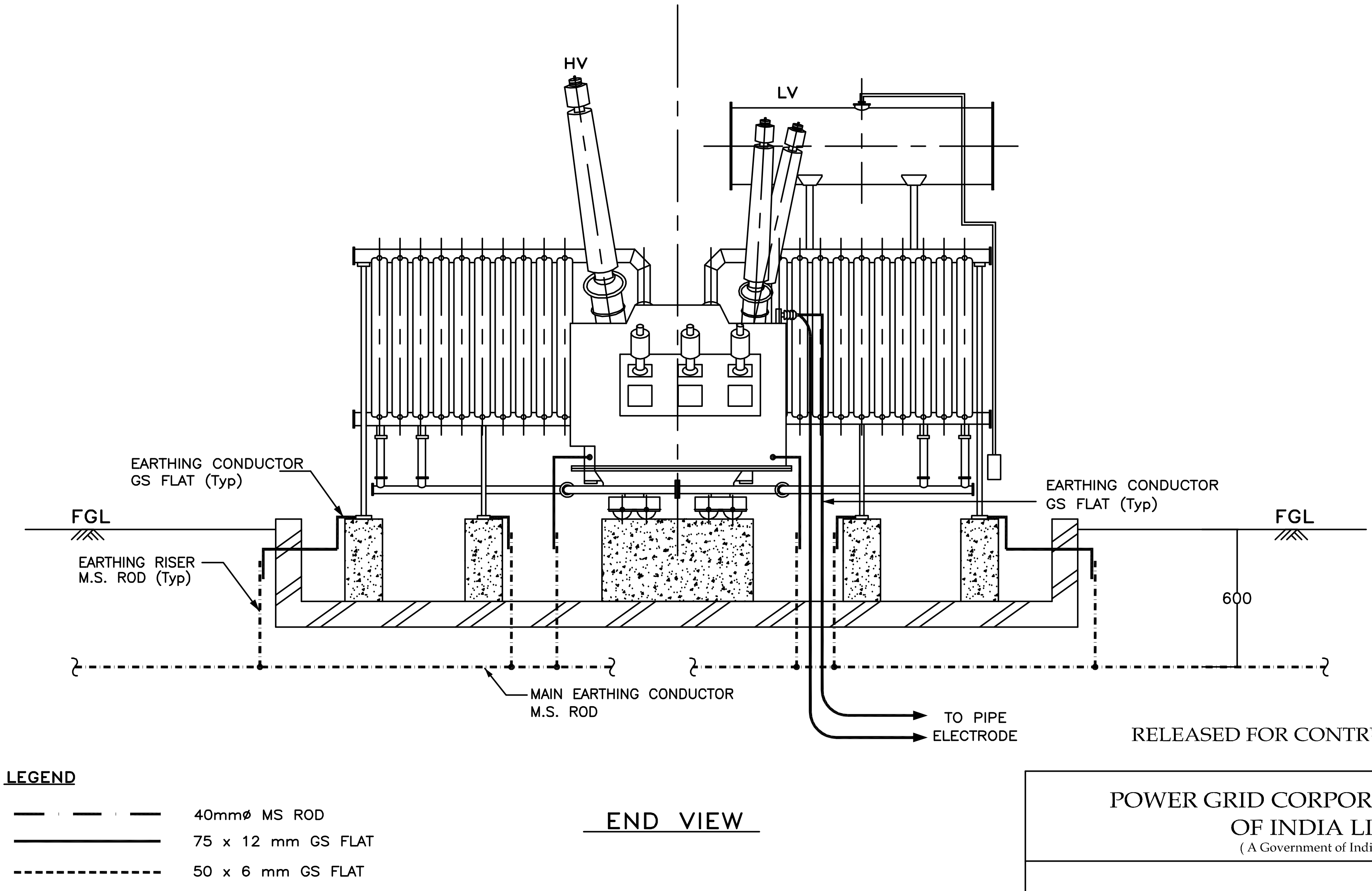
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 7
CKD BY	PRPD BY	Date	

EARTHING OF TRANSFORMER/ REACTOR

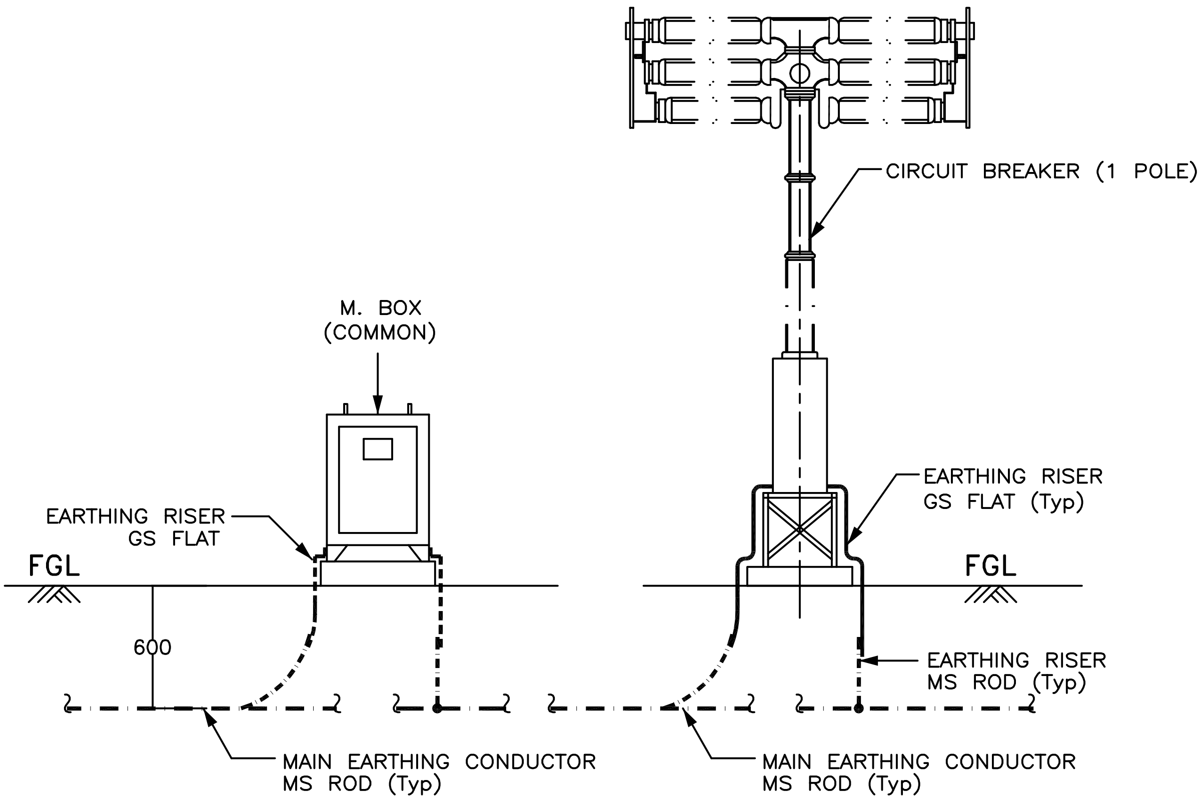


END VIEW

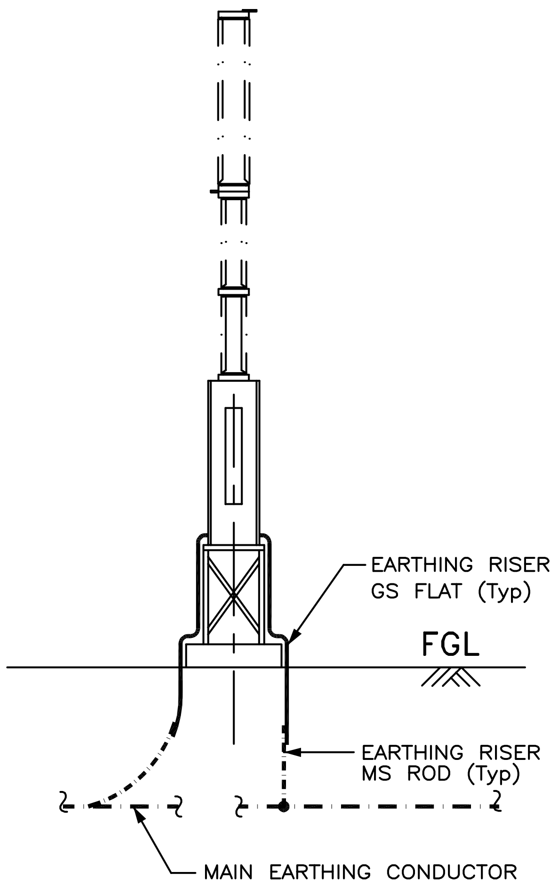
RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 8
CKD BY	PRPD BY	Date	

EARTHING OF CIRCUIT BREAKER



ELEVATION



NOTES :-

1. No. OF RISERS FOR CIRCUIT BREAKER = 2 Nos. / PHASE
1. No. OF RISERS FOR LADDER (IF Applicable) = 2 Nos.
2. No. OF RISERS FOR MAR. BOX = 2 Nos.
3. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

LEGEND

40mmø MS ROD

75 x 12 mm GS FLAT

50 x 6 mm GS FLAT

RELEASED FOR CONTRUCTION

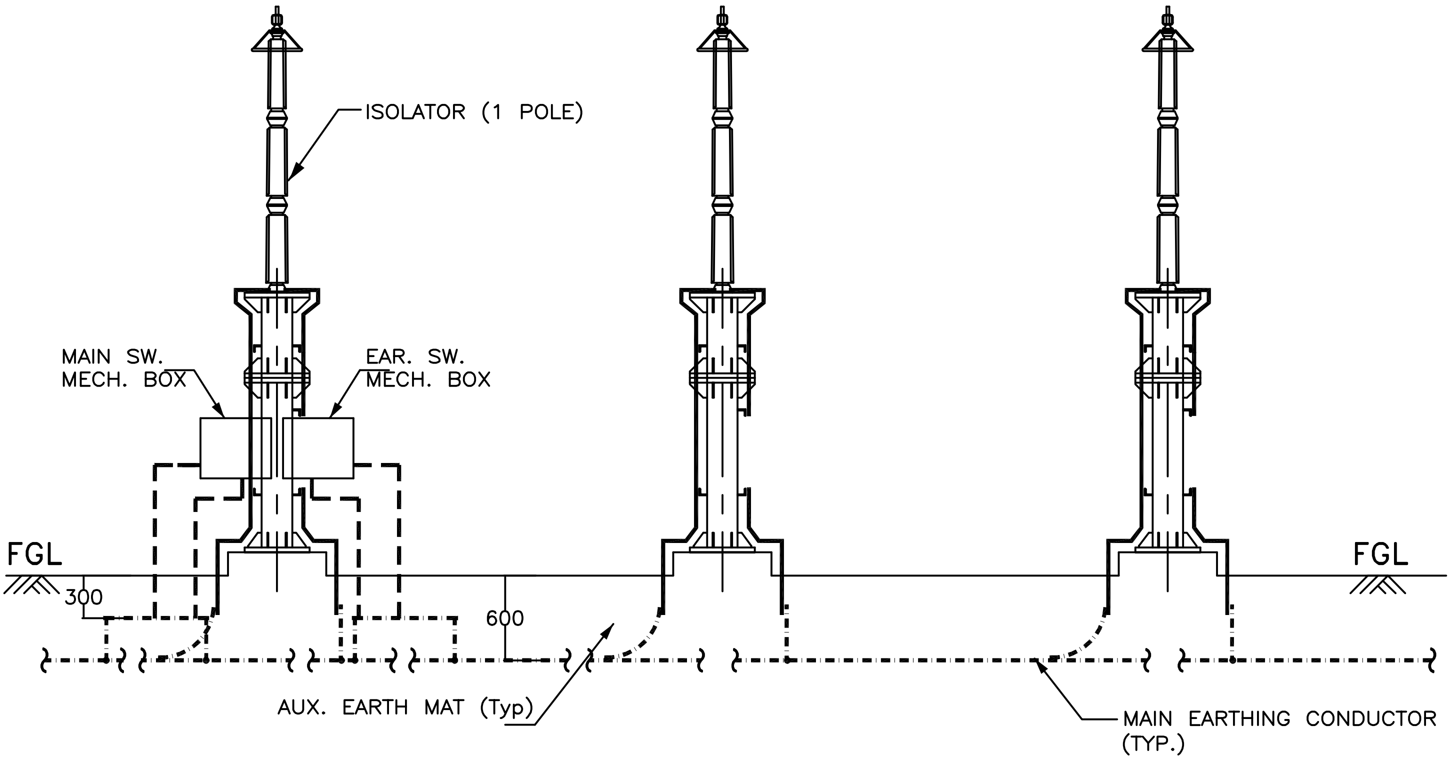
POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

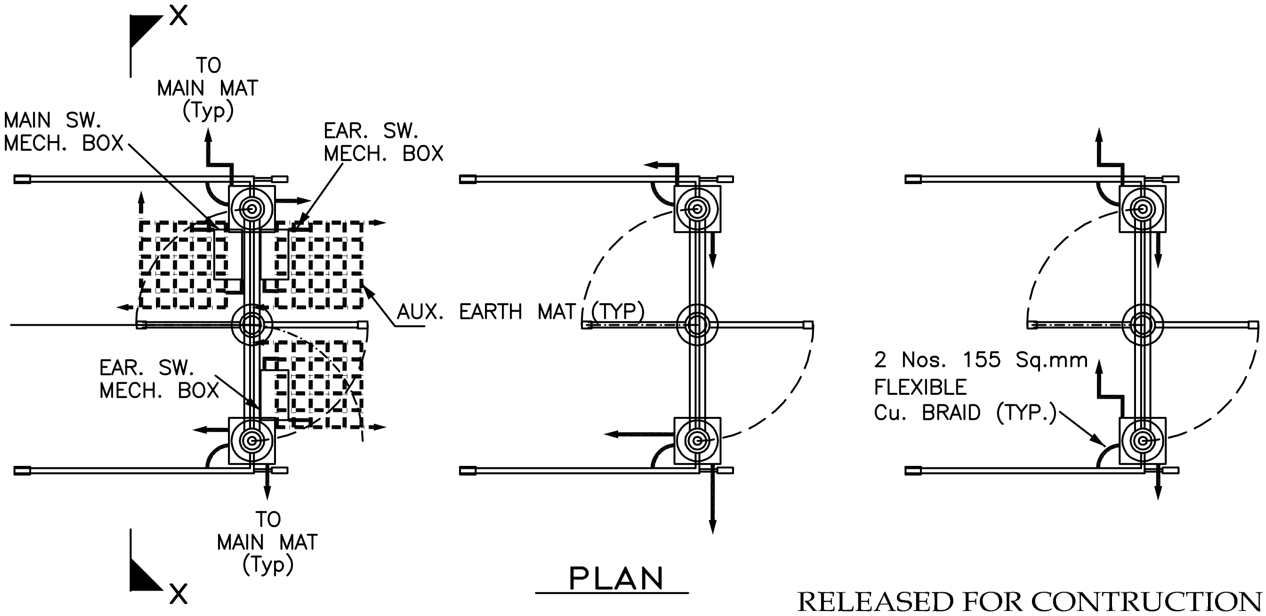
TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 9

EARTHING OF ISOLATOR



ELEVATION



PLAN

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

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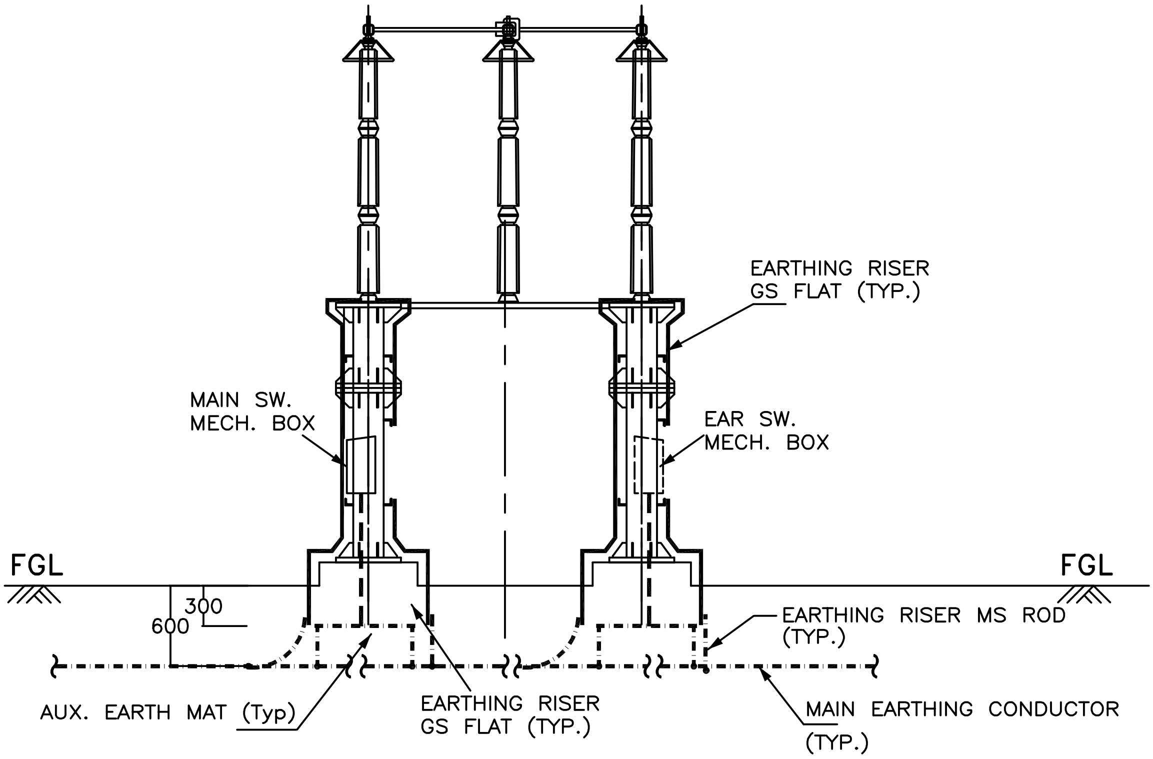
CKD BY	PRPD BY	Date	

EARTHING OF ISOLATOR (1 PH)



VIEW — X X

LEGEND

- 40mmø MS ROD
- 75 x 12 mm GS FLAT
- 50 x 6 mm GS FLAT

NOTES :—

1. No. OF RISERS FOR ISOLATOR = 4 Nos. / PHASE.
2. No. OF RISERS FOR MAIN MECH. BOX = 2 Nos.
3. No. OF RISERS FOR EARTH SW. MECH. BOX = 2 Nos. / BOX.
4. No. OF AUXILIARY EARTH MAT = 1 Nos. FOR EACH MB
5. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.
6. NO. OF AUX. EARTHMAT IS INDICATIVE ONLY. IT SHALL BE EXECUTED AS PER ACTUAL NUMBER/POSITION OF EARTH SWITCHES.

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POWER GRID CORPORATION
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PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
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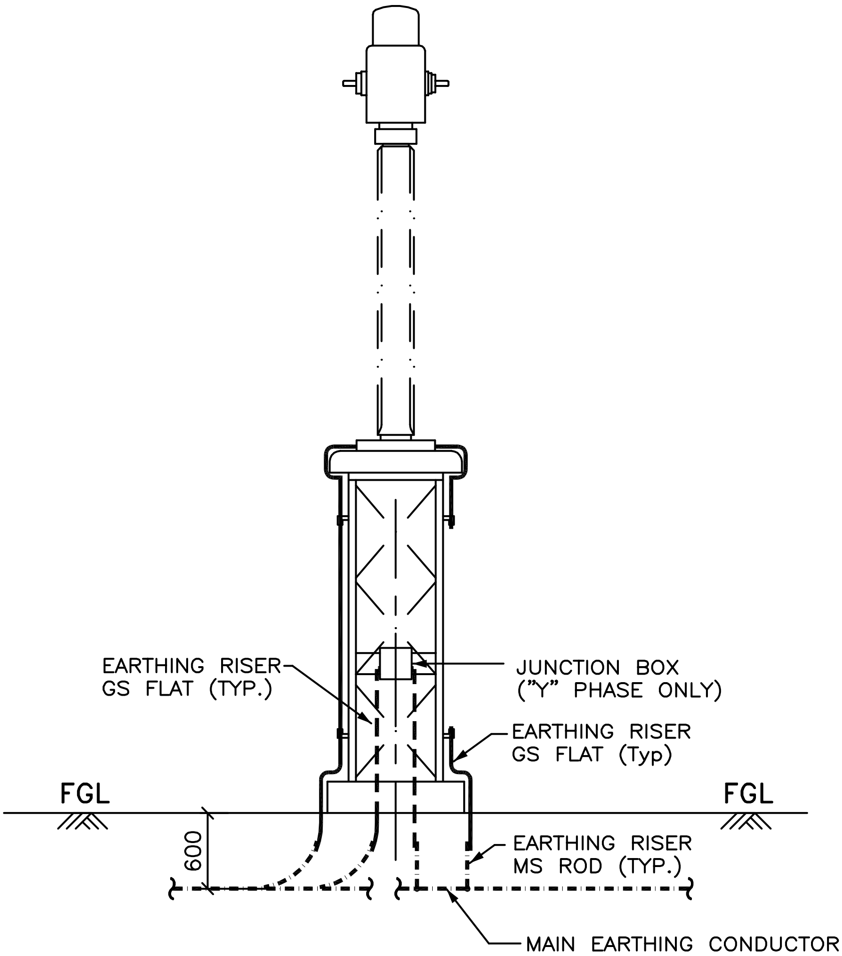
EARTHING OF CURRENT TRANSFORMER (1 PH)



ELEVATION

LEGEND

— · — · —	40mmø MS ROD
————	75 x 12 mm GS FLAT
- - - - - - -	50 x 6 mm GS FLAT

NOTES :-

1. No. OF RISERS = 2 Nos. / PHASE.
2. No. OF RISERS FOR JUN. BOX = 2 Nos.
3. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

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POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
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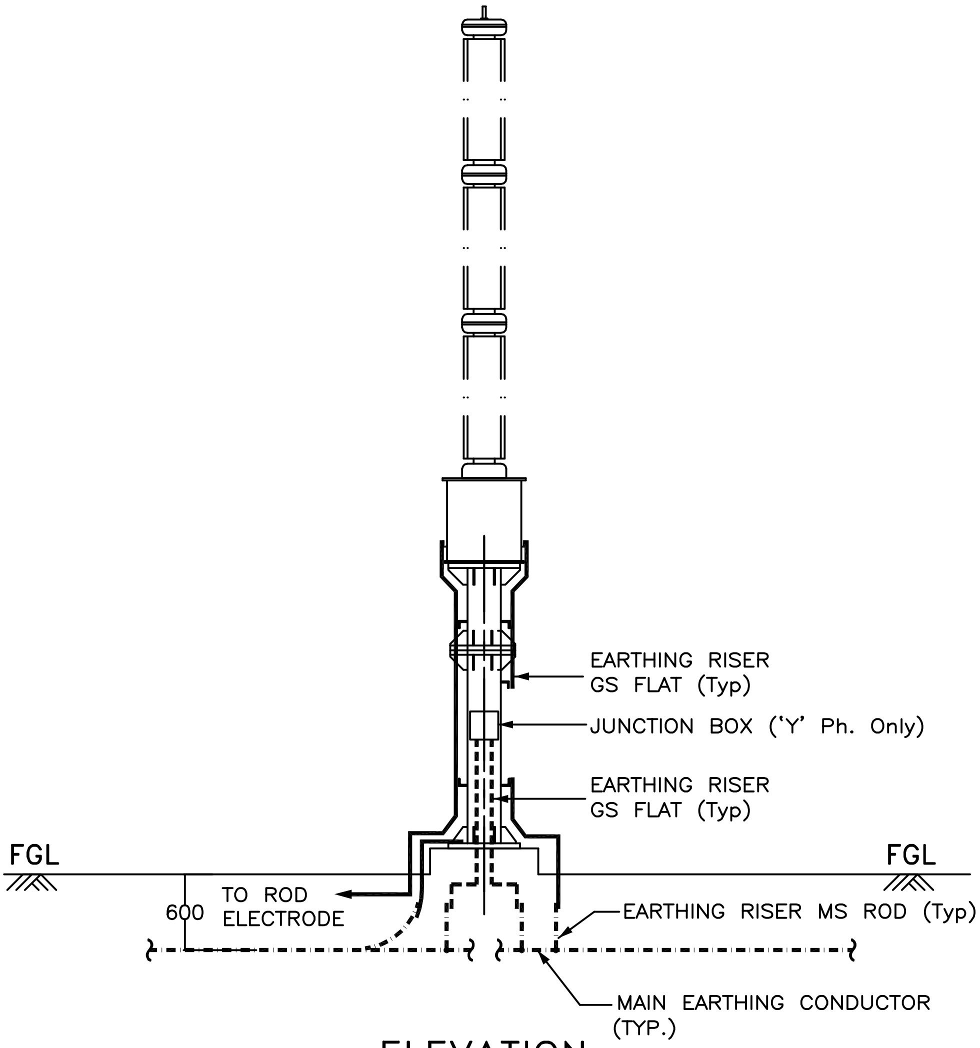
EARTHING OF CAPACITIVE VOLTAGE TRANSFORMER (1 PH)



ELEVATION

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT
- - - - -	50 x 6 mm GS FLAT

NOTES :–

1. No. OF RISERS = 3 Nos. / PHASE.
2. No. OF RISERS FOR J. BOX = 2 Nos.
3. No. OF ROD ELECTRODE REQUIRED = 1 No. / PHASE.
4. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

RELEASED FOR CONTRUCTION

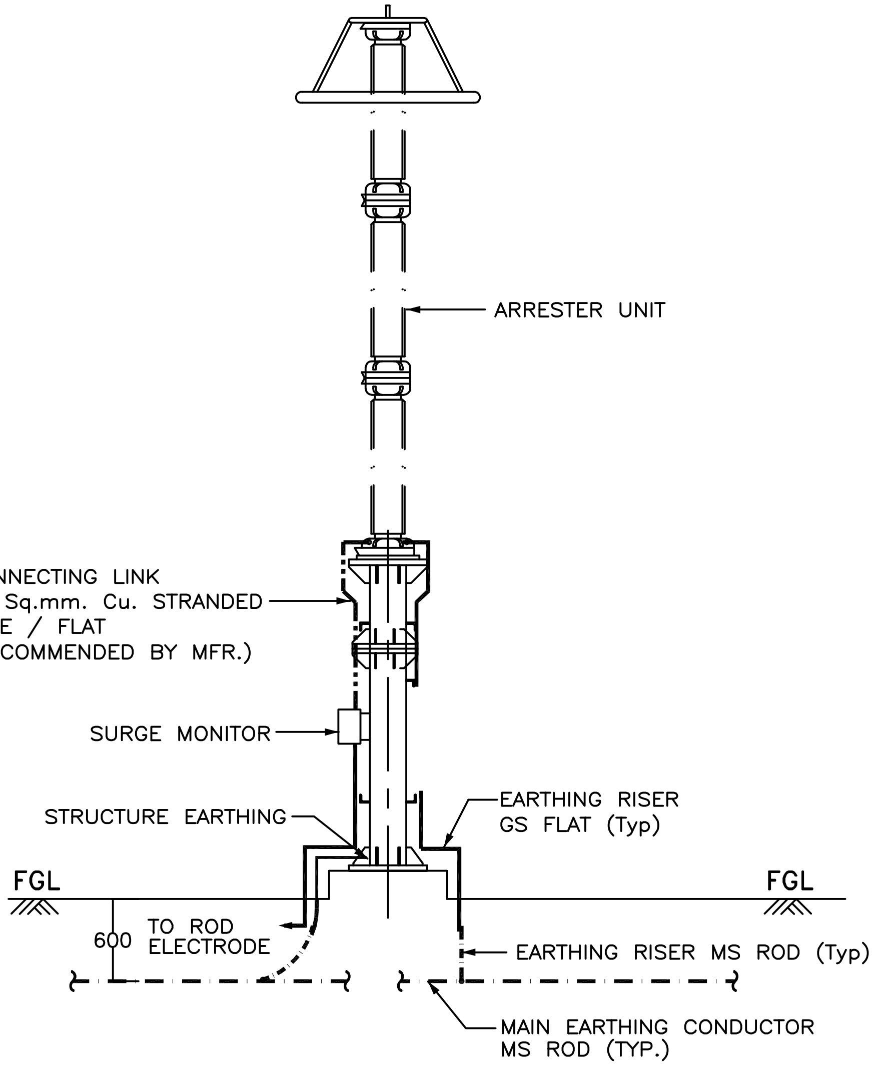
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 13

EARTHING OF SURGE ARRESTER (1PH)



ELEVATION

LEGEND

— · — · — 40mmø MS ROD

——— 75 x 12 mm GS FLAT

NOTES :–

1 . No. OF RISERS = 3 Nos. / PHASE.
2 . No. OF ROD ELECTRODE REQUIRED = 1 No. / PHASE.
3 . CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION
OF INDIA LIMITED
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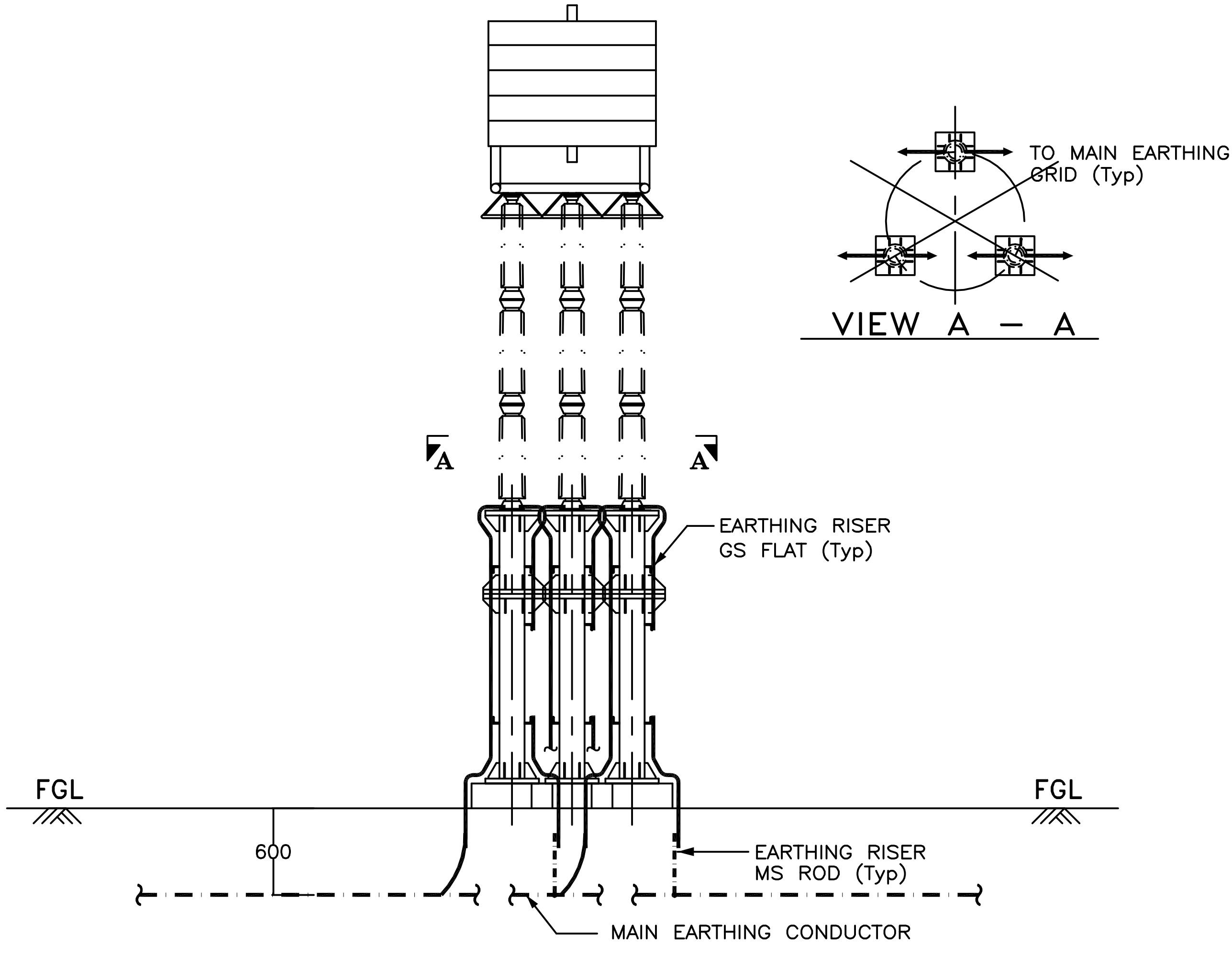
PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 14
CKD BY	PRPD BY	Date	

EARTHING OF WAVE TRAP (1PH)



ELEVATION

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT

NOTE :-

1. No. OF RISERS = 6 Nos. / PHASE.
2. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED
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पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

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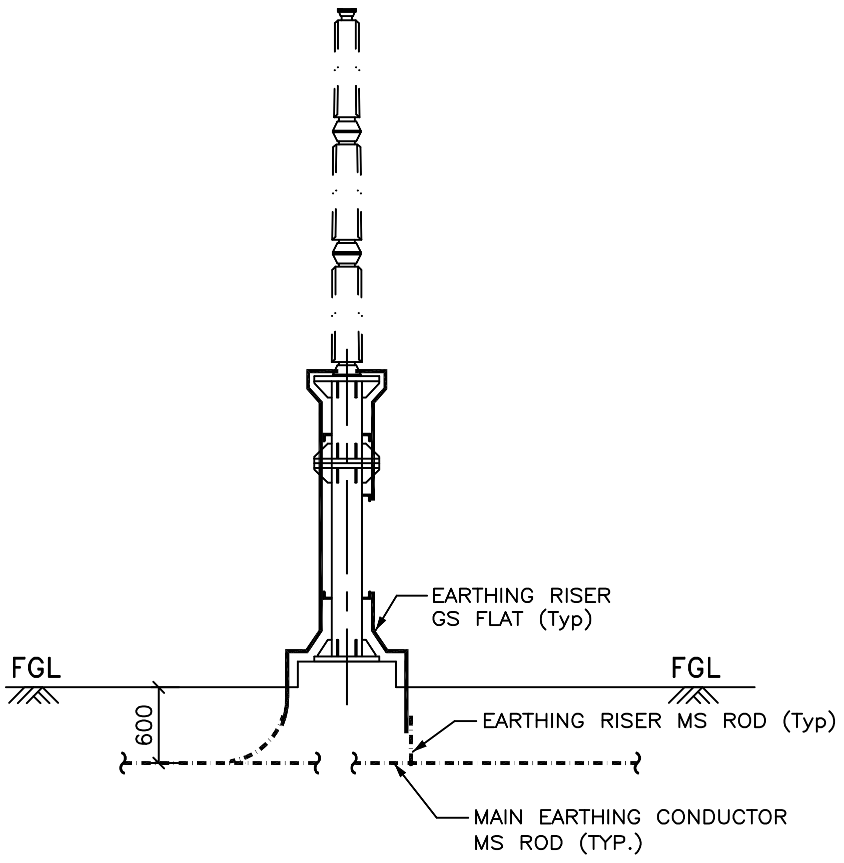
CKD BY	PRPD BY	Date	

EARTHING OF POST INSULATOR (1PH)



ELEVATION

LEGEND

— · — · —	40mmø MS ROD
————	75 x 12 mm GS FLAT

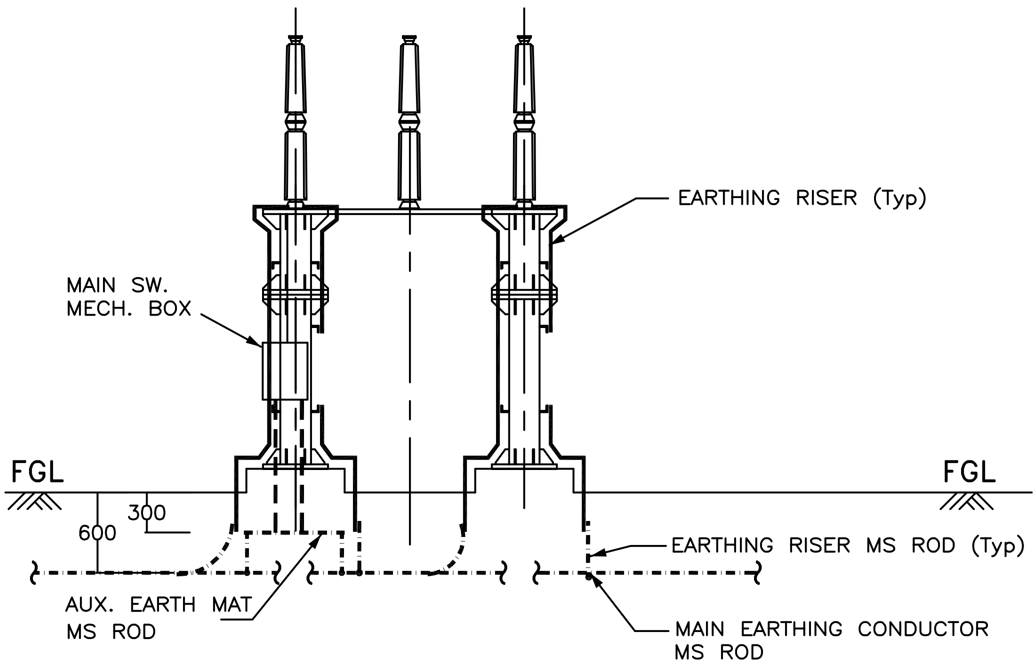
NOTES :-

1. No. OF RISERS = 2 Nos. / PHASE.
2. CLEAT CLAMP SHALL BE PROVIDED AT 1000mm INTERVAL.

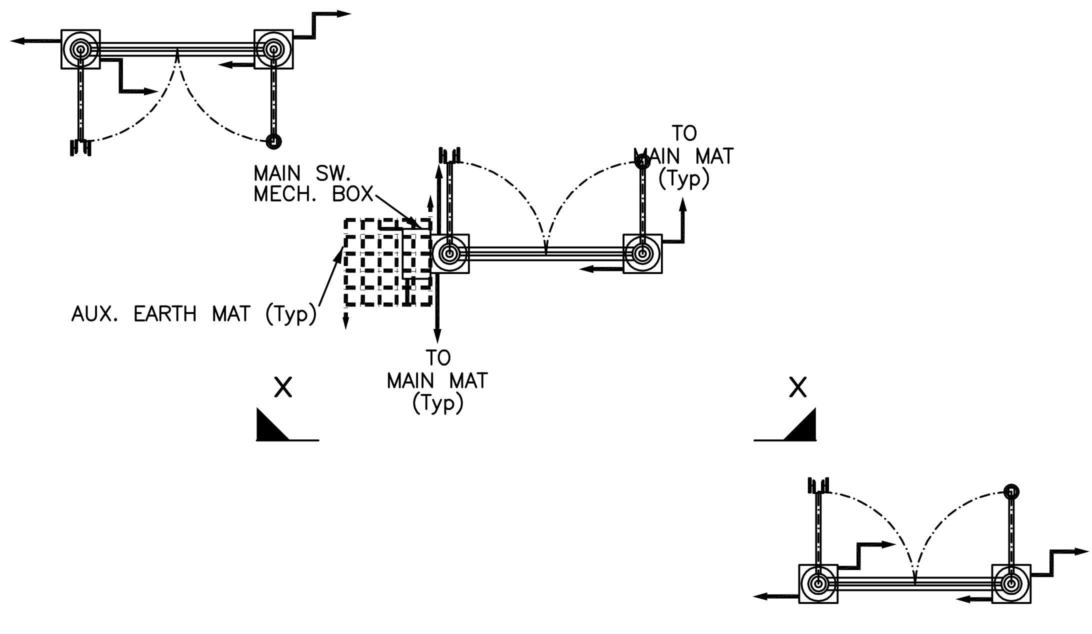
RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 16
CKD BY	PRPD BY	Date	

TANDEM ISOLATOR



VIEW — X X



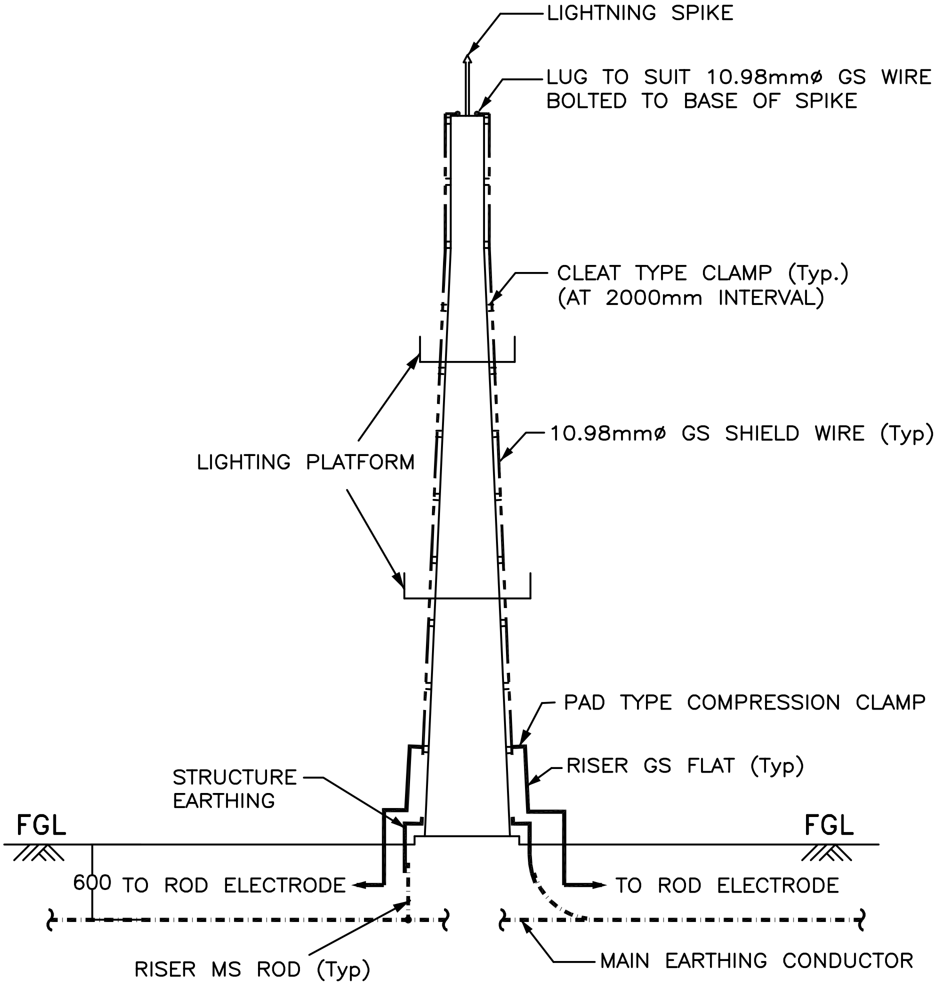
PLAN

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise)	पावरग्रिड
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION	
TITLE:- STANDARD EARTHING DETAILS	

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 17

EARTHING OF LIGHTNING MAST



ELEVATION

NOTES :-

1. No. OF RISERS = 4 Nos.
2. No. OF ROD ELECTRODE REQUIRED = 2 Nos.
3. No. OF PAD TYPE CLAMP = 2 Nos.

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
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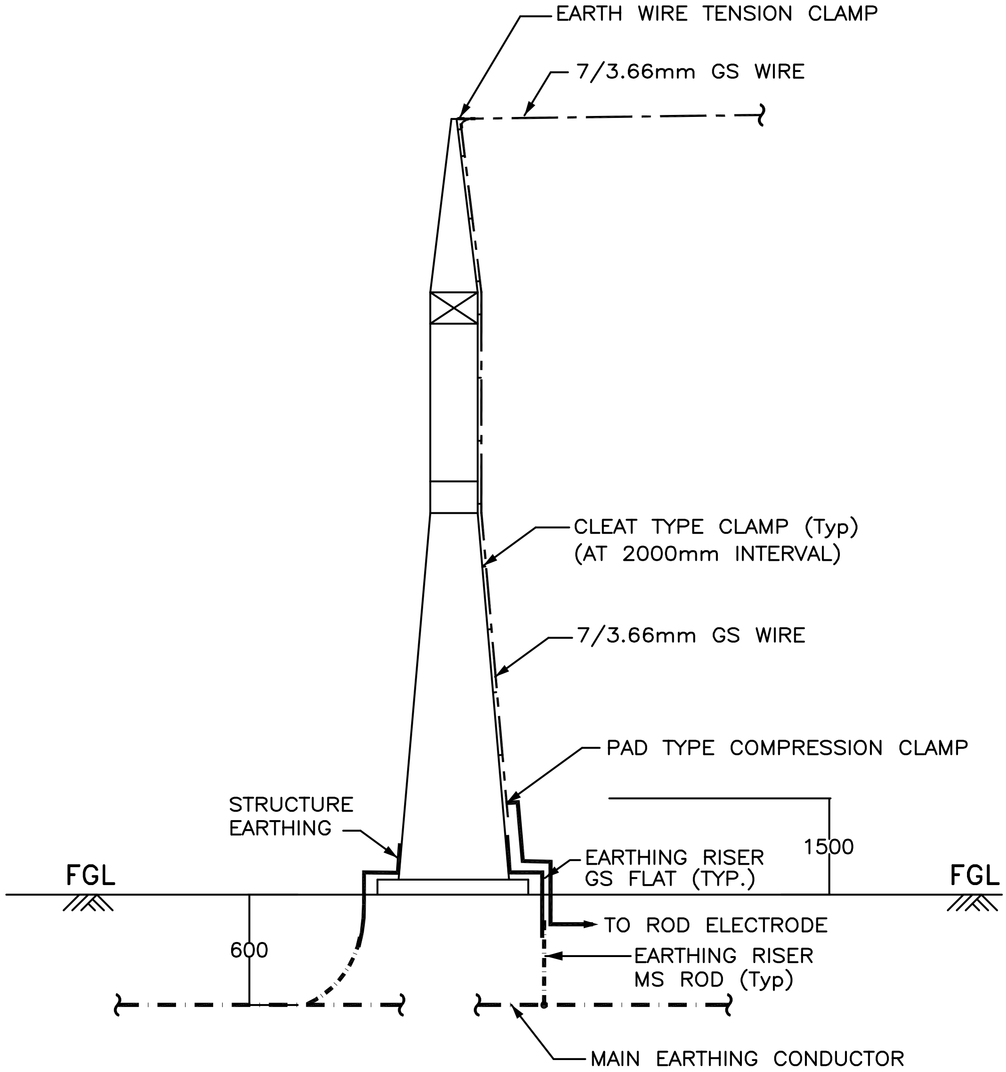
EARTHING OF TOWER WITH PEAK



ELEVATION

NOTES :-

1. No. OF RISERS = 3 Nos.
2. No. OF ROD ELECTRODE REQUIRED = 1 No.
3. No. OF PAD TYPE CLAMP = 1 No.

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT

RELEASED FOR CONTRUCTION

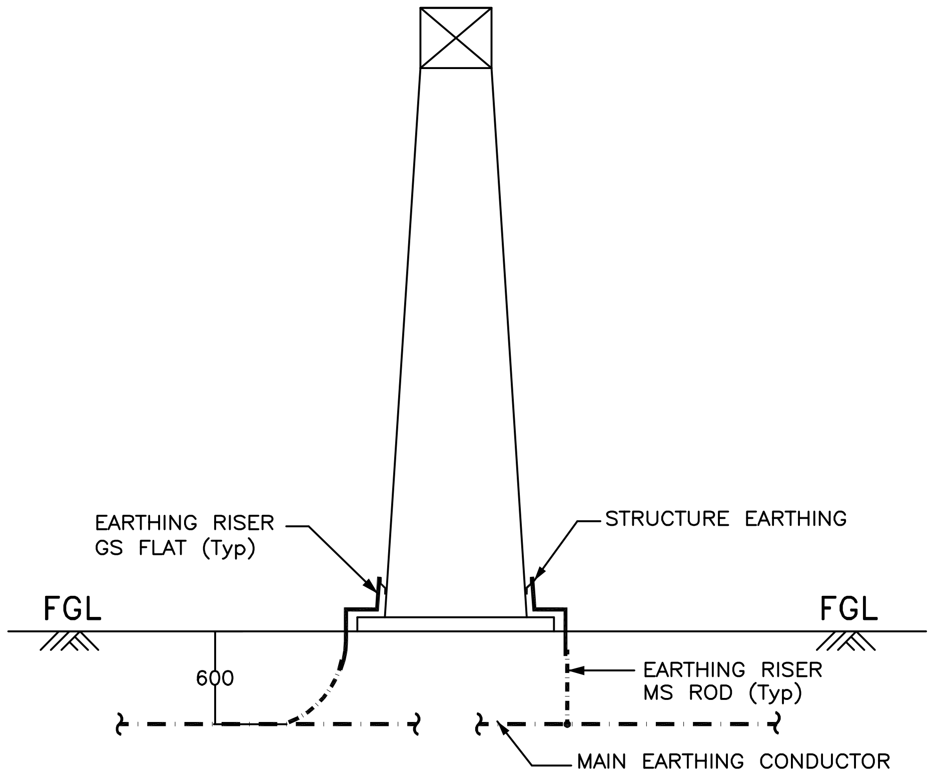
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 19

EARTHING OF TOWER WITHOUT PEAK



ELEVATION

LEGEND

— · — · — 40mmø MS ROD

——— 75 x 12 mm GS FLAT

NOTES :-

1. No. OF RISERS = 2 Nos.

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POWER GRID CORPORATION
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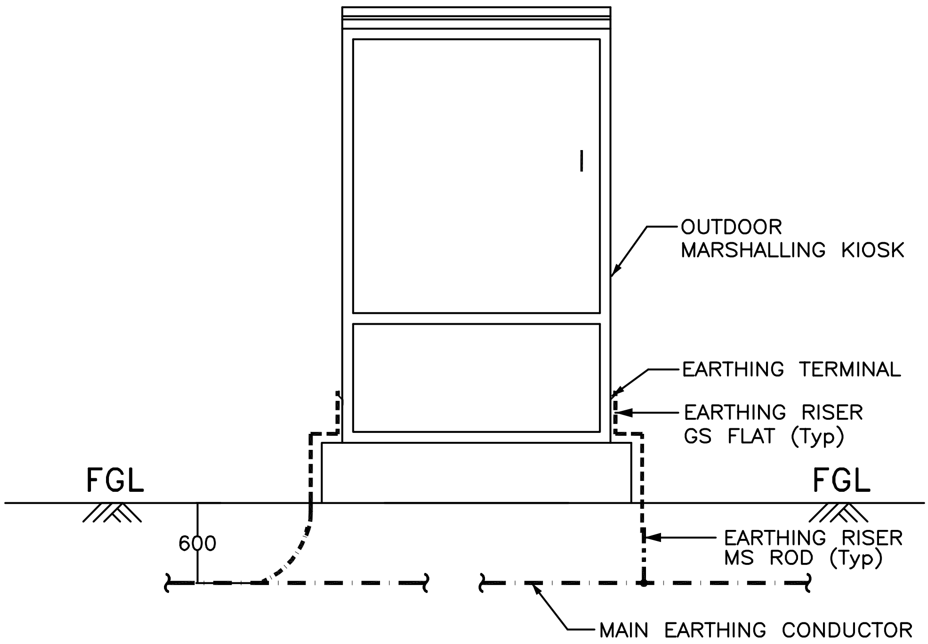
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 20
CKD BY	PRPD BY	Date	

EARTHING OF BAY MARSHALLING BOX



ELEVATION

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT
- - - - -	50 x 6 mm GS FLAT

NOTE :–

1. No. OF RISERS = 2 Nos.

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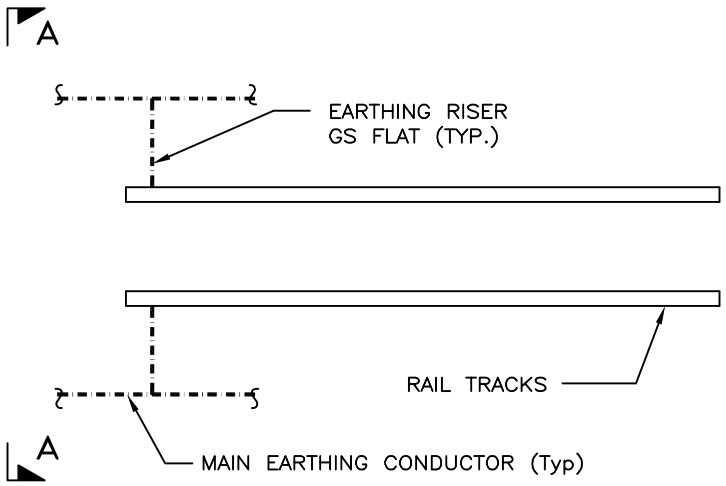
POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

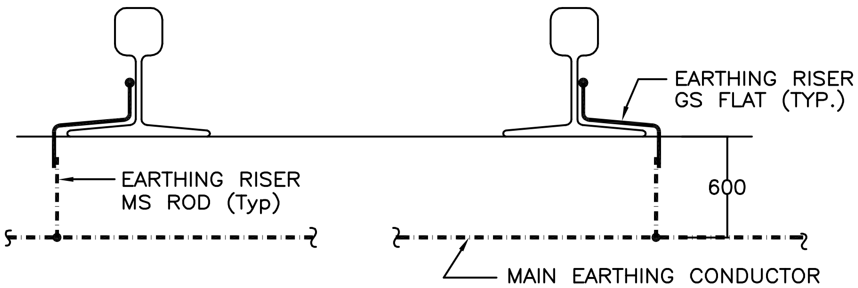
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 21
CKD BY	PRPD BY	Date	

EARTHING OF RAIL TRACK





SECTION A – A

LEGEND

- 40mmø MS ROD
- 75 x 12 mm GS FLAT

NOTES :–

1. EACH RAIL SHALL BE EARTHED AT 30M INTERVAL AND ALSO AT BOTH ENDS.

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POWER GRID CORPORATION
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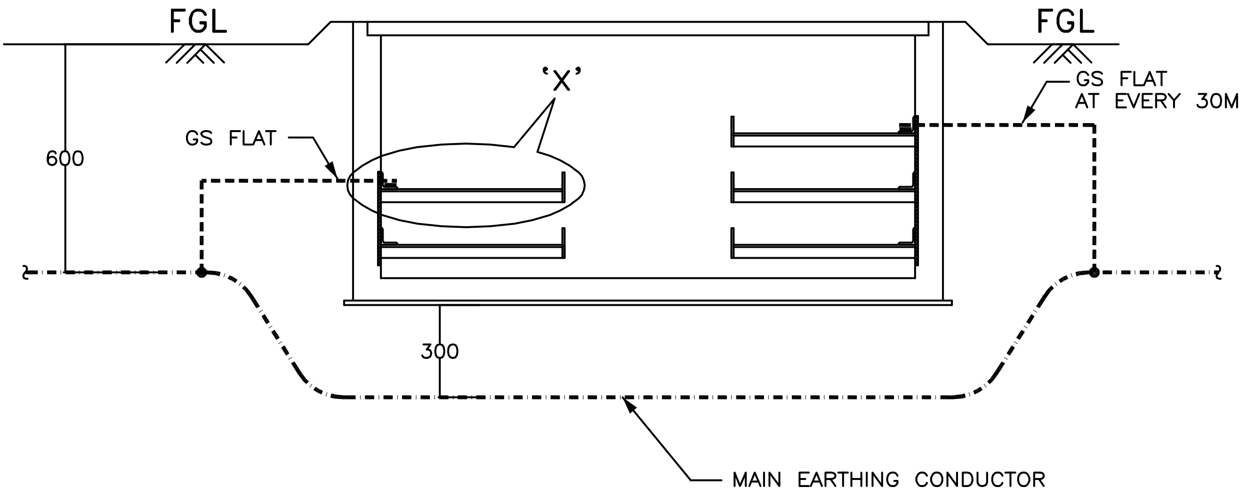
PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

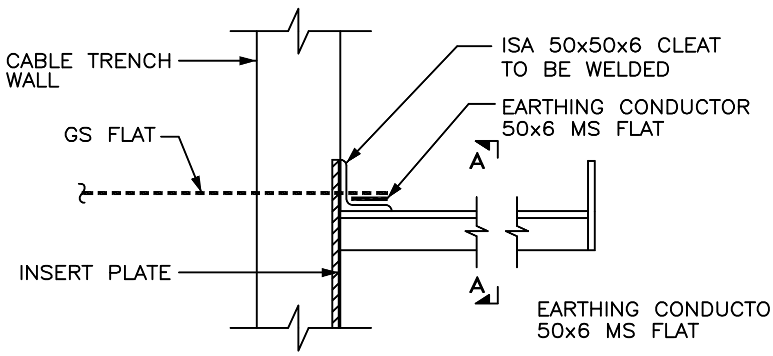
TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 22
CKD BY	PRPD BY	Date	

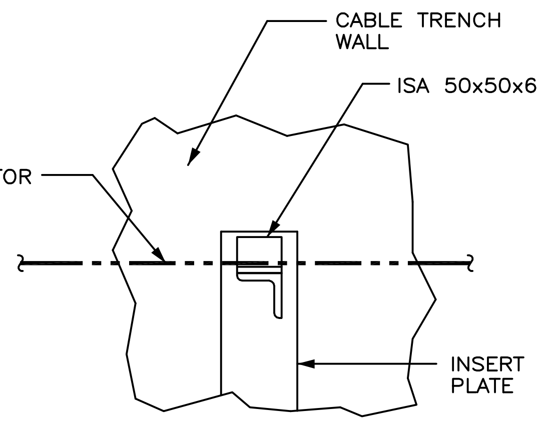
EARTHING OF CABLE TRENCH



TYPICAL CROSS SECTION OF CABLE TRENCH



DETAIL – X



SECTION A – A

NOTES :–

1. MS FLAT SHALL RUN ON TOP TIER ALL ALONG THE CABLE TRENCHES & WELDED TO EACH OF THE RACKS.
2. MS FLAT SHALL BE EARTHED AT 30M INTERVAL AND ALSO AT BOTH ENDS.

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POWER GRID CORPORATION
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पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

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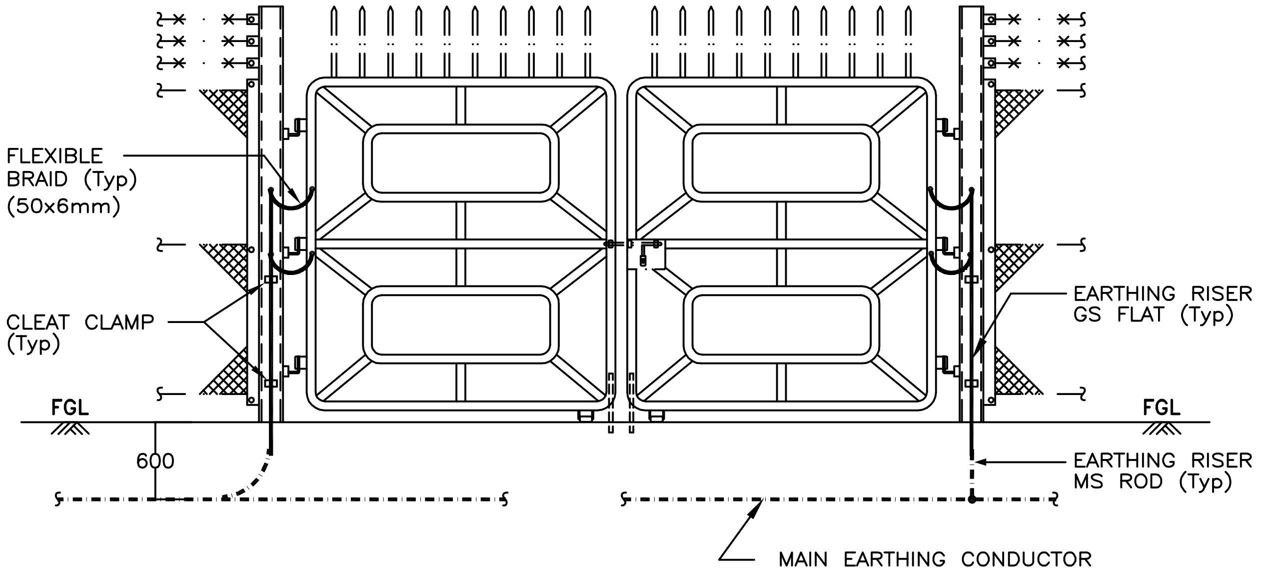
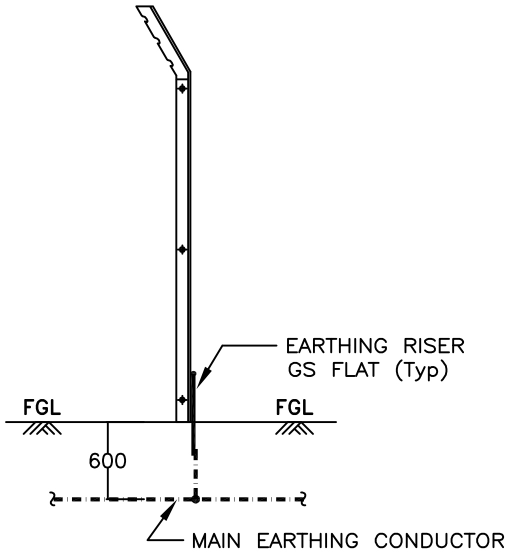
EARTHING OF GATES



MAIN GATE



FENCE POST
(ALTERNATE FENCE POST)

LEGEND

- 40mmø MS ROD
- 75 x 12 mm GS FLAT
- 50 x 6 mm MS FLAT

NOTES :–

	FENCE POST	MAIN GATE
1 . No. OF RISERS REQUIRED	1	2
2 . No. OF FLEXIBLE BRAID	–	4

3. ALL GATES & EVERY ALTERNATE FENCE SHALL BE CONNECTED TO EARTHING GRID.

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POWER GRID CORPORATION
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PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 24
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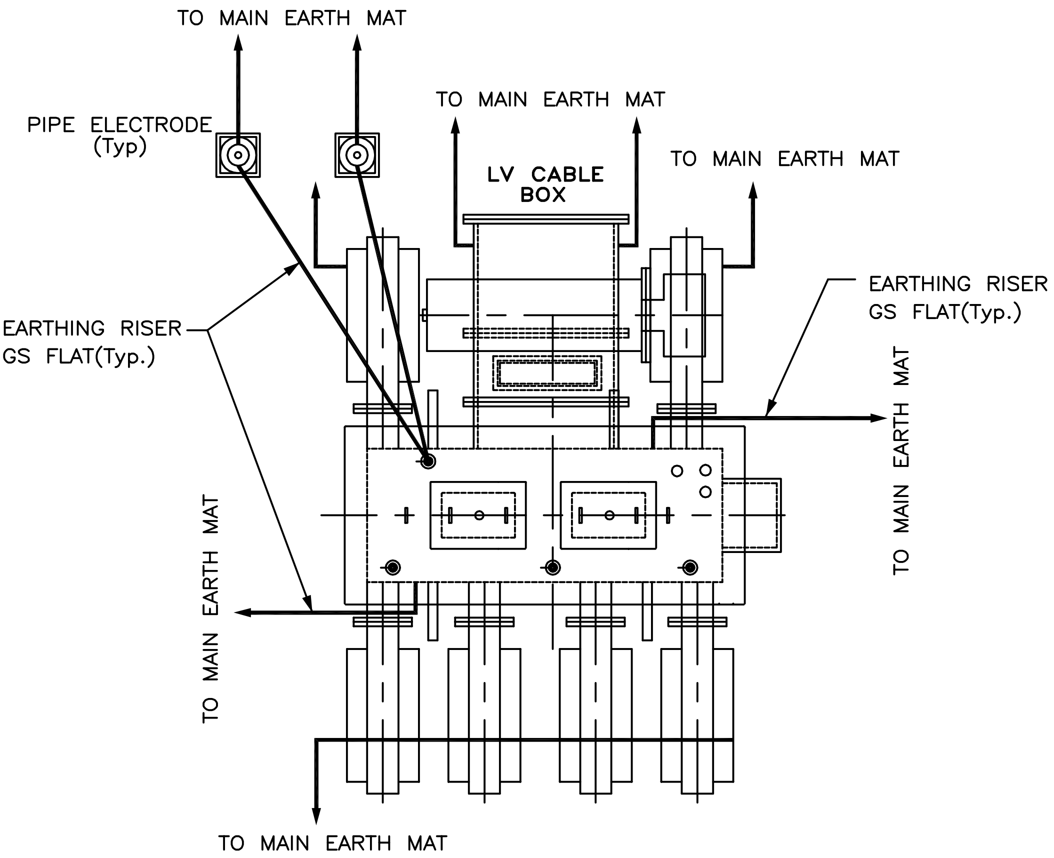
EARTHING OF LT TRANSFORMER



PLAN

LEGEND

— · — · —	40mmø MS ROD
———	75 x 12 mm GS FLAT
-------	50 x 6 mm GS FLAT

NOTES :–

1. No. OF RISERS FOR MAIN TANK & T.M. MAR. BOX = 4 Nos.
2. No. OF RISERS FOR LV CABLE BOX & RADIATOR = 4 Nos.
3. No. OF RISERS FOR PIPE ELECTRODE = 2 Nos.
4. No. OF PIPE ELECTRODES REQUIRED = 2 Nos.

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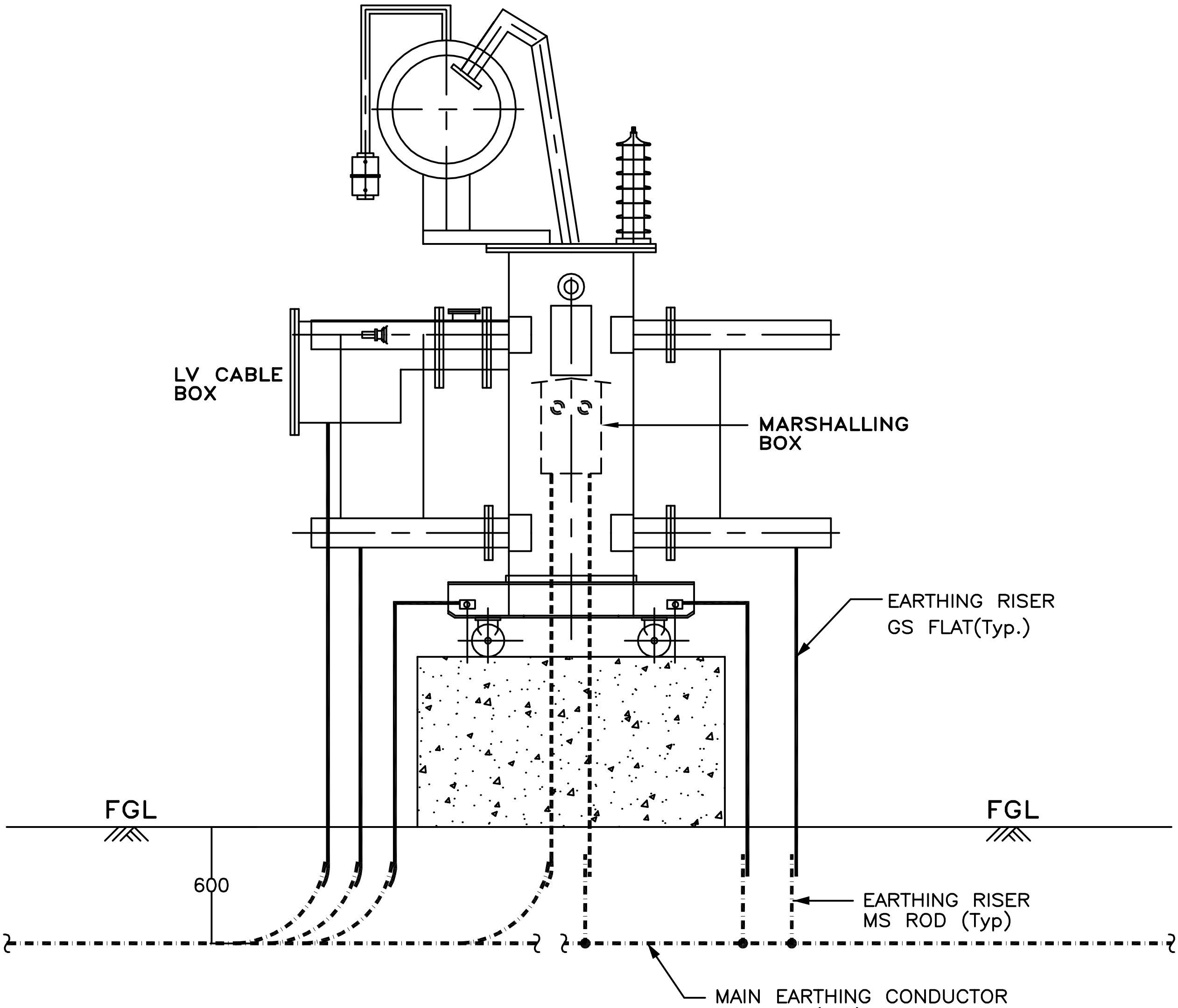
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 25
CKD BY	PRPD BY	Date	

EARTHING OF LT TRANSFORMER



END VIEW

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POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
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EARTHING OF PYLON SUPPORTS

Pylon supports shall be grounded through 50x6mm GI flat to the ring around the Pylon supports of 75x12mm GI flat which in tu rn is connected to the main grid (40 mm dia MS rod) at 2 to3 points as available.

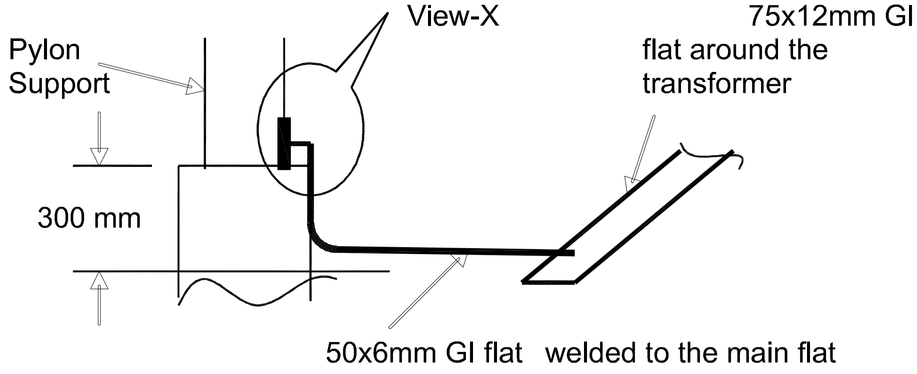

Fig.- Elevation (Earthing of Pylon Supports)

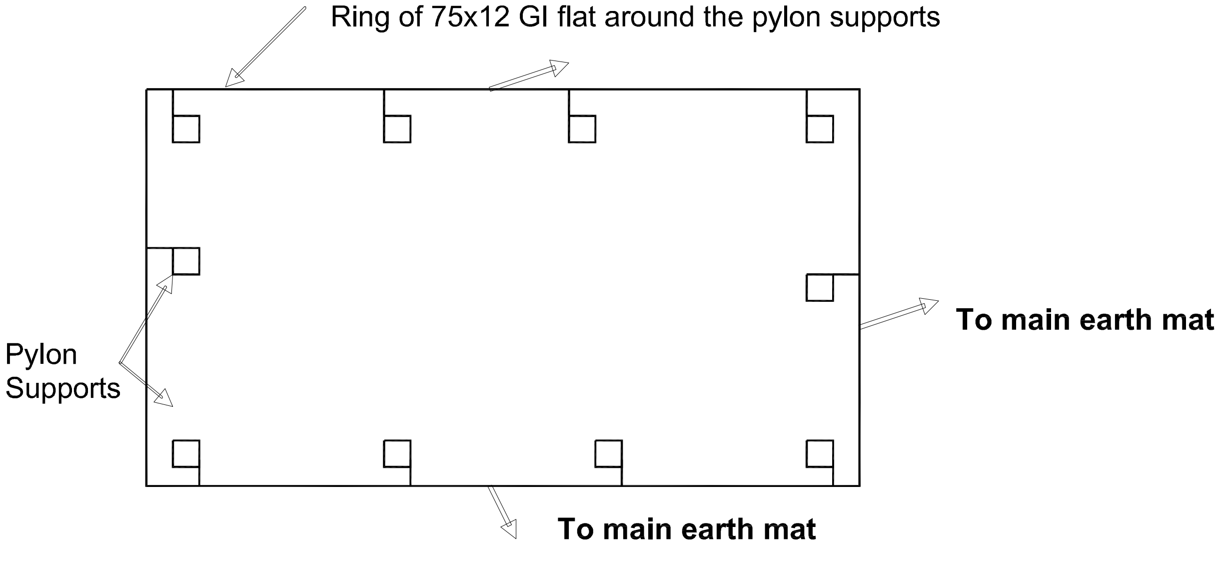

Fig.- Layout (Earthing of Pylon Supports)

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POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
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EARTHING OFHYDRANT/ HVW SPRAY PIPING

These pipes shall be grounded at pump house through 50x6mm GI flat connected to the main flat, 75x12mm running around the room.

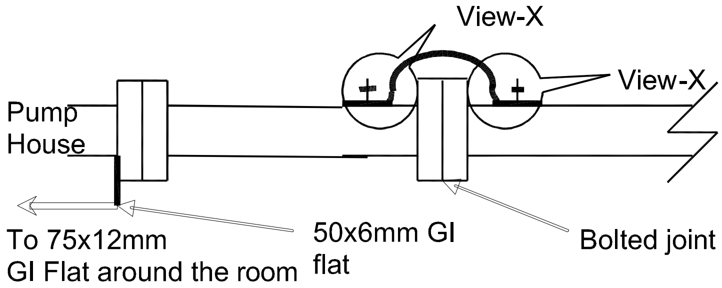


Fig.-Earthing of Hydrant / HVW Spray Piping

EARTHING OFHYDRANT POST/ HOSE BOX

A bolt shall be welded to these structures at the time of installation which can be used to connect them to the nearest riser or main 75x12mm GI flat through 50x6mm GI flat.

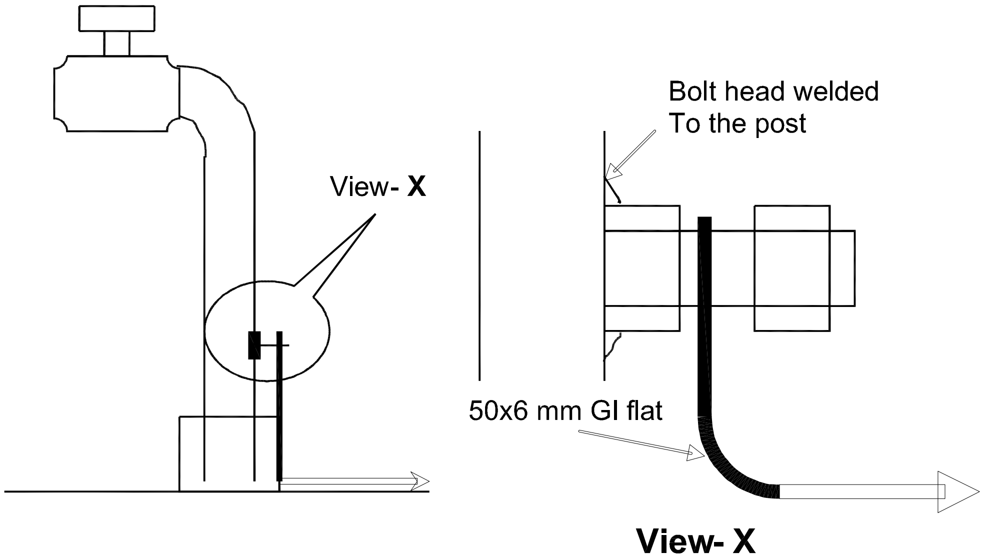


Fig.- Earthing of hydrant box / hose box

RELEASED FOR CONTRUCTION

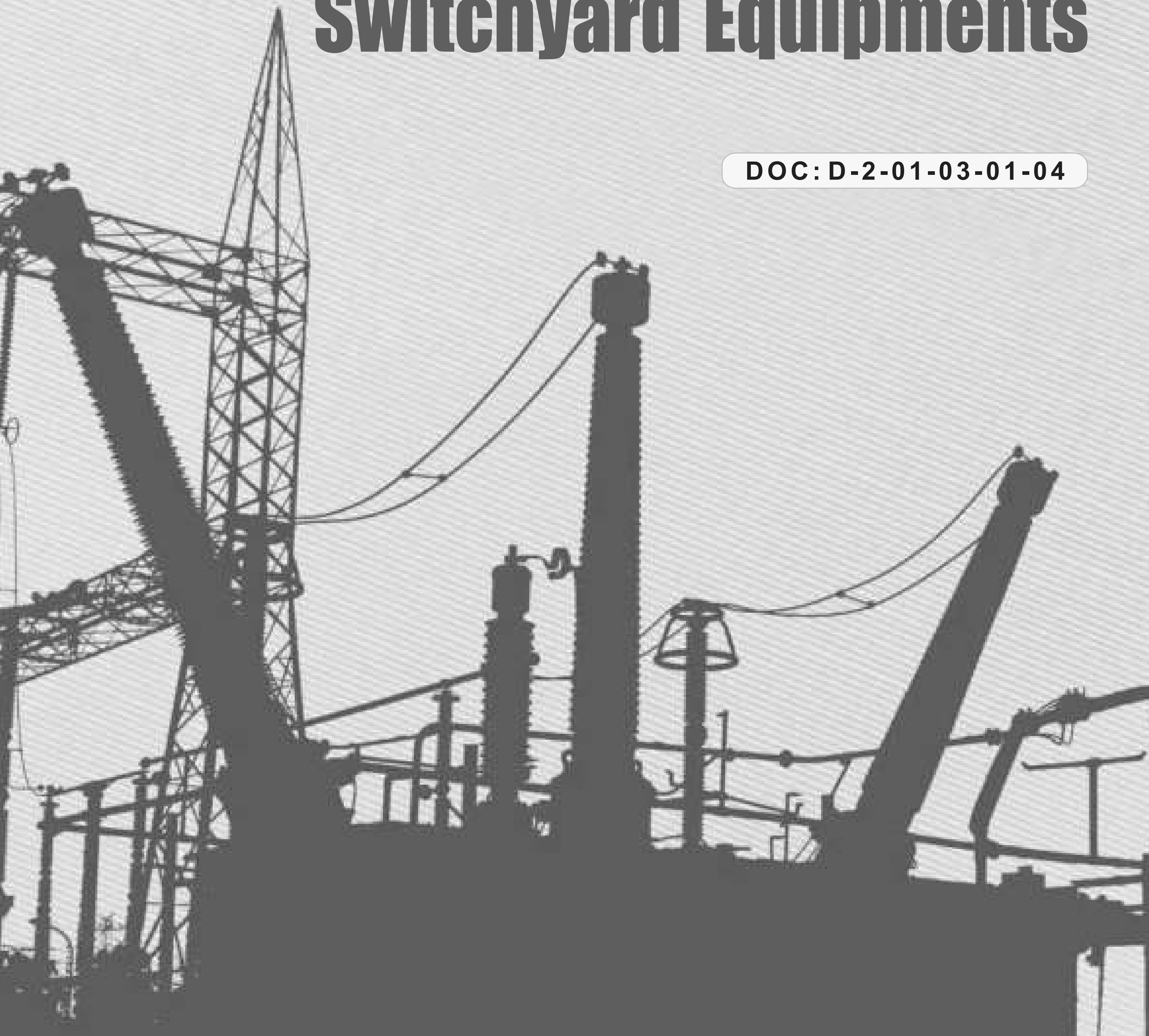
POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
K.K.Sarkar	K.K.Sarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 28

APRIL 2013

पावरग्रिड

Pre-Commissioning Procedures and Formats for **Switchyard Equipments**

DOC: D-2-01-03-01-04



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PRE-COMMISSIONING PROCEDURES FOR SWITCHYARD EQUIPMENTS

1.1 Purpose

This document is to provide guidance to POWERGRID personnel in carrying out Pre-commissioning checks along with formats for recording the test data and subsequently charging of Substation Bay equipments along with associated auxiliary equipments.

Pre-commissioning checks/ tests are the activities carried out to ascertain the correctness, completeness of installation and healthiness of the equipment before its charging. These checks/ tests are to be carried out by Contractor's representative in the presence of POWERGRID's authorized representative.

1.2 Commissioning Team

1.2.1 **Constitution of Commissioning team:** After completion of erection in all respects, a commissioning team may be constituted (as per procedures laid down in Works & Procurement Policy and Procedures -Clause C2.15.4.6 of WPPP Vol. II), to oversee/ coordinate with erection agency/ manufacturer of the equipment for the pre-commissioning tests and subsequently charging of the equipment. In case of Substation, Commissioning team may consist of following:

(i) I/C of Substation

(ii) O&M executive not below Manager

(iii) T&C executive not below Sr. Engineer

1.2.2 **Role of Commissioning team**: The Commissioning Team shall examine the following statutory and other clearances obtained by Execution Site prior to clearance for test charging of the equipment/transmission line at rated voltage:

Statutory Clearances:

a) Electrical Inspector's Clearance (provisional or final) for charging transmission line/bay equipment as per I.E. rules.

b) P.T.C.C. clearance.

c) Copy of notification informing public/administration regarding charging of the line.

d) Forest Clearance

Other Clearances:

a) Charging instruction from SEF Group of Corporate Engineering.

b) Relay setting details from Corporate Engineering.

(Clause C2.15.4.8 (v) of WPPP Vol-II)

1.2.3 **Responsibilities of Commissioning team** The responsibilities of the commissioning team are to go through statutory clearances and standing instructions before initial charging of new equipment, witness Pre-Commissioning tests after erection of individual equipment as per requirement of guidelines issued by Corporate OS or in line with manufacturer's recommendation and test charging, investigate failure of equipment during test charging, declare commencement of trial operation and evaluate guaranteed test results and recommend acceptance as may be provided in the contract, list out deviations/ exception/ incomplete work, for acceptance/ rejection (Clause C2.15.4.7 of WPPP Vol-II). Proper documentation also to be ensured by the Commissioning team based upon the observations for the above for future reference.

1.2.4 The Team shall also go through the factory test reports. If such tests have been repeated during pre-commissioning, the Team shall list out deviations, if any, in the results of pre-commissioning tests with respect to the factory tests.

(Clause C2.15.4.8 (vii) of WPPP Vol-II)

1.2.5 After all pre-commissioning checks and tests are found to be acceptable taking into account permissible deviation limits, the commissioning team, in consultation with regional O&M, shall give clearance for commissioning/ charging.

Please Note: In case of Transformers & Reactors, commissioning team shall forward the Pre-Commissioning report along with their recommendations to RHQ-OS and CC-OS for charging clearance and CC-OS shall give the final charging clearance after reviewing of the test results. In case of circuit breakers, operation timings and DCRM records to be sent to CC-OS for charging clearance.

1.3 Safety

All measures and precautions should be undertaken to prevent occurrence of unsafe acts. All the personnel involved should be thoroughly apprised about the safe procedures to be adopted while performing various activities including carrying out tests in the switchyard.
Adequate fire-fighting system as per procedures and their healthiness is to be ensured before charging.
Warning signs and Safety barriers should be positioned in conformity to IE rules as amended from time to time.

1.4 General Procedures during Pre-commissioning of Switchyard Equipment

All the equipment after erection/assembly at site, should be tested in order to check that it has not been damaged during transport, erection/assembly to such an extent that its future operation will be at risk. The significance of various tests with brief procedure has been elaborated in the subsequent sections of this document. Regarding the detailed testing methods / procedures for conducting various pre-commissioning tests refer to Doc. No. D-2-03-XX-01-01: Maintenance Procedures for Switchyard Equipments-Part 1: EHV Transformers & Reactors and Doc No. D-2-03-XX-01-01 –Part 2: Other Switchyard Equipments.

1.5 Documentation

The results of the test shall be documented on the test record formats as mentioned below, which are also part of this documentation:

Sl.No.	FORMAT NO.	EQUIPMENT
1.	No. CF/ICT/01/ R-4 DATED 01/04/2013	ICT
2.	No. CF/SR/02/ R-4 DATED 01/04/2013	SHUNT REACTOR
3.	No. CF/CB/03/ R-4 DATED 01/04/2013	CIRCUIT BREAKER
4.	No. CF/CT/04/ R-4 DATED 01/04/2013	CURRENT TRANSFORMER
5.	No. CF/CVT/05/ R-4 DATED 01/04/2013	CVT
6.	No. CF/BAY/06/ R-4 DATED 01/04/2013	BAY/FEEDER
7.	No. CF/ISO/07/ R-4 DATED 01/04/2013	ISOLATOR/GROUND SWITCH
8.	No. CF/SA/08/ R-4 DATED 01/04/2013	SURGE ARRESTOR
9.	No. CF/WT/09/ R-4 DATED 01/04/2013	WAVE TRAP
10.	No. CF/C&P/10/ R-4 DATED 01/04/2013	CONTROL & PROTECTION

These formats have all the tests recordings to be performed at site before energization/ charging. Switching and operational activities will be recorded in regular manner in the operator's log. Copies of this log, notes on special observations from inspections and other measurements will constitute the test records. The test records had to be signed by the responsible personnel from the OEM, the supplier, the erection agency and the POWERGRID representative. The test formats/records are to be distributed to Regional O&M office and Concerned Sub-Station library.

TRANSFORMER AND REACTOR

2.1 Following points to be checked after receipt of Transformer/Reactor at Site

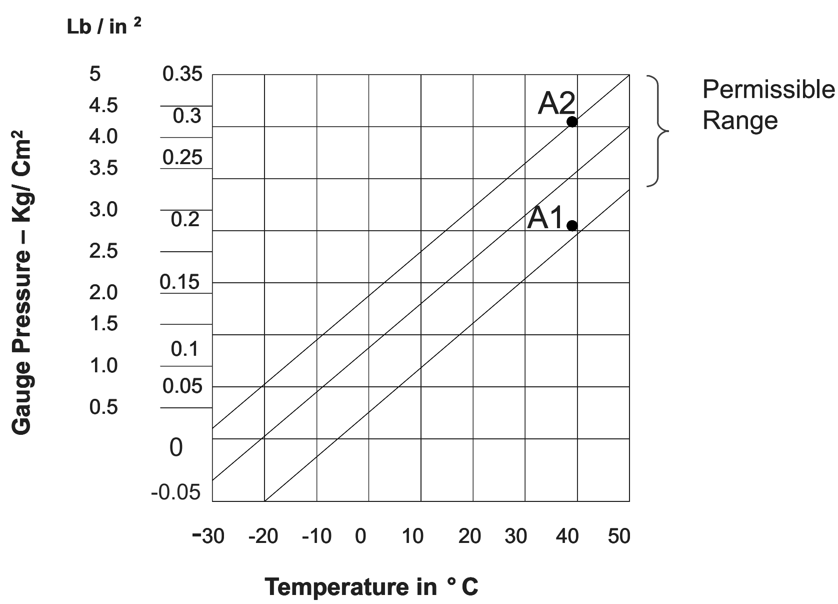
2.1.1 N_2 pressure and Dew point to be checked after receipt of Transformer at Site. It should be within permissible band (as per graph provided by manufacturer & given below in Fig-1)

2.1.2 Core Insulation Test shall be carried out to check insulation between Core (CC&CL) and Ground. (Not applicable for Air Core Reactors)

2.1.3 The data of impact recorder shall be analyzed jointly in association with the manufacturer. In case the impact recorder indicates shocks of ≥3g during shipment, further course of action for internal inspection shall be taken jointly with the manufacturer/ supplier. Impact Recorder should be detached from the Transformer/ Reactor preferably when the main unit has been placed on its foundation.

As present day impact recorders are of electronic type, analysis of impact recorder along with dew point and Core insulation tests to be performed on trailer itself. In case, the test results are not meeting permissible limits, same to be informed to OEM, CC-Engg. & CC-OS for further course of action.

Graph showing variation of Pressure v/s Temperature of gas for gas filled unit during Transport or storage



Example: For 40 °C Temperature (Depending upon the pressure of gas at the time of filling),
- minimum pressure of gas can be 0.185 Kg/ Cm^2 at point A1
- maximum pressure of gas can be 0.32 Kg/ Cm^2 at point A2

Fig. 1

2.1.4 Unpacking and inspection of all accessories to be carried out taking all precautions so that the tools used for opening do not cause damage to the contents. Proper storage of all accessories are to be ensured after unpacking. Fragile instruments like oil level gauge, temperature indicators, etc. are to be stored indoor. Any damaged or missing components should be reported to equipment manufacturer and insuring agency so that the same can be investigated or shortage made up as per the terms/ conditions of the contract.

2.1.5 Storage of the main unit and the accessories at site:

- ➢ If erection work can not start immediately due to some reasons, then accessories should be repacked into their own crates properly and packing list should be retained.
- ➢ All packing cases should be kept above ground by suitable supports so as to allow free air flow underneath. The storage space area should be such that it is accessible for inspection, water does not collect on or around the area and handling/transport would be easy. Proper drainage arrangement in storage areas to be ensured so that in no situation, any component gets submerged in water due to rain, flooding etc.
- ➢ It is preferable to store the main unit on its own location/foundation. If the foundation is not likely to be ready for more than three (3) months, then suitable action plan has to be taken from the manufacturer regarding proper storage of the Main Unit.
- ➢ If the transformer/ Reactor is to be stored up to three (3) months after arrival at site, it can be stored with N_2 filled condition. N_2 pressure to be monitored on daily basis so that chances of exposure of active part to atmosphere are avoided. In case of drop in N_2 pressure, dew point of N_2 has to be measured to check the dryness of the Transformer/ Reactor. If there is drop in dew point, fresh nitrogen need to be filled. Leaks are to be identified and rectified and Nitrogen to be filled to the required pressure.
- ➢ In case the transformer/ reactor is to be stored for more than 3 months, it needs to be stored in oil filled condition. Processed oil to be filled which complies the required specification and ppm ≤5ppm and BDV ≥70kV. In case of storage of transformer in oil-filled condition, the oil filled in the unit should be tested for BDV and moisture contents once in every three months. The oil sample should be taken from bottom valve. If BDV is less and moisture content is more than as given for service condition then oil should be filtered.

2.2 Insulating Oil

When oil is dispatched to site separately it is usually in sealed steel drums. In some of the cases, oil is supplied in tankers also. The oil to be used to filling and topping up must comply with oil specification given in POWERGRID Technical Specification for acceptance criteria. Oil Samples shall be taken from oil drums/ tanker received at site and sent to our nearest oil Lab for oil parameter testing (BDV > 50 kV, ppm<40, Resistivity > 150 x 10^{12} Ohm-cm & Tan delta < 0.0025 @ 90 °C). The later is important since dirty transportation vessels can significantly contaminate the oil. High dielectric losses cannot be removed by filter treatment, such lots have to be rejected. If the oil is supplied in railroad or trailer tanks, one or two samples are sufficient. If the oil is delivered in 200 litres drums, the following scheme for checking is recommended.

Number of drums delivered	No. of drums to be checked
2 to 5	2
6 to 20	3
21 to 50	4
51 to 10	7
101 to 200	10
201 to 400	15

In case any doubt arises, number of drums to be checked needs to be increased. However, before filling oil, each drum has to be physically checked for free moisture and appearance. A register needs to be maintained indicating the number of drums supplied in each lot as per LOA and number of drums of each lot used in filling a particular Transformer/ Reactor. The oil test results carried out as above should also be recorded.

The copy of test certificate of routine testing at oil refinery should be available at site for comparison of test results.

2.2.1 Samples from Oil Drum

Check the seals on the drums. The drum should first be allowed to stand with bung (lid) vertically upwards for at least 24 hours. The area around the bung should be cleaned & clean glass or brass tube long enough to reach to within 10mm of the lowermost part of the drum should be inserted, keeping the uppermost end of the tube sealed with the thumb while doing so. Remove the Thumb thereby allowing oil to enter the bottom of the tube. Reseal the tube and withdraw an oil sample. **The first two samples should be discarded**. Thereafter, the sample should be released into a suitable receptacle. Samples to be collected preferably in clean glass bottles. The bottles are to be rinsed with the same oil and to be without any air bubble.

2.3 Internal Inspection

Before starting erection, thorough internal inspection of Transformer/ Reactor is to be carried out by POWERGRID engineer along with manufacturer's representative.
Internal inspection should be preferred in dry and sunny weather and should be finished as quickly as possible to avoid ingress of moisture admitting dry air.
Prior to making any entry into the transformer tank, establish a foreign material exclusion programme to avoid the danger of any foreign objects falling into the transformer:

- ➢ Loose articles should be removed from the pockets of anyone working on the transformer cover.
- ➢ All jewellery, watches, pens, coins and knives should be removed from pockets.
- ➢ Protective clothing and clean shoe covers are recommended.
- ➢ Tools should be tied with clean cotton tape or cord securely fastened.
- ➢ Plated tools or tools with parts that may become detached should be avoided.
- ➢ An inventory of all parts taken into transformer should be recorded and checked before closing inspection cover to assure all items were removed.

If any object is dropped into the transformer and cannot be retrieved, the manufacturer should be notified.

The inspection should include:

- Removal of any shipping blocking or temporary support.
- Examination for indication of core shifting.
- Tests for unintentional core or core clamp grounds.
- Visual inspection of windings, leads, and connections including clamping, bracing, blocking, spacer alignment, phase barriers, oil boxes, and coil wraps.
- Inspection of DETC and in-tank LTCs including contact alignment and pressure.
- Inspection of current transformers, including supports and wiring harness.
- Checks for dirt, metal particles, moisture, or other foreign material.

In case of any abnormality noticed during internal inspection, same to be referred to manufacturer, CC-Engg. & CC-OS immediately before starting erection activities.
Detailed photographs of all visible parts/ components as per above are to be taken during internal inspection and to be attached with pre-commissioning report.

2.4 Precautions during erection

During erection, efforts to be made to minimize the exposure of active parts (core and coils) of transformer/ reactor. Moisture may condense on any surface cooler than the surrounding air. Excessive moisture in insulation or dielectric liquid lowers its dielectric strength and may cause a failure of Transformer/ Reactor.

Further, either dry air generator should be running all the time or dry air cylinders may be used to minimize ingress of moisture. The transformer should be sealed off after working hours. **Transformer/ reactor shall never be allowed to be opened without application of dry air.**

Remarks: As N2 is heavier than air, application of Vacuum to be ensured and thereafter dry air to be admitted before entering inside Transformer after shipment in N2 filled condition. Oxygen content should be between 19 % and 25 % prior to any entry. During inspection, dry air to be purged continuously.

It is practical to apply a slight overpressure overnight with dry air or N2 inside – less than 300 mbar (30 kPa or 0.3 atmospheres). Next day the pressure is checked and suspected leaks may be detected with leak detection instruments/ with soap water or with plastic bags tightened around valves (being inflated by leaking air)

For oil filled units whenever oil is drained out below the inspection covers, job will be treated as exposed. Other exposure activities are as below:

1) Bushing erections
2) Jumper connections of Bushings
3) Fixing bushing turrets
4) Core insulation checking (in case the checking point not accessible outside)
5) Buchholz relay pipe work fixing on cover
6) Gas release pipes/equalizer pipe fixing
7) Entering inside the tank for connections/inspection etc

For oil filled units depending upon the level up to which the oil is drained decides the exposure time. All such exposure time should be recorded in a log sheet to decide the oil processing (drying) and oil filling of transformer.

"GET THE TRANSFORMER UNDER OIL AS SOON AS POSSIBLE!" It is good practice to proceed with the erection in such a sequence that all fittings and auxiliaries with oil seals to the tank are assembled first. The oil filling will then be performed as easily as possible. The "active part" inside - core and coils - is then impregnated and protected. It has good time to soak properly, before the unit shall be energized, while remaining fittings are assembled on the unit, and commissioning checks carried out.

For transformers with a gas pressure of 2.5- 3 PSI, the acceptable limits of dew point shall be as under: (Courtesy: BHEL, Bhopal)

Temperature of Insulation in °F	Permissible dew point in °F	Temperature of Insulation in °C	Permissible dew point in °C
0	-78	-17.77	-61.11
5	-74	-15.0	-58.88
10	-70	-12.22	-56.66
15	-66	-9.44	-54.44
20	-62	-6.66	-52.22
25	-58	-3.33	-49.99
30	-53	-1.11	-47.22
35	-48	+1.66	-44.44
40	-44	+4.44	-42.22
45	-40	+7.44	-39.39
50	-35	+9.99	-37.22
55	-31	12.77	-34.99
60	-27	15.55	-32.77
65	-22	18.33	-29.99
70	-18	23.11	-27.77
75	-14	23.88	-25.55
80	-10	26.66	-23.33
85	-6	29.44	-21.11
90	-1	32.22	-18.33
95	+3	34.99	-16.11
100	+7	37.75	-13.88
110	+16	43.33	-8.88
120	+25	48.88	-3.88
130	+33	54.44	+0.55
140	+44	59.99	+5.55

TABLE 1- Variation of Dew Point of N2 Gas Filled in Transformer Tank w.r.t Temperature

2.5 Final tightness test with vacuum (i.e. leakage test or Vacuum Drop Test)

Before oil filling is started, a final check is made for the tightness of the transformer tank by applying vacuum. When vacuum is applied to a transformer without oil, a leakage test must be carried out to ensure that there are no leaks in the tank which would result in wet air being drawn into the transformer. The following procedure is to be adopted:

- Connect the vacuum gauge to a suitable valve of the tank. (Vacuum application and measurement should be performed only on top of the main tank) - A vacuum gauge of Mc Leod type or electronic type, with a reading range covering the interval - 1 kPa (1 - 10 mm mercury) to be used
- Connect the vacuum pump to another opening.
- Evacuate the transformer/ reactor tank until the pressure is below 50 mbar (5 kPa).
- Shut the vacuum valve and stop the pump.
- Wait for an hour and take a first vacuum reading – say P1
- Take a second reading 30 minutes later- say P2
- Note the volume of the tank (quantity of oil required according to the rating plate) and express as volume, V, in m^3
- Take the difference between P2 and P1, and multiply this with the oil quantity V. If the pressures are expressed in kPa, and the oil quantity in m^3, then the product shall be less than 3.6.

  (P2 – P1) x V < 3.6

  The transformer is then considered to be holding sufficient vacuum and is tight. Continue reading (at least 2 to 3) at successive 30 min intervals to confirm the result.
- If the leak test is successful, the pumping will be continued, until the pressure has come down to 0.13 kPa (1 Torr) or less. The vacuum shall then be held for the time given in Table-3 before the oil filling starts.
- If the specified vacuum cannot be reached, or if it does not hold, the leak in the transformer system shall be located and corrected.

In case the transformer is provided with an On Load Tap Changer (OLTC), while evacuating the main transformer tank, the diverter switch compartment may also be evacuated simultaneously so that no undue pressure is allowed on the tap changer chamber. While releasing vacuum, the tap changer chamber vacuum should also be released simultaneously. For this one pressure equalizer pipe should be connected between main tank and tap changer. Manufacturer's instruction manual should be referred to protect the air cell/diaphragm in the conservator during evacuation.

This vacuum must be maintained for the time specified as per the voltage class in Table-3 before and should also be maintained during the subsequent oil filling operations by continuous running of the vacuum pumps.

2.6 Oil Filling

Once the oil is tested from the drums and found meeting the requirements, the oil is transferred to oil storage tank for oil filtration before filling inside the transformer.

The drums or trailer tanks shall not be emptied to the last drop - a sump of an inch or so is left, to avoid possible solid dirt or water in the bottom.

Before being used, the tanks and hoses are visually inspected inside for cleanness. Any liquid residue from earlier use will be carefully removed, and the container flushed with a small quantity of new oil, which is then discarded.

After filtration, oil sample is tested for meeting POWERGRID specification for new oil.

Prior to filling in main tank at site and shall be tested for:

1. Break Down voltage (BDV)	:	70kV (min.)
2. Moisture content	:	5 ppm (max.)
3. Tan-delta at 90 °C	:	Less than 0.01
4. Interfacial tension	:	More than 0.035 N/m

For transformer dispatched with gas (N2) filled from the works, the filling of oil inside the tank is done under vacuum. Transformer of high voltage ratings and their tanks are designed to withstand full vacuum. Manufacturer's instructions should be followed regarding application of full vacuum during filling the oil in the tank.

When filling a transformer with oil it is preferable that the oil be pumped into the bottom of the tank through a filter press or other reliable oil drying and cleaning device should be interposed between the pump and the tank (please refer Fig-2).

The oil flow at the entry valve must be controlled to maintain a positive pressure above atmospheric and to limit the flow rate if necessary to 5000 litres / hour, or a rise in oil level in the tank not exceeding one meter / hour (as measured on the oil level indicator)

Continue oil filling until the level reaches approximately 200 mm above the ambient oil level indicated on the magnetic oil level gauge in the expansion vessel. Then, release the vacuum, with dry air of dew point -40deg C or better.

The diverter tank can now be topped up at atmospheric pressure. Reconnect oil outlet hose to valve on flange on tap changer diverter head. Reinstate breather and very slowly top up the diverter switch such that the correct level is reached in the diverter expansion vessel. In the event the expansion vessel is overfull drain oil from flange into a suitable container until the correct level is reached.

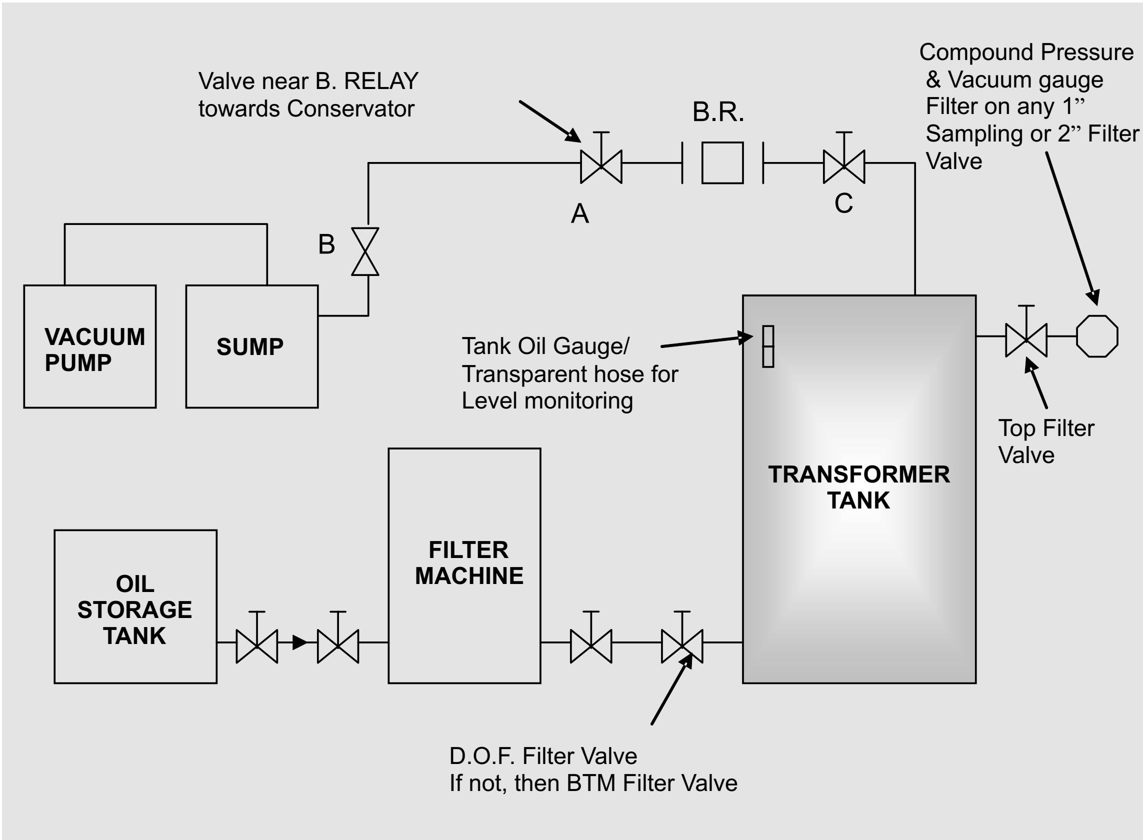


Figure-2 : Arrangement for Evacuation and Oil filling upto tank Oil gauge & Conservator

When the vacuum filling of the transformer and diverter tank is complete, the cooling system/ Radiator bank can be filled (WITHOUT VACUUM) at atmospheric pressure, via an oil processing plant. Oil must be admitted, very slowly, through the bottom cooler filter valve, with the cooler vented at the top and the top cooler filter valve unblanked and open to atmosphere. As the oil level reaches the top vent, then top valve to be closed and the processing plant can be shut down.

Note: Care must be taken not to pressurize the coolers/ radiators.

Upon completion, open the top cooler isolating valve in order to equalize the pressure in the cooler with the transformer tank. This will also allow contraction or expansion of the oil as the ambient temperature changes.

Before filling oil into the conservator, the air cell/ bellow to be inflated to 0.5 PSIG i.e. 0.035kg/cm2 max. by applying pressure (N2/Compressed dry air) so that it can take shape. After releasing pressure, breather pipe is to be fitted however it is recommended not to fit breather in position, instead a wire mesh guard over and flange of the pipe to prevent entry of any insect inside the pipe. This will ensure free air movement from the air cell to the atmosphere.

Use flow meter / indicator on outlet of filter machine and regulate the flow using the valve to limit oil filling rate to 2000 litres per hour (max.) in case filter capacity is more.

Oil to be pushed slowly into conservator through the transformer via valve No. 5 (valve 2,3 & 4 to remain open) till the oil comes out first through valve Nos. 2 & 3 (close these valves) and then through valve No. 4. Allow some oil to come out through valve No.4. Oil should come out freely into the atmosphere. This will ensure that air inside the conservator is expelled out and the space surrounding the air cell is full of oil. (Close valve No. 4). During all these operations valve No.1 shall be in closed position.

Excess oil from the conservator is to be drained by gravity only through valve No. 1 or through drain valve of the transformer via valve No. 5. Do not use filter machine for draining oil from the conservator. Also do not remove buchholz relay and its associated pipe work, fitted between the conservator and the transformer tank while draining oil.

Stop draining oil till indicator of magnetic oil level gauge reaches position-2 on the dial, which is corresponding to 30 °C reading on the oil temperature indicator. Fill the conservator according to the oil temperature and not the atmospheric temperature

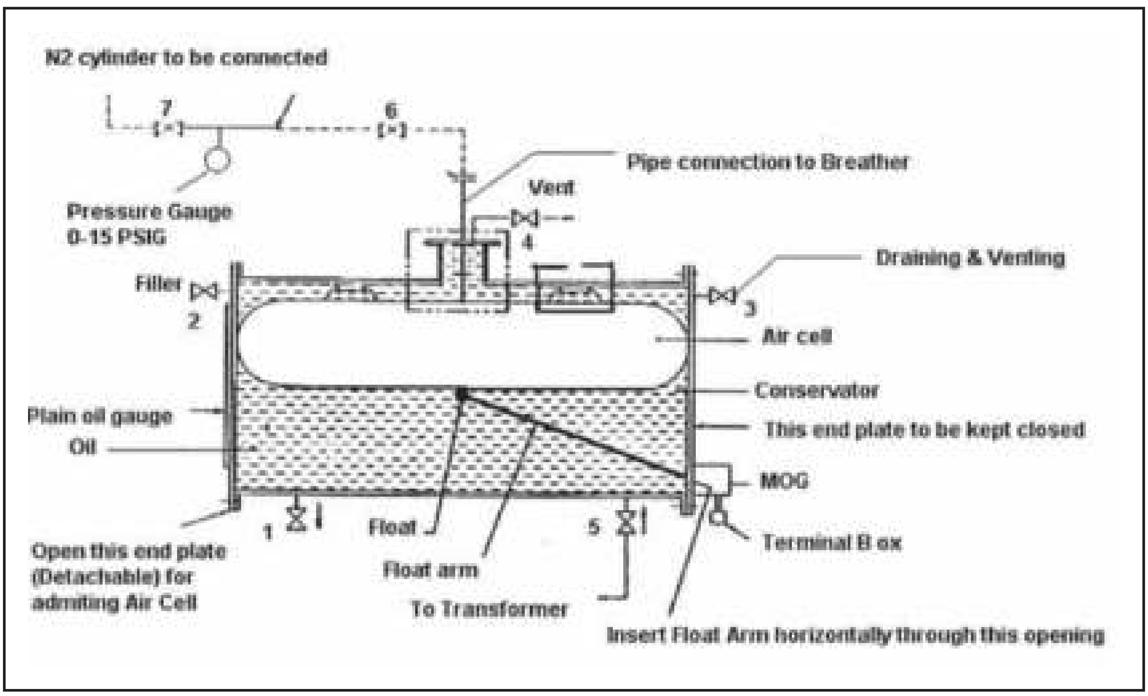


Figure-3 : General Arrangement For Oil Conservator

After Oil filling, Hot Oil Circulation has to be applied to all the Transformers/ Reactors except under the circumstances when active part of Transformer/ Reactor gets wet. Following conditions can be considered to define the Transformer/ Reactor wet:

1. **If Transformer/ Reactor received at site without positive N2 pressure.**
2. **If Dry air not used during exposure while doing erection activities**
3. **Overexposure of active part of Transformer/ Reactor during erection (Overexposure when exposure > 12 Hrs)**

Under above mentioned conditions, Manufacturer shall take necessary action for effective dry out of the Transformer/ Reactor. However general guidelines for dry out in such cases is given in section 2.8

2.7 HOT OIL CIRCULATION USING HIGH VACUUM OIL FILTER MACHINE

To ensure proper dryness and absorption of possible trapped gas bubbles, the oil in the tank is circulated through the vacuum filter and with circulation direction as shown in Fig.-4.

The circulation procedure for the main tank is as follows.

2.7.1 The Transformer/ Reactor is connected to the oil filter machine in a loop through the upper and lower filter valves. The direction of circulation shall be from the filter to the transformer at the top and from the transformer to the filter at the bottom. (Please note that at the initial oil filling time the direction is reverse to avoid air bubble formation).

2.7.2 The temperature of the oil from the filter to the Transformer should be around 60 ° C and in no case it should go beyond 70 ° C otherwise this may cause oxidation of oil.

2.7.3 The circulation shall proceed until a volume of oil has passed through the loop corresponding to 2 times the total oil volume in the tank. (At freezing ambient temperature the circulation time is increased, circulate 3 times the volume at temperature down to minus 20 ° C, increase to 4 times below that temperature).

The oil sample from the transformer tank, after filling in tank before commissioning should meet the following specifications (as per latest POWERGRID Revision) given in table-2 below.

Table-2

1.	Break Down voltage (BDV)	: 70 kV (min.)
2.	Moisture content	: 5 ppm (max.)
3.	Tan-delta at 90 °C	: 0.01 (max.)
4.	Total Gas Content	: < 1%
5.	Resistivity at 90 °C	: 6 X 10^{12} ohm-cm (min.)
6.	Interfacial tension	: 0.035 N/m (min.)
7.	*Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500 hour for inhibited oil)	
	a) Acidity	: 0.3 (mg KOH /g) (max.)
	b) Sludge	: 0.05 % (max.)
	c) Tan delta at 90 °C	: 0.05 (max.)

* For Sr. No. 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Powergrid.

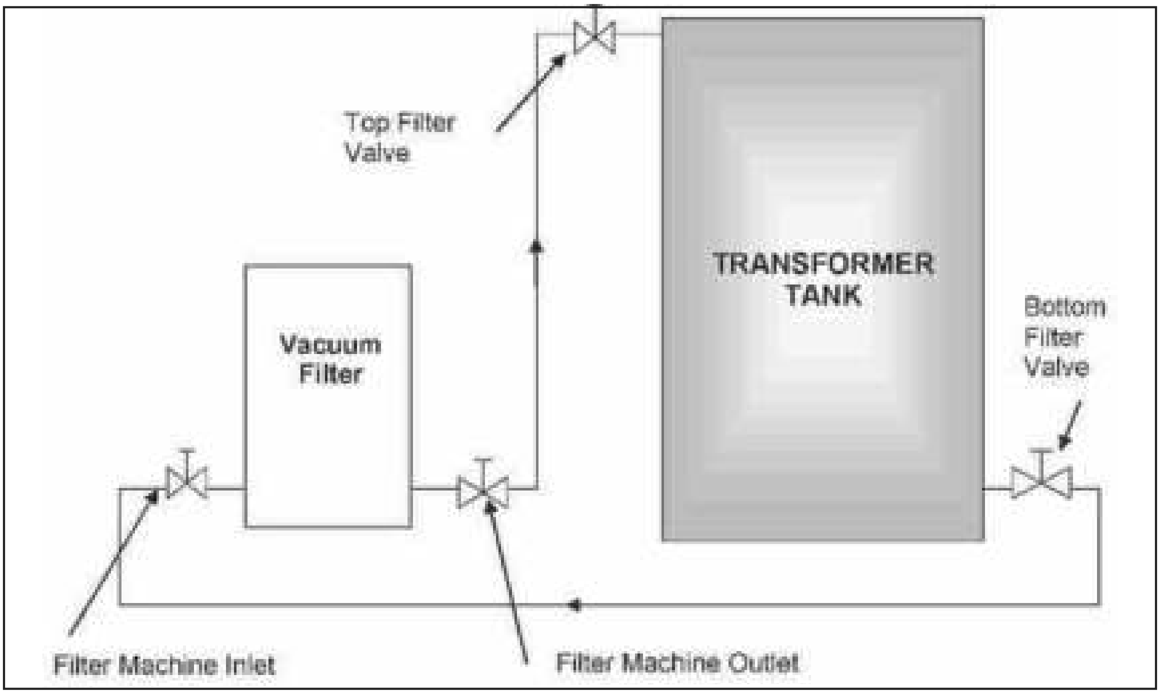


Figure-4: Arrangement for Hot Oil Circulation and Filtration

2.8 PROCEDURE FOR DRY OUT OF WET WINDING OF TRANSFORMER/REACTOR BY APPLICATION OF VACUUM, N2 FILLING AND HEATING

The drying of a new Transformer/ Reactor is required when the moisture gets absorbed by the solid insulation used in Transformers/ Reactors due to various reasons. The process of drying out a transformer requires care and good judgment. If the drying out process is carelessly or improperly performed, a great damage may result to the transformer insulation. In no case shall a transformer be left unattended during any part of the dry out period unless on-line dryout process is adopted which incorporates all necessary safety features. The transformer should be carefully watched throughout the dry-out process and all observations to be carefully recorded.

When the transformer is being dried out, it is necessary to ensure that fire fighting equipment is available near the transformer as a precaution as there are chances of fire as we are dealing with heat and inflammable oil.

2.8.1 Isolation Required

All the openings of transformer main tank like openings for coolers/radiators, conservator, OLTC etc. is to be properly isolated and totally blanked.

2.8.2 Procedure

a. Fill the main transformer/ reactor tank with Nitrogen (Use only Dry N2 gas as per IS: 1747 with less than 50 ppm moisture and 1% oxygen by volume) until it comes to a positive pressure of 0.15 Kg/cm^2. It is kept for about 48 hrs. At the end of 48 hrs, dew point of N_2 at outlet is measured. If the dew point is not within acceptable limits as per Table-I, dry out method should be continued.

b. While N2 circulation is in progress, the heaters are to be installed around the transformer tank. The heaters are to be kept ON until we achieve a temperature of about 75–80 °C of the core & winding of transformer as measured by top oil temperature in the transformer.

c. After ascertaining that there is no leakage, pull out vacuum and keep the transformer/reactor under near absolute vacuum (1-5 torr) and keep under vacuum for about 96 hours running the vacuum pump continuously. The duration of vacuum can vary between 48 to 96 hrs depending upon the dew point being achieved. Keep vacuum machine ON and collect condensate for measurement. Observe the rate of condensate collection on hourly basis. Depending on the value of rate of condensate (less than 40 ml/hr for 24 hrs), continuation of further vacuum shall be decided.

d. Then the vacuum is broken with dry nitrogen. The dew point of nitrogen at the inlet is to be measured and should be of the order of - 50 °C or better. When the nitrogen comes to the positive pressure of 0.15 kg/cm^2, it is stopped and kept for 24 hours. Heating from outside is to be continued while N2 circulation is in progress. Then the nitrogen pressure is released and the outlet nitrogen dew point is measured. If the dew point is within acceptable limits as per Table-I then the dryness of transformer is achieved. If not again the transformer is taken for vacuum treatment and then nitrogen is admitted as mentioned above and tested. The cycle is to be continued till desired dew point as per Table-1 is achieved.

e. Periodicity of vacuum cycle may vary between 48-96 hrs. Initially two N2 cycles may be kept for 24 hrs. After that it may be kept for 48 hrs depending upon dew point being achieved.

After completion of drying process, oil filling and hot oil circulation is to be carried out before commissioning. Please ensure standing time as per table-3 given below before charging.

Note: If already known that the transformer is wet based on the tests or exposure time, then (a) above can be skipped to save time.

Transformer HV Rated Voltage (in kV)	**Application of Vacuum & holding for (before oil filling)*** (in Hours)	**STANDING TIME After Oil circulation and before energising** (in Hours)
Up to 145kV	12 HRS	12 HRS
145 kV and up to 420kV	24 HRS	48 HRS
Above 420 kV	48 HRS	120 HRS

*Without running the vacuum pump and leakage rate to be ≤40mbar-lit/sec

Table-3

After the expiry of this time, air release operation is to be carried out in Buchholz relays, turrets and other release points given by the manufacturers before charging.

For subsequent activities, proceed to format no. CF/ICT/01/ R-4 Dated 01/04/2013 for ICT & format No. CF/SR/02/ R-4 Dated 01/04/2013 for Reactor. Refer pre-commissioning test procedures given in next section for all required tests to be performed.

2.9 RELATION BETWEEN DIFFERENT UNITS (CONVERSION OF UNITS)

Pressure

1 bar = 10^5 Pa = 750 Torr = 14.5 psi = 1.02kg/cm^2
1 Torr = 1.33 mbar = 0.133 kPa
1 kPa(kilo-Pascal) = 10^3 Pa = 10 mbar = 7.501 Torr(mm of mercury)
1 MPa = 10^6 Pa
1 atmosphere=0.1 MPa=1.02kg/cm^2= 14.5 psi

Force

1 kp = 9.807 N

Weight

1 ton=1000 kg=2200 lbs

Temperature

$$°C = \frac{5}{9} * (°F - 32)$$

$$°F = \frac{9}{5} * (°C) + 32$$

Volume

1m^3= 1000 litres=260 US gallons=220 Imp gallons
1 litre =0.26 US Gallons
1 US Gallons = 3.78 litres
1 litre =0.22 Imp Gallons

Benchmarks

1-mm mercury (Torr) is about 1 millibar or 0.1 kPa
1 m^3 of oil weights 0.9 tons –say 1 ton
1000 US gallons of oil weights 3.5 tons

PRE- COMMISSIONING CHECKS/TESTS FOR TRANSFORMERS AND REACTORS

Once oil filling is completed, various pre-commissioning checks/ tests are performed to ensure the healthiness of the Transformer/ Reactor prior to its energization. Various electrical tests are to be performed and their significance is given below

Sr. No.	Name of Test/ Check point	Purpose of test/ check
3.1	Core insulation tests	Allows for investigating accidental grounds which results in circulating currents if there is more than one connection between the core and ground.
3.2	Earth pit resistance measurement	To check the resistance of earth pit provided for Transformer. In case, the resistance is more, proper treatment is to be given.
3.3	Insulation Resistance (IR) measurement	Test reveals the condition of insulation (i.e. degree of dryness of paper insulation), presence of any foreign contaminants in oil and also any gross defect inside the transformer (e.g. Failure to remove the temporary transportation bracket on the live portion of tap-changer part)
3.4	Capacitance and Tanδ measurement of bushings	Measurement of C1 & C2 Capacitance and Tanδ in UST mode. Changes in the normal capacitance of an insulator indicate abnormal conditions such as the presence of moisture layer, short -circuits or open circuits in the capacitance network.
3.5	Capacitance and Tan δ measurement of windings	Dissipation factor/Loss factor and capacitance measurement of winding is carried out to ascertain the general condition of the ground and inter-winding insulation
3.6	Turns ratio (Voltage ratio) measurement	To determine the turns ratio of transformers to identify any abnormality in tap changers/ shorted or open turns etc
3.7	Vector Group & Polarity	To determine the phase relationship and polarity of transformers
3.8	Magnetic Balance test	This test is conducted only in three phase transformers to check the imbalance in the magnetic circuit
3.9	Floating Neutral point measurement	This test is conducted to ascertain possibility of short circuit in a winding.
3.10	Measurement of Short Circuit Impedance	This test is used to detect winding movement that usually occurs due to heavy fault current or mechanical damage during transportation or installation since dispatch from the factory.

Sr. No.	Name of Test/ Check point	Purpose of test/ check
3.11	Exciting/Magnetising current measurement	To locate defect in magnetic core structure, shifting of windings, failures in turn to turn insulation or problems in tap changers. These conditions change the effective reluctance of the magnetic circuit thus affecting the current required to establish flux in the core
3.12	Operational checks on OLTCs	To ensure smooth & trouble free operation of OLTC during operation.
3.13	Tests/ Checks on Bushing Current Transformers (BCTs)	To ascertain the healthiness of bushing current transformer at the time of erection
3.14	Operational Checks on protection System	Operational checks on cooler bank (pumps & Fans), Breathers (Silicagel or Drycol), MOG, temperature gauges (WTI/OTI), gas actuated relays (Buchholz, PRD, SPR etc.) and simulation test of protection system
3.15	Stability of Differential, REF of Transformer/ Reactor	This test is performed to check the proper operation of Differential & REF protection of Transformer & Reactor by simulating actual conditions. Any problem in CT connection, wrong cabling, relay setting can be detected by this test.
3.16	Frequency Response Analysis (FRA) measurement	To assess the mechanical integrity of the transformer. Transformers while experiencing severity of short circuit current looses its mechanical property by way of deformation of the winding or core. During pre-commissioning this test is required to ascertain that Transformer active part has not suffered any severe impact/ jerk during transportation.
3.17	Winding resistance measurement	To check for any abnormalities due to loose connections, broken strands and high contact resistance in tap changers
3.18	Dissolved Gas Analysis (DGA) of oil sample	Oil sample for DGA to be drawn from transformer main tank before commissioning for having a base data and after 24 hrs. of charging subsequently to ensure no fault gas developed after first charging. DGA analysis helps the user to identify the reason for gas formation & materials involved and indicate urgency of corrective action to be taken

3.1 CORE INSULATION TEST

This test is recommended first after receiving the equipment at site and to be performed on trailer itself. Thereafter, before the unit is placed in service or following modifications to the transformer that could affect the integrity of its core insulation and at other times, when indicated by DGA (key gases being ethane and/or ethylene and possibly methane) or usually during a major inspection.

For core-insulation to ground test, remove the cover of the terminal block, Disconnect the closing link that connects the two terminals CL-G. Apply 1.0 kV direct voltage between CL and CC + G (core grounding strap). The tank shall be grounded during the test.

Acceptable Limit: The insulation value after 1min. should be minimum 10 M for new transformer at the time of commissioning. Core insulation resistance is generally more than 100 M for new assembled transformer when tested at factory.

3.2 Earth pit resistance measurement

Earth tester is used for measurement of Earth resistance. If earth resistance is more, proper treatment is to be given. For measurement of earth pit resistance, pit earthing connection should be disconnected from main grid. Thereafter, measurement is to be carried out by three point method.

Working of Earth Tester: - There is hand operated D.C.generator. While feeding current to spike, D.C. current is converted into A.C. current by the converter and A.C. current received from spike is again converted in D.C. current by the help of rectifier, while going to generator. A.C. current is fed to the spike driven in earth because there should not be electrolytic effect.

Measurement of Earth Resistance (Three point method):-

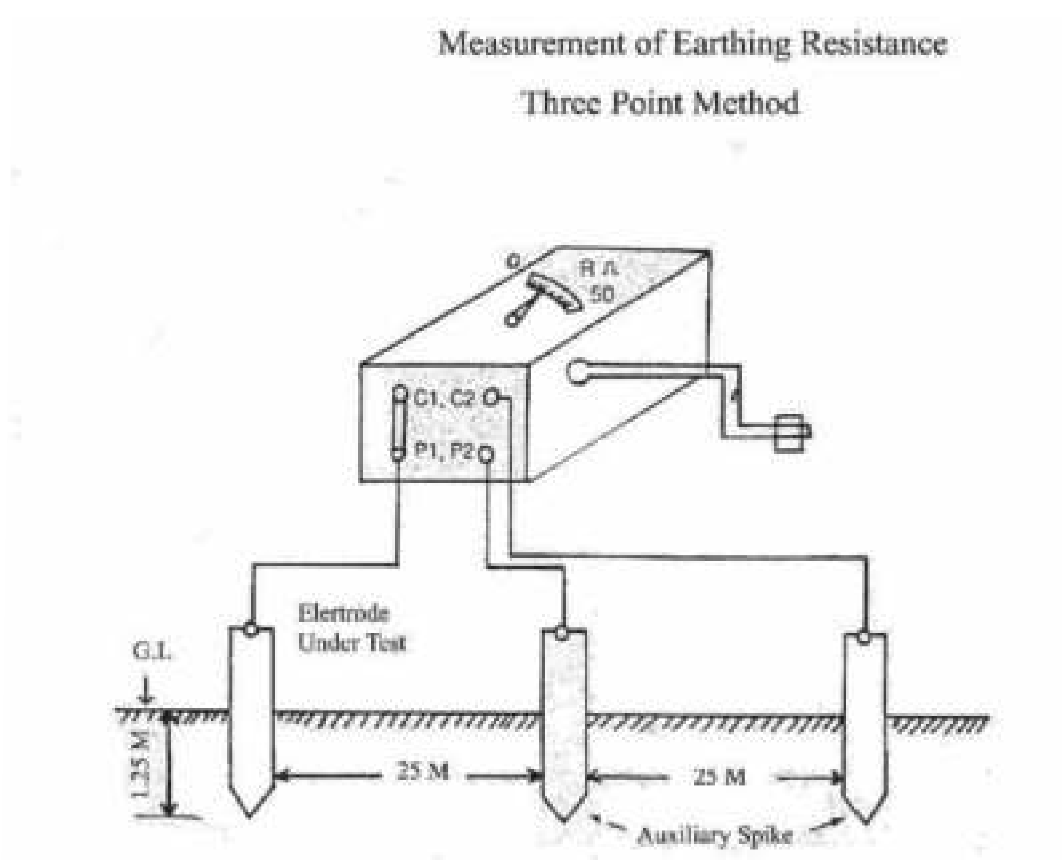


Figure-5

In this method, earth tester terminals C1 & P1 are shorted to each other and connected to the earth electrode (pipe) under test. Terminals P2 & C2 are connected to the two separate spikes driven in earth. These two spikes are kept in same line at the distance of 25 meters and 50 meters due to which there will not be mutual interference in the field of individual spikes. If we rotate generator handle with specific speed we get directly earth resistance on scale.

Acceptable Limit: Value of earth pit resistance should be less than or equal to 1Ω.

3.3 INSULATION RESISTANCE (IR) MEASUREMENT

IR measurements shall be taken between the windings collectively (i.e. with all the windings being connected together) and the earthed tank (earth) and between each winding and the tank, the rest of the windings being earthed. Before taking measurements the neutral should be disconnected from earth. Following table gives combinations of IR measurements for auto-transformer, three -winding transformer & Shunt Reactor

For Auto-transformer	For 3 winding transformer	For Shunt Reactor
HV + IV to LV	HV + IV to LV	HV to E
HV + IV to E	HV + LV to IV	
LV to E	HV + IV +LV to E	

Where HV-High voltage, IV-Intermediate voltage, LV-Low voltage/Tertiary voltage windings, E- Earth

Acceptable Limits: Unless otherwise recommended by the manufacturer, the following IR values as a thumb rule may be considered as the minimum satisfactory values at 30°C (one minute measurements) at the time of commissioning.

Rated Voltage class of winding	Minimum desired IR value at 1 minute (Meg ohm)
11kV	300 MΩ
33kV	400 MΩ
66kV & above	500 MΩ

Insulation resistance varies inversely with temperature and is generally corrected to a standard temperature (usually 20°C) using table (Source: BHEL instruction Manual) as given below:

Difference in temperatures (°C)	Correction Factor (k)
10	1.65
20	2.6
30	4.2
40	6.6
50	10.5

(The measured value to be multiplied by the factor k i.e $T_{20} = k*T_{measured}$)

The ratio of 60 second insulation resistance to 15 second insulation resistance value is called **dielectric absorption coefficient or Index (DAI).** For oil filled transformers with class A insulation, in reasonably dried condition the absorption coefficient at 30°C will be more than **1.3.**

The polarization index test is performed generally by taking mega ohm readings at 1min and 10min insulation resistance value. The **polarization index** is the ratio of the 10 min to the 1 min mega ohm readings.

PI= R_{10}/ R_1 (dimensionless), Where PI is Polarization Index and R is resistance

The following are guidelines for evaluating transformer insulation using polarization index values

Polarization Index	Insulation Condition
Less than 1	Dangerous
1.0-1.1	Poor
1.1-1.25	Questionable
1.25-2.0	Fair
2.0 – 4.0	Good
Above 4.0	Excellent

A PI of more than 1.25 and DAI of more than 1.3 are generally considered satisfactory for a transformer when the results of other low voltage tests are found in order. PI less than 1 calls for immediate corrective action. For bushings, an IR value of above 10,000 MΩ is considered satisfactory.

3.4 Capacitance and Tan δ measurement of Bushings

Dissipation Factor
Dissipation factor/loss factor (Tan delta) is defined as the ratio of resistive component (I_r) of current to that of capacitive current (I_c) flowing in an insulating material.

Power Factor
Power factor is the ratio of resistive current to that of total current. For very low value of resistive currents, values of dissipation factor and power factor are same (up to 2%).

UST
Test set connected for Ungrounded Specimen Test mode. This is used when specimen is isolated from earth e.g. Transformer bushing, CTs with test tap, CVTs and CB voltage grading capacitors. The test mode is often used to reduce the effect of stray capacitance losses to ground, and to reduce the effect of interference pickup from energized apparatus.

GST
Test set connected for grounded specimen test mode. This is used when specimen do not have two specific points (isolated from ground) for Tan delta measurement e.g. Transformer/ Reactor winding, CTs without test tap etc.

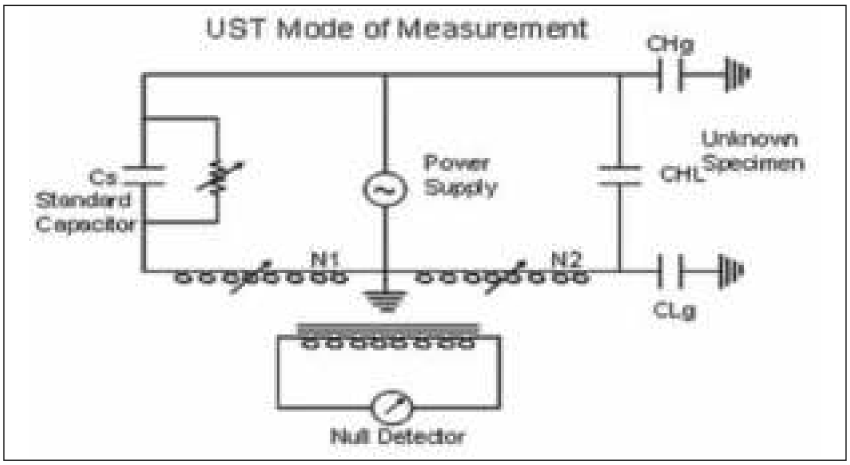
GSTg
This test is used to separate the total values of a GST test into separate parts for better analysis. Often this test is used with GST test to confirm the test readings made using the UST mode

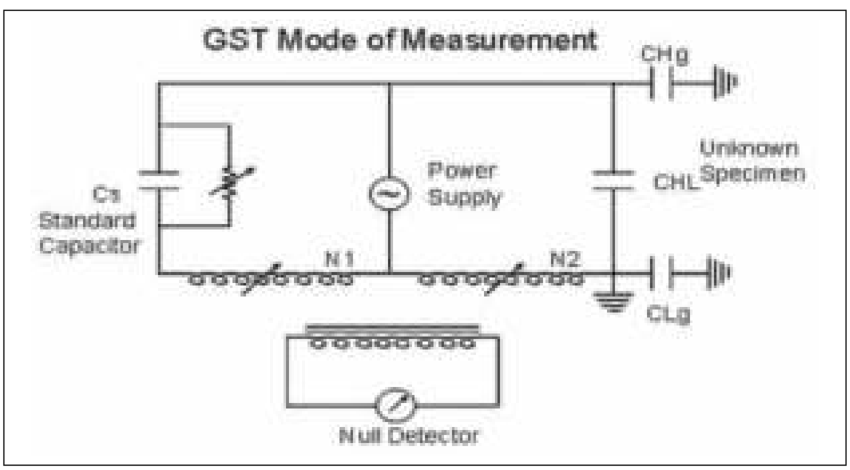
TEST EQUIPMENT
10 KV or 12 KV fully automatic Capacitance and Tan delta test kit to be used for accurate measurement and repeatability of test results.

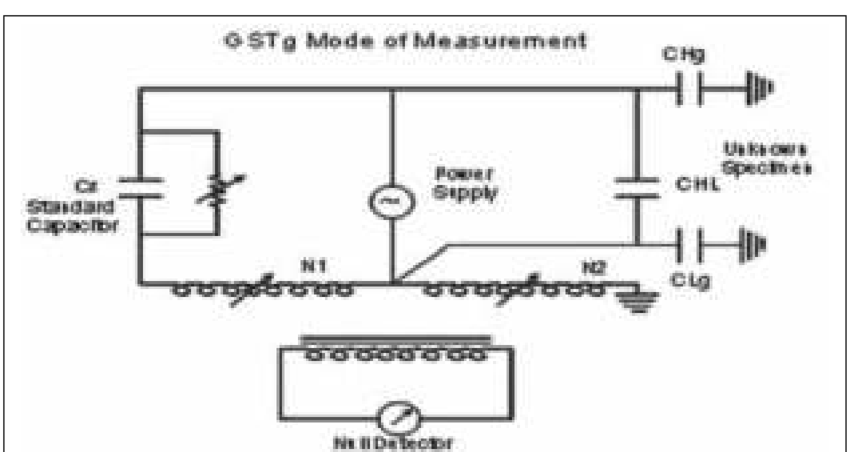
TESTING PROCEDURE

Typical arrangement for Tan δ measurement is given below:

Figure-6







PRECAUTIONS

a) There should be no joints in testing cables.

b) HV lead should be screened with double shield and shields should not have internal shorting otherwise tests in GST/GSTg modes, shall not be possible. Check the same by Insulation Tester(100V)

c) Test leads should not touch any live part.

d) Never connect the test set to energized equipment

e) The ground cable must be connected first and removed at last

f) High voltage plugs should be free from moisture during installation and operation.

g) Testing must be carried out by **experienced/ certified** personnel only.

h) After testing with high voltage (10 kV), test terminals must be grounded before being touched by any personnel.

- For 3-Ph auto-transformer, short together all 400kV, 220kV and Neutral (isolated from earth) Bushings. Also short all 33kV Bushings and earth the same.

  Measurement of C1 Capacitance and Tanδ: Connect the crocodile clip of the HV cable to the top terminal of the shorted HV/IV bushings. Unscrew the test tap cover, Insert a pin in the hole of the central test tap stud by pressing the surrounding contact plug in case of 245 kV OIP Bushing and remove the earthing strip from the flange by unscrewing the screw (holding earth strip to the flange body) in case of 420 kV OIP Bushing. Connect the LV cable to the test tap (strip/central stud) of the bushing under test to the **C & TANδ KIT** through a screened cable and earth the flange body. Repeat the test for all Bushings by changing only LV lead connection of the kit to test tap of the Bushing which is to be tested

  Measurement of C2 Capacitance and Tanδ : HV lead to be connected to the test tap of the bushing under test (if required additional crocodile type clip may be used) and LV of the kit to be connected to the ground. HV of the bushing is to be connected to the Guard terminal of the test kit. Test to be carried out in GSTg mode at 1.0kV.

- For measurement of 33kV Bushing Tan Delta, earth HV/IV Bushings (already shorted). Apply HV lead of the Test kit to shorted 33kV Bushings and connect LV lead of the test kit to Test tap of the Bushing under test.

- Measurements shall be made at similar conditions as that of a previous measurement. The oil-paper insulation combination of bushings exhibit fairly constant tan delta over a wide range of operating temperature. Hence, effort is to be made for testing at temperature near to previous test and correction factor need not be applied.

- Do not test a bushing (new or spare) while it is in its wood shipping crate, or while it is lying on wood. Wood is not as good an insulator as porcelain and will cause the readings to be inaccurate. Keep the test results as a baseline record to compare with future tests.

- It is to be ensured that C& Tan δ measurement of bushings and testing of turrets carried out before installation. This will prevent installation of bushings having C& Tan δ values beyond permissible limits.

- It is to be ensured that Test Tap points are earthed immediately after carrying out the measurements for that particular Bushing and earthing of test tap to be ensured by carrying out continuity test.

  Acceptable Limits: Bushing Tan δ should be less than 0.5% for all type of bushings.

3.5 CAPACITANCE AND TAN δ MEASUREMENT OF WINDINGS

The combination for C & tan δ measurement of winding is same as that of measurement of IR value. The summery of probable combination is given below.

Auto-Transformer (Two winding)	Test Mode	Shunt Reactor	Test Mode	3 winding Transformer	Test Mode
HV + IV to LV	UST	HV to E	GST	HV to LV1	UST
HV + IV to E	GSTg			HV to LV2	UST
LV to E	GSTg			LV1 to LV2	UST
				HV to Ground	GSTg
				LV1 to Ground	GSTg
				LV2 to Ground	GSTg

Table 4: Combination for C & tan δ measurement of winding for various transformers/ Shunt Reactor

- Ensure that test specimen is isolated from other equipments. **Removal of Jumpers from Bushings is Pre-Requisite for C & Tan δ Measurement of Windings.**
- **For ICTs (Auto-Transformers):** Shorting of all three phase Bushings (400kV&220kV) and neutral to be done. In case of single phase, 400kV, 220kV and neutral Bushings to be shorted Capacitance and Tan δ measurement of windings should be done in following combinations.

Test No.	Winding Combination	Test mode	Cap Symbol	Test lead Connection	Remarks
1.	HV-IV/LV	UST	C_{HL}	HV lead of test kit to HV/IV bushings of transformer LV lead of test kit to LV bushing of transformer	
2.	HV-IV/ LV+G	GST	$C_{HL}+C_{HG}$	-do-	
3.	HV-IV / LV with Guard	GST_g	C_{HG}	do–	LV to be Guarded
4	HV-IV/LV	UST	C_{HL}	LV lead of test kit to HV/IV bushings of transformer HV lead of test kit to LV bushing of transformer	
5	LV/ HV-IV +G	GST	$C_{HL}+C_{LG}$	-do-	
6.	LV/ HV-IV with Guard	GST_g	C_{LG}	-do-	HV to be Guarded

Table 5:.Winding combination for C & tan δ measurement for auto transformer

· Measurement inter-check can be done by calculating $\mathbf{C_1 = C_2 - C_3}$ **&** $\mathbf{C_4 = C_5 - C_6}$ & $\mathbf{DF_1 = C_2DF_2 - C_3DF_3 / C_2 - C_3 = C_4DF_4 - C_5DF_5 / C_4 - C_5}$ Where C stands for capacitance and DF for dissipation factor or tan δ and attached suffix (1…6) denotes the sr. no. of test in above table.

· For Reactors: All 400kV and neutral Bushings to be shorted. HV of the test kit to be connected to shorted Bushings and LV of the test kit to be connected to Earth connection. Measure the Capacitance and tan δ in GST mode. Neutral connection with earth/ NGR to be isolated before the test.

Acceptable Limit: Winding Tan δ should be less than 0.5% in all combinations.

3.6 TURNS RATIO (VOLTAGE RATIO) MEASUREMENT

Ratio measurements must be made on all taps to confirm the proper alignment and operation of the tap changers. The test should preferably be performed by automatic Transformer turns ratio (TTR) meter.

Open turns in the excited winding will be indicated by very low exciting current and no output voltage. Open turns in the output winding will be indicated by normal levels of exciting current, but no or very low levels of unstable output voltage. The turns-ratio test also detects high-resistance connections in the lead circuitry or high contact resistance in tap changers by higher excitation current and a difficulty in balancing the bridge.

Acceptable Limit: Results of the voltage ratio are absolute, and may be compared with the specified values measured during factory testing. The turns-ratio tolerance should be within 0.5 % of the nameplate specifications. For three phase Y connected winding this tolerance applies to phase to neutral voltage. If the phase-to-neutral voltage is not explicitly indicated in the nameplate, then the rated phase-to-neutral voltage should be calculated by dividing the phase-to-phase voltage by √3.

3.7 VECTOR GROUP AND POLARITY

Polarity and phase-relation tests are of interest primarily because of their bearing on paralleling or banking two or more transformers. Phase-relation tests are made to determine angular displacement and relative phase sequence. Phase-relation or vector group verification test is performed on a three phase transformer or on a bank of three single-phase transformers. The details of Additive and Subtractive polarity are given in IS: 2026-Part 1 and IEC 60076-1.

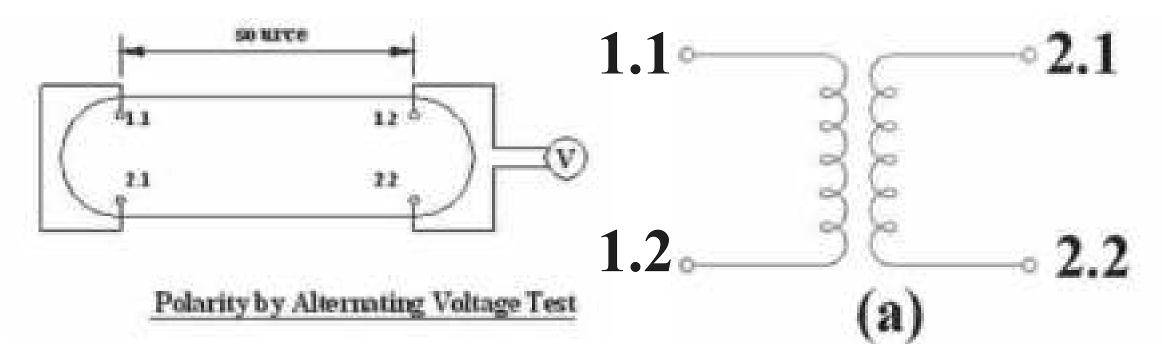


Figure-7

For a single-phase transformer having a ratio of transformation of 30 to 1 or less, the polarity test shall be done as follows. The line terminal of high voltage winding (1.1) shall be connected to the adjacent line terminal low-voltage winding (2.1) as shown in figure 7.

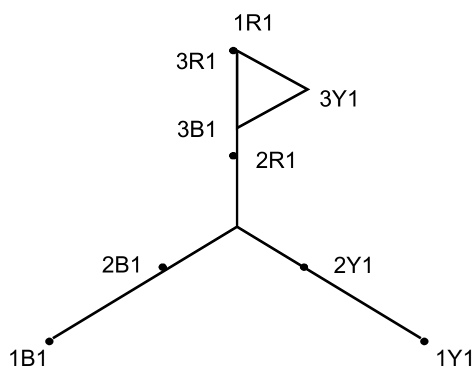
Any convenient value of alternating voltage shall be applied to the full high-voltage winding and readings shall be taken of the applied voltage and the voltage between the right-hand adjacent high-voltage and low-voltage leads.

When the later reading is greater than the former, the polarity is additive.

When the later reading is less than the former (indicating the approximate difference in voltage between that of the high-voltage and low-voltage windings), the polarity is subtractive. The test shall be conducted with 3 phase, 415V supply.

By the measured voltage data, it should be verified that the desired conditions of vector group and polarity are fulfilled

Example for Y D11



- Connect neutral point and LV phase with Earth
- Join 1R1 & 3R1 Terminals
- Apply 415 , 3-Ø supply to HV
- Ensure 2R1-N=2Y1-N=2B1-N=Constant
- If 3R1-N>3Y1-N>3B1-N, and 3Y1-1B1>3Y1-1Y1

Vector group Yna0d11 is confirmed and polarity verified.

Please Note: Most of the auto transformers in POWERGRID are of Yd11configuration.

3.8 MAGNETIC BALANCE TEST

This test is a low voltage test conducted at factory and site by applying single phase voltage between phase and neutral of a winding and measuring voltage induced in other two phases of the same winding. This test is carried out only in three phase units.

Keep the tap in nominal tap position. Disconnect transformer neutral from ground. Apply single phase 230 V across one phase of Highest Voltage (HV) winding terminal and neutral (call it v1) then measure voltage in other two HV terminals across neutral (call them v2 and v3 respectively). Repeat the test for each of the three phases. Repeat the above test for Intermediate Voltage (IV) winding also. The identical results confirm no damage due to transportation. The following points may be noted.

Transformer neutral should be disconnected from ground

(i) No winding terminal should be grounded, otherwise results would be erratic and confusing.

(ii) Zero voltage or very negligible voltage induced in any of the other two phases shall be investigated.

(iii) It is proposed that a set of readings should be taken for information and comparison later during service of the transformer.

Acceptable Limit: Also the applied voltage may be expressed as 100% voltage and the induced voltage may be expressed as percentage of the applied voltage. This will help in comparison of the two results when the applied voltages are different. **The voltage induced in the centre phase shall be 50 to 90% of the applied voltage. However, when the centre phase is excited then the voltage induced in the outer phases shall be 30 to 70% of the applied voltage.**

Zero voltage or very negligible voltage induced in the other two windings should be investigated.

3.9 FLOATING NEUTRAL POINT MEASUREMENT

This test is conducted by applying 3 phase 415 volt supply across HV windings or IV winding as the case may be after disconnecting the transformer neutral from the ground. For a healthy transformer, when 3 phase balance voltage is applied, the voltage between neutral and ground is zero or otherwise a negligible voltage will appear. But in case there is a short circuited winding, the voltage between the neutral and the ground is appreciable. This test will also help in detecting the gradual deterioration or development of fault in the winding during service.

Acceptable Limit For a healthy transformer the voltage between neutral and ground should be zero or negligible. **In case, significant voltage appears between neutral and ground, matter to be referred to the manufacturer.**

3.10 MEASUREMENT OF SHORT CIRCUIT IMPEDANCE

This test is used to detect winding movement that usually occurs due to heavy fault current or mechanical damage during transportation or installation since dispatch from the factory.

Ensure the isolation of Transformer from High Voltage & Low voltage side with physical inspection of open condition of the concerned isolators/ disconnectors. In case tertiary is also connected, ensure the isolation of the same prior to commencement of testing

The measurement is performed in single phase mode. This test is performed for the combination of two windings. The one of the winding is short circuited and voltage is applied to other winding. The voltage and current reading are noted.

The test shall be conducted with variac of 0-280 V, 10 A, precision RMS voltmeter and ammeter. The conductors used for short-circuiting one of the transformer windings should have low impedance (less than 1m-ohm) and short length. The contacts should be clean and tight.

Acceptable Limit: The acceptable criteria should be the measured impedance voltage having agreement to within **3 percent of impedance specified in rating and diagram nameplate** of the transformer. Variation in impedance voltage of more than 3% should be considered significant and further investigated.

3.11 EXCITING/ MAGNETISING CURRENT MEASUREMENT

This test should be done before DC measurements of winding resistance as saturation of winding due to the application of DC voltage may alter the test results. If there is suspected residual magnetism in the winding, transformer under test may be demagnetized before commencement of magnetizing current test.

Three-phase transformers are tested by applying Single-phase 10 kV voltage to one phase (HV terminals) and keeping other winding open circuited and measuring the current at normal, minimum and max. tap positions.

Keep the tap position in normal position and keep HV and LV terminals open. Apply 1phase 10kV supply on IV terminals. Measure phase to phase voltage between the IV terminals and current on each of the IV windings.

Acceptable Limit: The set of reading for current measurement in each of the tap position should be equal. Unequal currents shall indicate possible short circuits in winding. Results between similar single-phase units should not vary more than 10 % .The test values on the outside legs should be within 15 % of each other, and values for the centre leg should not be more than either outside for a three-phase transformers. Results compared to previous tests made under the same conditions should not vary more than **25%. If the measured exciting current value is 50 times higher than the value measured during pre-commissioning checks, then there is likelihood of a fault in the winding which needs further analysis**. The identical results confirm no damage due to transportation. The availability of test data of normal condition and faulty condition results help us to analyze the problem in future.

3.12 OPERATIONAL CHECKS ON OLTC

Following checks should be carried out during pre-commissioning:

- Manual Operation: The tap changer has to be run manually by the hand crank through the total operating cycle. In each operating position, the position indicators of motor drive and tap changer (On TC head) show the same position.
- Motor drive for step by step tap changing operation: Push button to be kept pressed till the motor stops i.e. driving motor should be automatically switched off when the tap changer has performed one switching operation.

(Note: At the time of change over selector operation (i.e. 9b to 10 & vice-versa), higher torque is required. Tap changer end position should be checked that the same is not overrun to avoid any failure during operation. Same can be seen through the inspection glass in the tap changer head cover).

With the tap-changer fully assembled on the transformer the following sequence of operations shall be performed:

a. With the transformer un-energized, one complete cycles of operations (a cycle of operation goes from one end of the tapping range to the other, and back again). Check continuity of winding during this test. Ensure that the voltmeter needle does not deflect to zero. Specify where and how to connect the analog Voltmeter.

b. With the transformer un-energised, and with the auxiliary voltage reduced to 85% of its rated value, one complete cycle of operation.

c. With the transformer energized at rated voltage and frequency at no load, one complete cycle of operation.

The following additional check points/ guidelines for OLTC is recommended in consultation with OLTC manufacturer to ensure the absence of problems and proper operation:

a) Function of control switches

b) OLTC stopping on position

c) Fastener tightness

d) Signs of moisture such as rusting, oxidation or free standing water and leakages

e) Mechanical clearances as specified by manufacturer's instruction booklet

f) Operation and condition of tap selector, changeover selector and arcing transfer switches

g) Drive mechanism operation

h) Counter operation, Position indicator operation and its co-ordination with mechanism and tap selector positions

i) Limit switch operation

j) Mechanical block integrity

k) Proper operation of hand-crank and its interlock switch

l) Physical condition of tap selector

m) Freedom of movement of external shaft assembly

n) Extent of arc erosion on stationary and movable arcing contacts

o) Inspect barrier board for tracking and cracking

p) After filling with oil, manually crank throughout entire range

q) Oil BDV and Moisture content (PPM) to be measured and recorded (Min BDV should be 60 KV and Moisture content should be less than 10 PPM)

3.13 TESTS/ CHECKS ON BUSHING CURRENT TRANSFORMERS (BCTs)

Continuity, Polarity and secondary winding resistance tests of individual cores of Bushing CTs.

3.14 OPERATIONAL CHECKS ON PROTECTION SYSTEM

(For detailed procedure, please refer to DOC NO: D-2-03-XX-01-01 Maintenance Procedures for Switchyard Equipments Part1: EHV Transformers/ Reactors)

1) Operational Checks on Breathers (Conventional Silcagel or Drycol as supplied with the transformers).

2) Visual check of MOG of Main Conservator
3) Marshalling Box & Kiosk Checks
4) Valve Operational Checks
5) Checks on Cooling System
   i. Checks on cooling fans-rotation, speed & Control (Manual /temp /load) setting checks
   ii. Checks on Cooling pumps- rotation, vibration/noise, oil flow direction
6) Checks on temperature Gauges (OTI/WTI-Calibration and Cooler Control, alarm & trip setting tests)
7) Checks on gas actuated (SPRs/ PRDs/ Buchholz) relays –Operational checks by simulation as well as shorting the respective contacts as applicable
8) Checks on tightness of Terminal connectors - micro-ohm measurement of each connection
9) Checks on Transformer/ Reactor protection (differential, REF, Over-current & stability tests etc.)

3.15 STABILITY OF DIFFERENTIAL, REF OF TRANSFORMER/ REACTOR

This test is performed to check the correctness of CT polarity, CT secondary core connections, connections at relay terminals and operation of relay under fault conditions. Here the entire electrical protection scheme is checked.

3.15.1 REF STABILITY TEST FOR TRANSFORMER

1) After opening the Circuit Breaker and isolators at both side (H.V. and L.V. side) of transformer, use "Primary Test Tap (M point or PI1/PI2)" provided in the BUSHING TURRET CTs to bypass the Transformer with the help of Primary current injection leads. Now, after ensuring completion of all CT wiring & normal polarity, inject current with the help of Primary Injection kits in the relevant turret CTs of R phase & Neutral, subject to the maximum rating of Primary Test Tap.
2) Measure the spill current in REF relay which should be nearly zero.
3) Switch off Current Injection.
4) Reverse the polarity of R phase Bushing CT and again start Current Injection. Appreciable spill current will appear in REF relay.
5) Normalize the CT circuit which was reversed in step no. (4), after switching off Current injection.
6) Repeat the same procedure for Y and B phases and note down the results in formats.
7) Normalize the connections of CT.
8) This test has to be performed from both HV side & LV side w.r.t. Neutral.

However, if Primary Test Tap is not available in the Turret CTs, adopt following procedure:

1) After opening the Circuit Breakers and Isolators at both side (H.V. and L.V. side) of transformer apply 440V three phase voltage at three phase bushing of H.V. side with the help of three phase variac.
2) Earth the R phase of the LV side (through isolator earth switch or discharge rod).
3) Measure the spill voltage (in mV)/ spill current (in mA) at REF relay which should be nearly zero.
4) Switch off 440V supply.
5) Reverse the polarity of R phase Bushing CT and again switch on 440V supply. Appreciable spill voltage/ current will appear in REF relay.
6) Normalize the CT circuit which was reversed in step no. (5), after switching off 440V supply.
7) Repeat the same procedure for Y and B phases and note down the results in formats.
8) Normalize the connections of CT and remove feeding of three phase supply.

3.15.2 REF STABILITY TEST FOR REACTOR

1) After opening the Circuit Breaker and Isolators of Reactor, use "Primary Test Tap (M point or PI1/PI2)" provided in the BUSHING TURRET CTs to bypass the Reactor with the help of Primary current injection leads. Now, after ensuring completion of all CT wiring & normal polarity, inject Current with the help of Primary Injection kits in the relevant Turret CTs of R phase of Reactor & earth side CT of NGR, subject to the maximum rating of Primary Test Tap.
2) Measure the spill current in REF relay which should be nearly zero.
3) Switch off Current Injection.
4) Reverse the polarity of R phase Bushing CT and again start Current Injection. Appreciable spill current will appear in REF relay.
5) Normalize the CT circuit which was reversed in step no. (4), after switching off Current injection.
6) Repeat the same procedure for Y and B phases and note down the results in formats.
7) Normalize the connections of CT.

However, if Primary Test Tap is not available in the Turret CTs, adopt following procedure:

1) After opening the C.B. and isolators of Reactor, remove the jumpers of three phase bushings. Reactor Neutral will remain connected to NGR, however Earth connection of NGR Bushing will be opened.
2) Apply 415 volts, phase to phase voltage across R phase bushing of Reactor & earth side Bushing of NGR, after ensuring completion of all CT wiring & normal polarity.
3) Measure the spill voltage (in mV)/ spill current (in mA) in REF relay which should be nearly zero.
4) Switch off 415V supply to Reactor / NGR Bushing.

5) Reverse the polarity of R phase bushing CT.

6) Switch on 415V supply to Reactor / NGR Bushing.

7) Appreciable spill voltage/ current will appear in REF relay.

8) Now normalize the polarity of the Bushing CT which was reversed in step (5).

9) Repeat the same procedure for Y and B phase and note down the results in formats.

10) After completing the test for all three phases normalize the reactor CT connection and jumpers & Earth connection of NGR Bushing.

3.16 FREQUENCY RESPONSE ANALYSIS (FRA) MEASUREMENT

Frequency Response Analysis (FRA) is conducted to assess the mechanical integrity of the transformer which may get disturbed due to transportation shocks. FRA signatures will be taken after assembly and oil filling and compared with factory testing to ensure the healthiness of core /coil assembly during transportation. These signatures will be the benchmark for future reference. The FRA signatures should be analyzed in conjunction with Impact Recorder readings. Report of Impact recorder readings is to be obtained from manufacturer.

It is recommended to follow the standard procedure for the SFRA measurement as per the Table-7. It should be done on maximum, normal and minimum tap of the transformer.

Combination of tests for Auto Transformer

Test Type	Test	3 Φ	1 Φ
Series Winding (OC) All Other Terminals Floating	Test 1	H1-X1	H1-X1
	Test 2	H2-X2	
	Test 3	H3-X3	
Common Winding (OC) All Other Terminals Floating	Test 4	X1-H0X0	X1-H0X0
	Test 5	X2-H0X0	
	Test 6	X3-H0X0	
Tertiary Winding (OC) All Other Terminals Floating	Test 7	Y1-Y3	Y1-Y2 (Y1-Y0)
	Test 8	Y2-Y1	
	Test 9	Y3-Y2	
Short Circuit (SC) High (H) to Low (L) Short (X1-X2-X3)	Test 10	H1-H0X0	H1-H0X0 Short (X1-H0X0)
	Test 11	H2-H0X0	
	Test 12	H3-H0X0	
Short Circuit (SC) High (H) to Tertiary (Y) Short (Y1-Y2-Y3)	Test 13	H1-H0X0	H1-H0X0 Short (Y1-Y2)
	Test 14	H2-H0X0	
	Test 15	H3-H0X0	
Short Circuit (SC) Low (L) to Tertiary (Y) Short (Y1-Y2-Y3)	Test 16	X1-H0X0	X1-H0X0 Short (Y1-Y2)
	Test 17	X2-H0X0	
	Test 18	X3-H0X0	

Table-7: Various combinations for FRA measurement in Auto Transformer

Combination of tests for Shunt Reactor

In case of Shunt Reactor, FRA to be done in following combinations:

- **H1-H0**
- **H2-H0**
- **H3-H0**

3.17 WINDING RESISTANCE MEASUREMENT

Preferably to be carried out using Automatic kit, in case of non availability V/I method can be adopted.

To reduce the high inductive effect, it is advisable to use a sufficiently high current to saturate the core. This will reduce the time required to get a stabilized reading. It is essential that temperatures of the windings are accurately measured. Care shall be taken that self inductive effects are minimized. Care also must be taken to ensure that direct current circulating in the windings has settled down before the measurement is done. In some cases this may take several minutes depending upon the winding inductance.

The winding resistance shall be preferably done when the difference in the top and bottom temperature of the winding (temperature of oil in steady-state condition) is equal to or less than 5 °C.

The winding resistance should preferably be carried out last after completion of all other LV tests, as after this test core gets saturated and tests like magnetizing current, magnetic balance etc. carried out after winding test may be affected and indicate a misleading results, if the core is not de-magnetized before carrying out these tests.

For star connected auto-transformers the resistance of the HV side is measured between HV terminal and IV terminal, then between IV terminal and the neutral AT ALL TAPS. The tap changer should be changed from contact to contact so that contact resistance can also be checked. Measurement of winding resistance is to be carried out from tap position 1 to 17 and again from 17 to 9. While doing measurements in reverse order, 2 to 3 steps shall be enough.

During tap changing operation, continuity checks between HV to neutral to be carried out by analog multimeter while changing tap.
For delta connected windings, such as tertiary winding of auto-transformers, measurement shall be done between pairs of line terminals and resistance per winding shall be calculated as per the following formula:

Resistance per winding = 1.5 x Measured value

Take the winding temperature reading while doing the resistance measurement.

Calculate the resistance at 75°C as per the following formula

$\mathbf{R_{75} = R_t (235+75)/(235+t)}$**,** Where R_t = Resistance measured at winding temperature t

Acceptable Limit: The resistance value obtained should be compared with the factory test value. Results are compared to other phases in Star-connected transformers or between pairs of terminals on a Delta–connected winding to determine if a resistance is too high or low. Because field measurements make it unlikely that precise temperature measurements of the winding can be made, the expected deviation for this test in the field is not more than **5.0%** of the factory test value.

3.18 DISSOLVED GAS ANALYSIS (DGA) OF OIL SAMPLE

Dissolved Gas Analysis (DGA) is a powerful diagnostic tool to detect any incipient fault developing inside the oil-filled equipment. The oil sample is to be taken after oil filling (before commissioning) as a benchmark and there after 24hrs of charging, 7 days, 15 days, one month and three months after charging to monitor the gas build up if any. The oil samples are to be sent to the designated labs for DGA and first two samples for oil parameter testing also.

For detailed procedure for each test, please refer Transformer and Reactor Maintenance manual (Doc No. D-2-03-XX-01-01)-First Revision, Part B, C & D.

CHECK LIST FOR ENERGISATION OF TRANSFORMER/ REACTOR

4.1 PRELIMINARY CHECKS

1. Release air at the high points, like oil communicating bushings, buchholz petcock, tank cover and the cooling devices including headers, radiators, pumps, expansion joints etc. of the transformer. Air release should be resorted from low points to high points.

2. Check the whole assembly for tightness and rectify where necessary.

3. Check the general appearance and retouch the paint work if needed.

4. Check that the valves are in the correct position :
   - Tank: valves closed and blanked
   - Cooling circuit: valves open
   - Conservator connection:valves open
   - By-pass: valves open or closed as the case may be.
   - On-load tap changer:valves open
5. Check that the silica gel is completely filled in the breather and is blue and that there is oil in the breather cup (oil seal)
6. Ensure that CC & CL are properly grounded.
7. Check the oil level in the main conservator and the conservator of on-load tap changer, as per manufacturers recommendations
8. Check the bushings:
   - Oil level (bushings fitted with sight-glasses)
   - Adjustment of spark-gaps /arcing horn –gaps, if provided
   - Conformity of connection to the lines (no tensile stress on the terminal heads)
   - Bushing CT secondary terminals must be shorted and earthed, if not in use.
   - Neutral bushing effectively earthed
   - Tan delta cap should be tight and properly earthed.
9. Check the on-load tap changer:
   - Conformity of the positions between the tap changer control cubicle and the tap changer head

- Adjustment of the tap-changer control cubicle coupling
- Electric and mechanical limit switches and protective relays
- Step by step operation- local and remote electrical operation as well as manual operation and parallel operation, if any
- Signaling of positions

10. Check the quality of the oil:
    - Draw a sample from the bottom of the tank.
    - Carry out DGA and oil parameters test

11. **Prior to energization at site, oil shall be tested for following properties & acceptance norms as per below generally in line with IS: 1866 / IEC 60422:**

1.	Break Down voltage (BDV)	: 70 kV (min.)
2.	Moisture content	: 5 ppm (max.)
3.	Tan-delta at 90 °C	: 0.01 (max.)
4.	Total Gas Content	: < 1%
5.	Resistivity at 90 °C	: 6 X 10^{12} ohm-cm (min.)
6.	Interfacial tension	: 0.035 N/m (min.)
7.	*Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500 hour for inhibited oil)	
	a) Acidity	: 0.3 (mg KOH /g) (max.)
	b) Sludge	: 0.05 % (max.)
	c) Tan delta at 90 °C	: 0.05 (max.)

· *For Sr. No. 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of POWERGRID

12 Check that equalizing link between OLTC tank and Main tank is removed

13 Extraneous materials like tools, earthing rods, pieces of clothes, waste etc. should be removed before energizing.

4.2 CHECKING OF AUXILIARY AND PROTECTIVE CIRCUITS

1. Ensure that the temperature indicators are calibrated.
2. Check the setting and working of the mercury switches of winding and oil temperature indicators

3. Ensure presence of oil in the thermometer pockets.
   - Follow the same procedure for the thermal replicas
4. Check the direction of installation of buchholz relay.
5. Check the operation of the buchholz relay and the surge protective relay of the tap-changer for:
   - Alarm and tripping
   - Protections and signals associated with these relays
6. Check the insulation of the auxiliary circuits with respect to ground by 2 kV insulation tester for 1 min. It should withstand the test.
7. Check the earthing of the tank and auxiliaries like cooler banks at two places.
8. Measure the supply voltages of the auxiliary circuits
9. Check the cooling system for the following:
   - Check the direction of installation of oil pumps
   - Check the direction of rotation of the pumps and fans
   - Check the working of the oil flow indicators
   - Check the setting of the thermal overload relays
   - Go through the starting up sequences, control and adjust, if necessary, the relay time delays
10. Check that there is sufficient protection on the electric circuit supplying the accessories and tightness of all electrical connections
11. Check the heating and lighting in the cubicles
12. Check the schemes of differential protection, over-current protection, restricted earth fault protection, over-fluxing protection etc. With implementation of settings as recommended by CC/Engg

After the inspection / tests are completed, the transformer may be energized from the incoming side on NO LOAD, 400kV or 220kV. The initial magnetizing current at the time of switching will be very high, depending upon the particular moment in the cycle. The transformer should be kept energised for twelve hours before taking on load. During this time, vibrations, abnormal cracking noise, etc. are to be observed.

After that it may be checked for gas collection. If the gas prove to be inflammable, try to detect the cause which may probably be an internal fault. If the breaker trips on differential /REF, buchholz or any other protective device, the cause must be investigated thoroughly before re-energizing the transformer/ reactor. After successful charging, performance of transformer / rector should be checked under loading; OTI/WTI readings should be monitored for 24 hours and ensured that they are as per loading.

DGA samples may be sent as per Standard practice (after 24 hrs of energizing, one week, 15 days, one month and three months after charging, thereafter as per normal frequency of 6 months). Loading data may be forwarded to CC/OS and manufacturer (if requested by them).

POST COMMISSIONING CHECKS/TESTS FOR TRANSFORMERS AND REACTORS

Sr. No.	Name of Test/ Check point	Purpose of test/ check
5.1	Thermovision Infra-red scanning (IR thermography)	A thermo vision Camera determines the temperature distribution on the surface of the tank as well as in the vicinity of the Jumper connection to the bushing. The information obtained is useful in predicting the temperature profile within the inner surface of tank and is likely to provide approximate details of heating mechanism.
5.2	On Line moisture measurement	To determine the moisture content in paper insulation by measuring % Relative Saturation/ Active Water. This test to be carried out once the Transformer/ Reactor is stabilized and operating at higher temperature (>60 deg C).
5.3	Vibration measurement of Oil-immersed Reactor	To measure the vibrations of core /coil assembly in the tank of the reactor. Movement of the core-coil assembly and shielding structure caused by the time–varying magnetic forces results in vibration of the tank and ancillary equipment. These vibrations have detrimental effects such as excessive stress on the core-coil assembly

5.1 THERMOVISION SCANNING (IR THERMOGRAPHY)

Once the transformer/ reactor is charged and loaded, Thermovision scanning is to be carried out to see any hotspots. Thermovision scanning of transformer to be done at least after 24 hrs. of loading and repeated after one week.

5.2 ON LINE MOISTURE MEASUREMENT

5.3 VIBRATION MEASUREMENT OF OIL-IMMERSED REACTOR

Movement of the core-coil assembly and shielding structure caused by the time –varying magnetic forces results in vibration of the tank and ancillary equipment. These vibrations have detrimental effects such as excessive stress on the core-coil assembly. The shunt reactor under test shall be completely assembled in normal operating condition with cooling equipments, gauges and accessories. The shunt reactor shall be energized at rated voltage and frequency. Three phase excitation for 3-ph units. The shunt reactor should be mounted on a level surface that will provide proper bearing for the base, in order to eliminate the generation of abnormal tank stresses.

The vibration of shunt reactor shall be measured by transducers, optical detectors or equivalent measuring devices. The measuring equipment should be accurate within +/- 10 % at 2nd harmonic of the exciting frequency. The peak-to-peak amplitude shall be determined by direct measurement or calculated from acceleration or velocity measurement. The average amplitude of all local maximum points shall not exceed 60 µm (2.36 mils) peak to peak. The maximum amplitude within any individual reading shall not exceed 200 µm (7.87 mils) peak to peak.

PRE-COMMISSIONING CHECKS/TESTS FOR OTHER SWITCHYARD EQUIPMENTS

Once erection is completed, various pre-commissioning checks/ tests are performed to ensure the healthiness of the switchyard equipments prior to their energisation. Various major electrical tests to be performed and their significance are given below:

Sr. No.	Name of Test / Check point	Purpose of test/ check
6.1	Tan δ & Capacitance measurement of CT, each stack of CVT & total capacitance, CB voltage grading capacitor & each stack of Surge Arresters	The purpose of the dissipation factor measurement of high voltage insulation is to detect incipient weaknesses in HV insulation. The most important benefit to be gained from this measurement is to obtain a "benchmark reference reading" on costly and high voltage equipment when the equipment is new and insulation is clean, dry and free from impurities. Tan delta & Capacitance values shall be comparable with factory test results and in no case shall be more than 0.5 %.
6.2	**Checks/ Tests applicable for CTs**	
6.2.1	Polarity test for CT	To ascertain whether the polarity markings are correct or not as per drawing.
6.2.2	Magnetization characteristics of CT	To prove that the turns of CTs secondary windings are not short circuited and to check healthiness of CT cores. The magnetizing currents at KPV (Knee point voltage) shall be less than the specified value. The ratio of secondary and primary voltage shall also be measured.
6.2.3	Ratio test for CT	The ratio errors of the primary to the secondary currents should within specified ratio errors.
6.2.4	IR measurement of CT (Primary & Secondary windings)	Changes in the normal IR value of CT indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of CT and degradation of insulation.
6.2.5	DGA test of CT oil	This test shall be conducted after 30 days of commissioning. The purpose is to identify evolving faults in the CT and DGA values shall be comparable with factory values (if available)
6.3	**Checks/ Tests applicable for Circuit Breakers**	
6.3.1	Dew point measurement of SF6 gas	Dew point of SF6 gas is to measure moisture content in SF6 gas which shall indicate whether CB evacuation is done properly or not. This test shall be carried out preferably at rated pressure of SF6 gas.
6.3.2	Measurement of Circuit	To measure closing/ tripping/ CO timings. These timings

Sr. No.	Name of Test / Check point	Purpose of test/ check
	Breaker Operating Timings including PIR Timings	should be within permissible limits and shall be comparable with factory values. Pole discrepancies and Break to Break discrepancies shall be less than specified values.
6.3.3	DCRM Contact Travel Measurement / DC injected currents and trip/ close coil currents.	DCRM is the technique for measuring Contact Resistance during operation (Close/ Trip) of a circuit breaker with a delay Tco of 300ms. A DC current of at least 100 Amp is injected through the circuit breaker. The current and voltage drop are measured and resistance is calculated. The resistance and travel versus time data provides useful information on the condition of the circuit breaker contacts and is used as a diagnostic tool. DCRM test signatures shall be approved by Corporate OS.
6.3.4	Operational lockout checking for EHV Circuit Breakers	To ensure various lockout operation of CB by simulating the actual conditions at the specified pressure of oil/ air/ operating medium.
6.3.5	Measurement of static contact resistance	This test is conducted to evaluate healthiness of Main contacts. 100 Amp DC is injected and voltage drop is measured across each CB contact to compute contact resistance.
6.3.6	Checking the Anti-Pumping feature	By giving simultaneous close/ trip commands, CB hunting shall not take place by operation of Mechanical/ Electrical anti pumping feature.
6.3.7	Checking the Anti-Condensation Heaters	To check correct operation of Thermostat provided for anti condensation heaters.
6.3.8	Pole discrepancy relay testing	To test tripping of CB in case of pole discrepancy more than 2.5 seconds or specified value.
6.3.9	Checking the N2 priming pressure	This test is to check healthiness of N2 accumulators provided in Hydraulic drive mechanisms. N2 priming pressure shall be as per the rated pressure.
6.4	**Checks/ Tests applicable for CVTs**	
6.4.1	CVT polarity, Ratio test	This test is conducted in the same manner as for CT to determine correct CVT polarity, ratio and phasor group.
6.4.2	Insulation resistance measurement of Primary & secondary winding	Changes in the normal IR value of CVT indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of CVT and degradation of insulation.
6.5	**Checks/ Tests applicable for Isolators**	
6.5.1	MILLIVOLT Drop test	The voltage drop gives a measure of resistance of current carrying part and contacts by injecting minimum 100 A DC current.

Sr. No.	Name of Test / Check point	Purpose of test/ check
6.5.2	50 operation tests	To test operation of contacts etc with jumpers connected and contact resistance to be measured after 50 operations. There shall not be any change from the previous value.
6.6	**Checks/ Tests applicable for Surge Arrestors**	
6.6.1	Third Harmonic Resistive Current (THRC) for surge arrestors	To monitor healthiness of Surge arrestors by monitoring third harmonic resistive current from the leakage current. This test is to be conducted after charging of Las. The value of THRC shall be less than 30 µA.
6.6.2	IR measurement of each stack of LA	Changes in the normal IR value of LA indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of LA and degradation of insulation.
6.6.3	Checking of operation of LA counter	This test is done to check the healthiness of LA counter.
6.7	**Checks/ Tests for other areas/ equipments**	
6.7.1	Earth resistance measurement	To ensure value of earth resistance is below 1 ohm.
6.7.2	Secondary current injection test	Conducted for testing of protecting devices, circuit breakers, trip coils, motor overloads etc.
6.7.3	Contact Tightness check of Bay contacts by Primary injection method	Since complete bay contact resistance measurement is practically not possible because DC current may not be injected in CT primary, hence contact tightness check by primary injection method has been introduced to check overall contact tightness.
6.7.4	Stability check for Bus Bar	This test is performed to check the proper operation of Bus Bar protection by simulating actual conditions. Any problem in CT connection, wrong cabling, relay setting can be detected by this test.

6.1 TAN DELTA & CAPACITANCE MEASUREMENT OF CT, CVT, CB VOLTAGE GRADING CAPACITORS AND LA STACKS

To measure dissipation factor/loss factor (Tan delta) and Capacitance measurement of EHV class CTs, CVTs, CB Voltage Grading Capacitors & LA stacks by applying test voltages up to 10kV.

A) CURRENT TRANSFORMERS

CTs with test taps

1. Tan delta tap to be disconnected from ground.
2. High voltage lead from tan delta kit to be connected to primary(HV) Terminal and LV lead to be connected to the Tan delta test tap.
3. P1 and P2 to be shorted
4. Porcelain surface to be thoroughly cleaned.
5. Measurements have to be taken in UST mode with fully automatic test kit.
6. Standard procedure(as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/induced voltage conditions should be followed for measurement of capacitance and tan delta values.
7. It is to be ensured to connect the test tap to ground terminal after carrying out the test.

B) CB VOLTAGE GRADING CAPACITOR

1. Connect LV cable to the middle of the double interrupter.
2. Connect HV cable to the other end of the Grading capacitor to be tested.
3. The opposite end of the grading capacitor has to be grounded using earth switch.
4. Measurements have to be taken in UST Mode with fully automatic test kit.
5. Disconnect the HV cable and connect the same to the other grading capacitor and ground the previous grading capacitor. Now the second grading capacitor is ready for testing.
6. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/induced voltage conditions should be followed
7. Measurements are to be carried out at 10 kV/ 12 KV.

C) CAPACITOR VOLTAGE TRANSFORMERS

1. Testing procedure for Top and Middle Stacks:
   (a) Apply 10 KV between flanges of Top/Middle stacks (whichever is being tested)
   (b) Carry out measurements in UST mode at 10.0 KV
   (c) While measuring Middle/ Bottom stacks, Top/ middle stacks to be shorted.

2. Testing procedure for Bottom Stack connected to EMU PT
   (a) Connect HV of the test kit at the top flange of bottom stack. HF point to be grounded. Earth connection of the neutral of the PT to be opened/ isolated from ground.
   (b) Top of CVT to be guarded. LV lead of the kit to be connected at the top of the CVT for guarding.

(c) Carry out measurements in GSTg mode at 10.0 KV
(d) Repeat the Test with neutral of PT connected to ground.
(e) In case Tan delta value is negative or erratic, only capacitance values are to be monitored.
(f) Measurement to be carried out using fully automatic kit.

3. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.

D) SURGE ARRESTERS

1. Testing procedure for Top, Middle and Bottom Stacks:
   (a) Apply 10 KV between flanges of Top/Middle/ Bottom stacks (whichever is being tested)
   (b) Carry out measurements in UST mode at 10.0 KV with fully automatic test kit.
   (c) While measuring Middle/ Bottom stacks, the stacks above the HV lead to be shorted.
2. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.
3. While doing measurement of bottom stack the earth connection to be removed.

6.2 CHECKS/ TESTS APPLICABLE FOR CTs

6.2.1 POLARITY TEST FOR CT

A centre zero voltmeter is connected across CT secondary. A 1.5 Volt battery is touched to primary of CT. The deflection of pointer should be similar in case of each CT core.

At any instant current entering the primary from P1 the current should leave secondary from the terminal marked S1. A setup shown in the Figure 9 can show whether the polarity markings are correct or not.

When the key is pressed, current enters the primary through terminal P1, the voltmeter connected as shown, should read positive. A general arrangement of polarity test setup is indicated in Fig. 10.

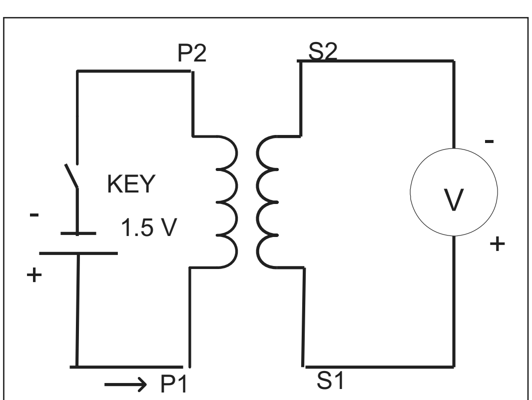


Figure - 9

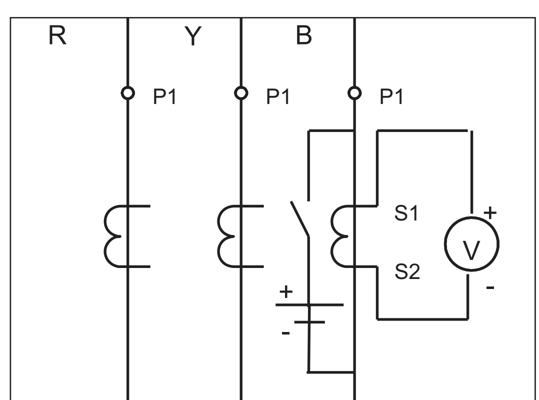


Figure - 10

6.2.2 MAGNETIZATION CHARACTERISTICS OF CTs

PRECAUTIONS

a) There should be no joints in testing leads/cables.
b) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.

Test Equipment: Voltage source of 5 kV, Voltmeter of range 0 to 5 kV, Ammeter of range 0 to 500 Amps, testing leads/cables etc.

Test Procedure: Make connections as per diagram shown below (Fig- 11). After making proper connections, applied voltage is increased from zero to rated Knee Point Voltage in steps of 25%, 50%, 75% and 100%. Measure the current drawn by the CT secondary core at respective applied voltages and record the test results

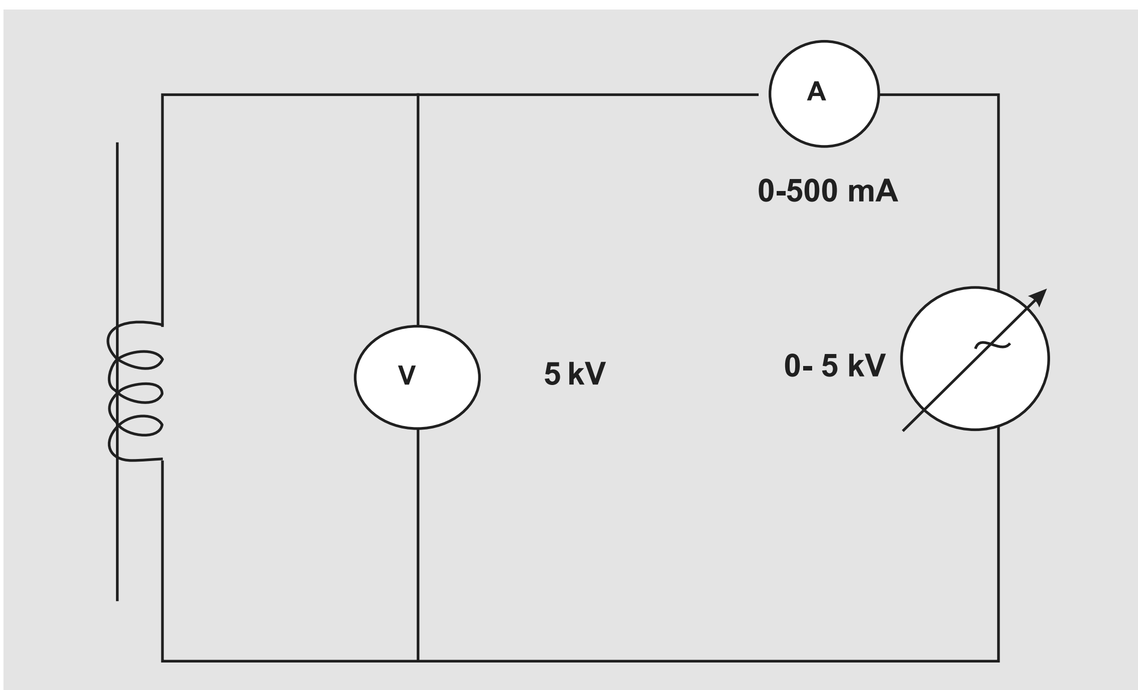


Figure - 11

Knee Point Voltage is normally defined as the voltage at which 10% increase in the applied voltage causes 30 to 50% increase in secondary current. The magnetization current at rated Knee Point Voltage should not be more than the specified/designed value. A curve can be drawn between applied voltage and magnetizing current. Typically, the curve drawn should be like the one given below in Fig.-12.

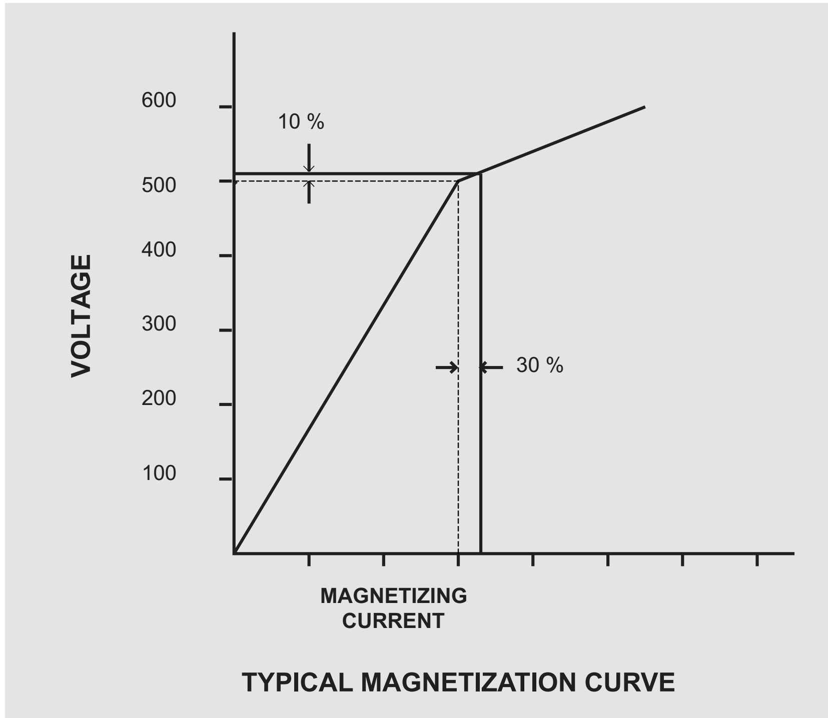


Figure - 12

From the curve it can be implied that up to rated KPV (Knee Point Voltage), the VI curve should be almost a straight line. However, if this line is not linear, this indicates that the magnetizing characteristics are not desirable. If the slop of the curve starts increasing, it indicates that magnetizing induction becomes low and total primary current is utilized in exciting the core alone. Consequently, out put of CT secondary disappears.

6.2.3 RATIO TEST FOR CURRENT TRANSFORMER

The ratio check has to be carried out as indicated in Fig-13 below.

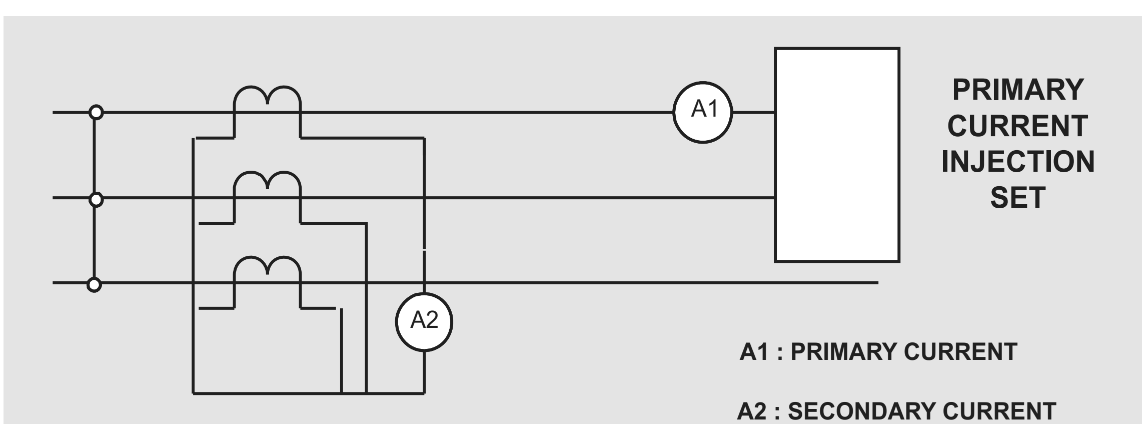


Figure - 13

It is customary to conduct this in conjunction with the primary injection test. Current is passed through the primary circuit with the secondary winding circuit to its normal circuit load. The ratio of the primary to the secondary currents should approximate closely to that stamped under CT identification plate.

Alternatively, ratio test is to be conducted as per the following method (Fig-14).

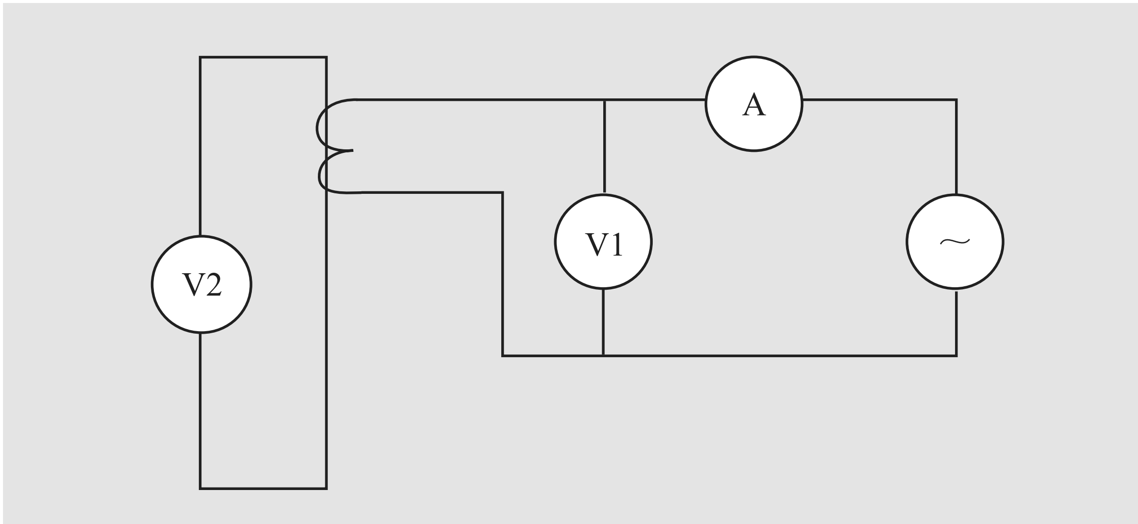


Figure - 14

Apply voltage from secondary of the CT and measure voltage in primary winding. Increase voltage in secondary up to rated KPV/ ISF and by recording Primary Voltage, compute ratio of V1/ V2. The ratio should match with the specified value.

6.2.4 INSULATION RESISTANCE MEASUREMENT OF CURRENT TRANSFORMER

PRECAUTIONS

a) There should be no joints in testing cables.

b) Test leads should not touch any live part.

c) Megger body should be earthed (if separate terminal is provided).

d) Surface/terminals should be cleaned.

e) IR measurement should be carried out preferably in dry and sunny weather.

f) Never connect the test set to energized equipment.

g) The ground terminal must be connected first and removed at last.

h) High voltage plugs should be free from moisture during installation and operation.

i) If oil traces are found on the surface of CT, the same should be cleaned by Methyl Alcohol only. Petrol or diesel should never be used.

j) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing engineer only.

k) After testing with high voltage, test terminals must be grounded before being touched by any personnel.

l) Test leads should be properly screened/ shielded.

Connect the Megger as per figure-15 given below. Connect the HV terminal to the Primary terminal of CT by using crocodile clip for firm grip

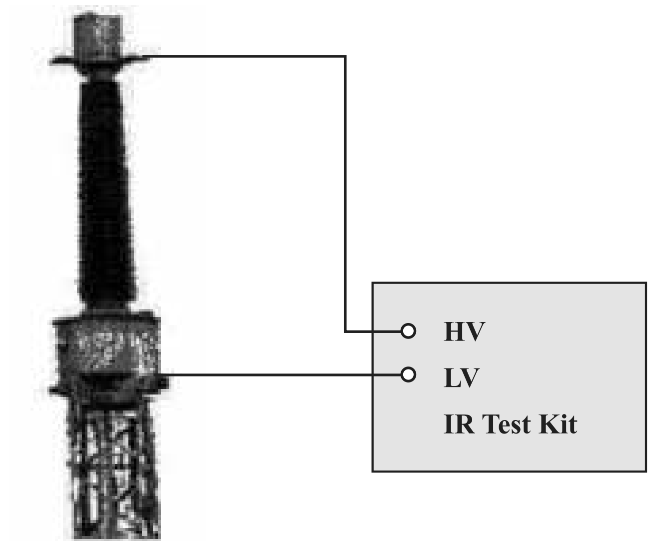


Figure-15 Typical Arrangement for IR measurement

Carry out the measurement as per standard procedure given by the kit supplier.

A test voltage as specified is applied as per the above connections and successive readings are taken. Values of IR should be recorded after 15 seconds, 60 seconds and 600 seconds. Ambient temperature and weather conditions are to be recorded.

6.2.5 DGA Test of CT Oil: Oil samples to be collected in 300ml bottles and to be sent to CIOTL Hyderabad for testing. Test results should be comparable to factory values. In case of any deviation, test results to be forwarded to CC-OS for approval.

6.3 CHECKS/ TESTS APPLICABLE FOR CIRCUIT BREAKERS

6.3.1 DEW POINT MEASUREMENT OF SF6 GAS FOR CIRCUIT BREAKER

Dew Point is the temperature at which moisture content in SF6 gas starts condensing.

Dew Point at rated pressure of CB: Dew Point when measured keeping regulating valve in service at the outlet of dew point kit to allow required flow rate of gas, is called at rated pressure of CB. Inlet valve is opened completely.

Dew Point at atmospheric pressure : Dew Point when measured by regulating the gas flow at the inlet of dew point kit and keeping outlet regulating valve (if provided) in fully open condition so that flow rate of gas is maintained as required, is called at atmospheric pressure.

TESTING PROCEDURE

a) Make the connections to the kit from CB pole ensuring that regulating valve is fully closed at the time of connections of the Dew Point kit.

b) By regulating the flow rate of SF6 gas (0.2 liter/min to 0.5 liter/min - ref. IEC 60480), the value of dew point is observed till it becomes stable.

c) If the regulating valve is provided at outlet of the dew point kit then values as given in Doc. no. for rated pressures are to be monitored.

Dew Point of SF6 gas varies with pressure at which measurement is being carried out. This is due to the fact that Saturation Vapour Pressure decreases with increase in Pressure of the SF6 gas. Hence, dew point of SF6 gas at higher pressure is lower than dew point at atmospheric pressure Therefore, it is to be ensured that if measurement has been done at a pressure other than the atmospheric pressure, same is to be converted to the atmospheric pressure as given in the table below used at the time of commissioning for various CB manufacturers: Method for converting dew point at different gas pressures, is given/described in IEC-60480.

Sl. No.	Make of CB	Dew point at rated pressure	Dew point at Atmospheric Pressure (Limit)
1	BHEL	(-) 15° C	- 36° C
2	M & G	-	- 39° C
3	CGL	(-) 15° C	- 35° C
4	ABB	(-) 15° C	- 35° C
5	NGEF	(-) 15° C	- 36° C

6.3.2 MEASUREMENT OF CIRCUIT BREAKER OPERATING TIMINGS INCLUDING PRE INSERTION RESISTOR TIMINGS

PRECAUTIONS

a) There should not be any joint in testing cables.
b) Test leads should not touch any live part.
c) Never connect the test set to energised equipment.
d) The ground cable must be connected first and removed at last.
e) High voltage plugs should be free from moisture during installation and operation.
f) Circuit Breaker Analyser body should be earthed (if separate earth is provided).
g) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.
h) Surface/terminals should be cleaned where the connections for testing are to be made.
i) Clean earth point with sand paper/wire brush where earth terminal is to be provided.
j) Ensure that all the poles trip simultaneously through single close/trip command.

TESTING PROCEDURE

a) Make connections as shown in the figure-16 below. It is to be ensured that R, Y, B phase marking cables are connected with the proper place in the CB analyser and colour codes are to be maintained for all the three poles of CB.
b) Make connections for recording operating timings of Auxiliary contacts.
c) Extend power supply to Circuit Breaker Analyzer.
d) Give closing command to closing coil of CB and note down the PIR and main contact closing time. Take the print out from the Analyzer.

e) Give tripping command to trip coil-I of CB & note down the main contact tripping time.

f) Give tripping command to trip coil-II of CB & note down the main contact closing time.

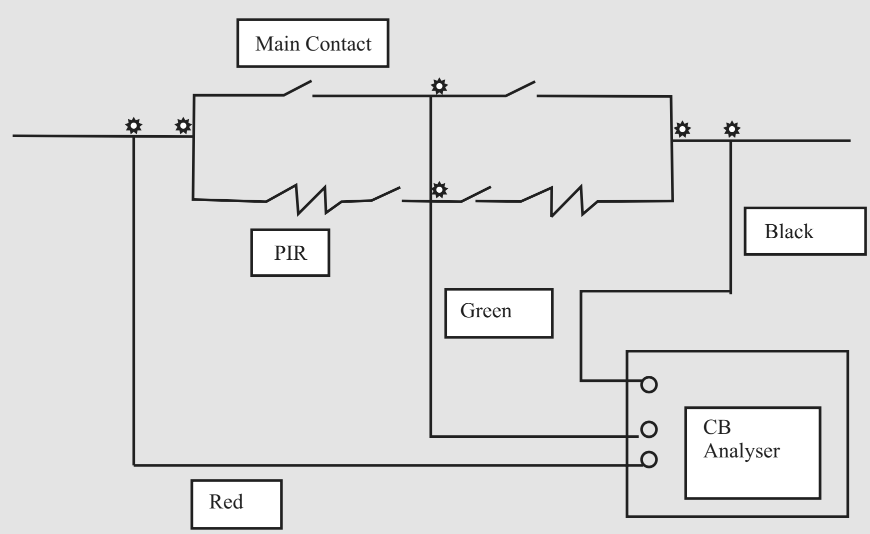
g) Note down the timings for `CO', and `OCO' by giving respective commands. CO command to be given without time delay but 300ms time delay to be given between O and CO operation in testing for OCO.

h) To find out opening time of PIR contacts, PIR assembly has to be electrically isolated from Main contacts and then PIR contacts are to be connected to separate digital channels of the Analyzer.

EVALUATION OF TEST RESULTS

A) CLOSING TIMINGS

Closing timings and Discrepancy in operating times of PIR and main contacts should not exceed the permissible limits as specified in the DOC NO: D-5-02-XX-01-03. In any case, main contacts should not close prior to closing of PIR contacts and PIR contacts should not open prior to closing of main contacts. In case, contact bouncing is observed in operating timings for PIR and main contacts, same should be rectified by tightening the cable connections.



Typical Arrangement for Operating Timings Measurement of CB

Figure - 16

B) TRIPPING TIMINGS

Trip time and pole discrepancy in operating timings should not exceed beyond permissible value given in Doc. No. D-5-02-XX-01-03. In case of ABB, NGEF and CGL make CBs, while tripping, PIR contacts should not open after opening of main contacts.

C) 'CO' TIMINGS

CO timings should be within permissible limits as specified by different manufacturers.
If operating timings of CB poles are not within limits, same may be corrected by:

1. Equalizing the SF6 gas pressure in all the poles
2. Adjusting plunger movement of trip/ close coils
3. Adjustment in operating mechanism
4. Changing of trip/ close coils (if required)

It is also important to measure timings of auxiliary contacts from the point of view of variations w.r.t. the main contacts.

6.3.3 DYNAMIC CONTACT RESISTANCE MEASUREMENT (DCRM) AND CONTACT TRAVEL MEASUREMENT OF EHV CIRCUIT BREAKERS

Test Equipment: 100 Amp. DCRM kit with CB operational analyzer with 10k Hz sampling frequency.

Isolation Required

a) CB should be in open position.
b) Isolator of both sides of CB should be in open position.
c) Earth switch of one side of CB should be in open position.

Precautions

a) There should be no joints in testing leads/cables.
b) It should be ensured that whole testing equipment along with testing procedures are available at testing site. Testing must be carried out in presence of testing personnel only.
c) Current leads should be connected such that voltage leads are not outside area of current flow.

Testing Procedure

1. Follow the standard procedure as given in instruction manual of DCRM kit.
2. The tightness of connections at CB flanges is most important to ensure error free measurement. CB during CO operation generates lot of vibrations and failure of connections during this period can dramatically change the dynamic signature of CB resistance.
3. DCRM signatures should be recorded for CO operation. Open command should be extended after 300 ms from the close command.
4. Clean portions of incoming and outgoing flanges of CB with polish paper to remove paint, oxidation etc, at points where Current clamps are mounted.
5. Select this point of connection, as close as possible to the end of porcelain insulator to ensure that minimum resistance is offered by flanges, bolts, terminal connectors etc.
6. It should be ensured that Travel Transducers are properly fitted.
7. Sampling frequency during measurement should be 10 KHz.
8. Resistance, travel, injected current and Trip/ Close coil currents are to be recorded.

The variations in the measured resistance versus time will be seen as a finger print for the breaker contacts and can be used as a bench mark for comparing with future measurements on the same breaker. This provides information on the condition of the breaker contacts, driving mechanism, operating levers etc.

Dynamic Contact Resistance Measurement for CB healthiness

By application of Dynamic Contact Resistance Measurement, condition of arcing contact, main contact, operating levers, driving mechanism can be predicted. If DCRM signature shows vide variations and also there is change in arcing contact insertion time, it indicates erosion of the arcing contacts to main contacts and subsequent failure.

Contact Travel Measurement

Transducers are attached to the operating rod or interrupting chamber in order to record the contact travel. When CB closes, contact travel is recorded. Contact bounces or any other abnormality is also clearly indicated by the Contact Travel Measurement.

If contact travel, contact speed and contact acceleration signature are compared with the original signatures, then it may indicate problems related with the operating mechanism, operating levers, main/ arcing contacts, alignments etc.

DCRM along with Contact Travel measurement is useful in monitoring length of Arcing contacts. Erosion of Arcing contacts may lead to commutation failures and current may get transferred to Main contacts. Due to heat of arc, main contacts may get damaged.

6.3.4 OPERATIONAL LOCKOUT CHECKING FOR EHV CIRCUIT BREAKERS

6.3.4.1 TESTING PROCEDURE:

A. SF6 GAS PRESSURE LOCKOUT

a) LOW PRESSURE ALARM

Close Isolation Valve between CB Pole(s) and density monitor. Start releasing SF6 gas from density monitor till the low pressure gas alarm contacts are actuated which is detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated.

b) OPERATIONAL LOCKOUT:

Continue releasing SF_6 gas from isolated zone till the operational lockout Alarm Contacts are actuated which are detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated. This is called operational lockout pressure.

B. PNEUMATIC OPERATING SYSTEM LOCKOUT

a) COMPRESSOR START/STOP SWITCH

Close the isolating valve of CB. Release air into atmosphere from the compressor. Note down the value of pressure at which Compressor starts building up air pressure and pressure at which Compressor stops.

b) CB AUTO RECLOSE LOCKOUT

Close isolation valve between pneumatic system and pressure switches. Release air from the isolated zone to atmosphere. Note down pressure at which A/R L/O contacts of pressure switch get actuated which are detected by Multimeter. The leads of the Multimeter should be connected to the contactor where the AR L/O of CB are made.

c) CB CLOSING LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB Closing L/O contacts of pressure switch get actuated which are detected by Multimeter.

d) CB OPERATIONAL LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB Operational L/O contacts of pressure switch get actuated which are detected by Multimeter.

e) MECHANICAL CLOSING INTERLOCK (FOR ABB & BHEL CBs ONLY)

CB should be in closed position. Release air from pneumatic system of CB to atmosphere and observe whether CB poles start opening, if so, note down the pressure at which tie rod starts coming down. In such case the closing interlock is to be opened for inspection and if required, replace the closing interlock.

C. HYDRAULIC OPERATING SYSTEM LOCKOUT

a) Pump START/STOP

By opening pressure release valve, note down the pressure at which Pump starts building up oil pressure and pressure at which pump stops.

b) CB AUTO RECLOSE LOCKOUT

Close Isolation valve between hydraulic system and pressure switches. Release oil from the isolated zone to oil tank. Note down pressure at which A/R L/O contacts of pressure switch get actuated which are detected by Multimeter.

c) CB CLOSING LOCKOUT

Release oil from the isolated zone to oil tank. Note down pressure at which CB Closing L/O contacts of pressure switch get actuated which are detected by Multimeter.

d) CB OPERATIONAL LOCKOUT

Release oil from the isolated zone to container. Note down pressure at which CB Operational L/O contacts of pressure switch get actuated which are detected by Multimeter.

D. OPERATING PRESSURE DROP TEST:

For Pneumatic/ Hydraulic operating system, operating pressure drop test to be performed during OCO operation of CB, keeping AC supply of Hydraulic pump/ Compressor in off condition. Hydraulic/ Pneumatic pressure drop should be within limits (as recommended by Manufacturer)

6.3.4.2 EVALUATION OF TEST RESULTS

A. SF6 GAS PRESSURE LOCKOUT

All the SF6 gas pressure switches settings should be checked and corrected with ambient temperature. Settings of SF6 gas pressure switches should be within ± 0.1 bar/ Kg/cm^2 of the set value (after taking into account the temperature correction factor).

B. AIR PRESSURE LOCKOUT

All the air pressure switches settings should be checked and corrected and should be within ± 0.3 bar/ Kg/cm^2 of the set value.

C. OIL PRESSURE LOCKOUT

All the oil pressure switches settings should be checked and corrected and should be within ± 0.3 bar/ Kg/cm^2 of the set value.

6.3.5 MEASUREMENT OF STATIC CONTACT RESISTANCE

The Static contact resistance of main circuit of each pole of a circuit breaker is of the order of a few tens of micro ohms. 100 A DC is injected and milli volt drop is measured across each CB contact to compute contact resistance. The values should be within specified limits.

6.3.6 CHECKING THE ANTI-PUMPING FEATURE

When the breaker is in open position and closing and opening commands are given simultaneously the breaker first closes and then opens, but does not reclose even though the closing command is maintained.

6.3.7 CHECKING THE ANTI-CONDENSATION HEATERS

Check the supervisory circuit of the anti-condensation heaters for correct functioning. With the heaters switched ON, measure their current output.

6.3.8 POLE DISCREPANCY RELAY TESTING

Pole Discrepancy is defined as the difference in closing & opening timings of different poles of CB.

A. WHEN CB IN OPEN POSITION

Closing Command is extended to close one pole, say R-Pole, of CB. After closing R-Pole of CB, this Pole should automatically open after 2.5 seconds (as per pole discrepancy timer settings). Repeat the test for remaining two poles of CB.

B. WHEN CB IN CLOSED POSITION

Tripping Command is extended to trip one pole, say R-Pole, of CB. Remaining Y and B- Poles of CB should automatically open after 2.5 seconds. Repeat the same test for remaining two poles of CB.

C. EVALUATION OF TEST RESULTS

Permissible value of pole discrepancy between two poles of CB is 3.33 msec. from system point of view and it should not be confused with the setting of pole discrepancy timer which is generally 1.0 or 2.5 sec. depending on Auto-reclose scheme.

6.3.9 CHECKING THE NITROGEN PRIMING PRESSURE

Close the pressure release valve. Shortly after the oil pump starts, the priming pressure (200 bar at 20 °C) in the accumulator can be read. The relationship between the pressure and temperature is indicated in Fig. 17.

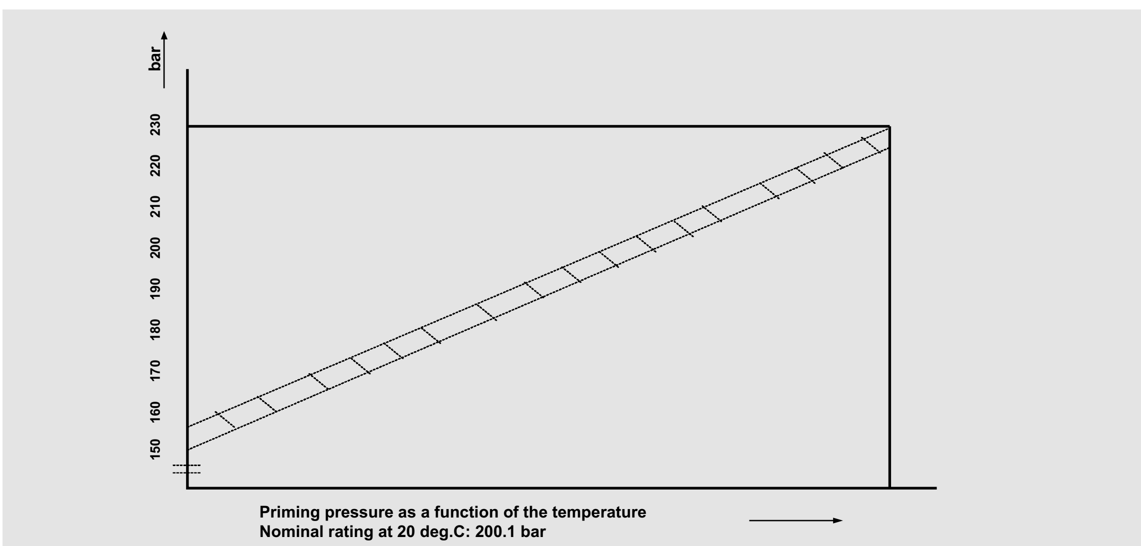


Figure - 17

6.4 CHECKS/ TESTS APPLICABLE FOR CVTs

6.4.1 CVT POLARITY, RATIO TEST

CVT polarity is checked in the same manner as for CT, taking care to ensure that the battery is connected to the primary winding. In case of star/star winding configuration care has to be taken to ensure that the primary and secondary neutral points are not connected together. It is necessary to verify that the phase rotation sequence of the 3 phase CVT is correct. The secondary voltage between phases and neutral are measured and then phase rotation meter is connected across the three phase terminal.

6.4.2 INSULATION RESISTANCE MEASUREMENT OF PRIMARY & SECONDARY WINDING

6.5 CHECKS/ TESTS APPLICABLE FOR ISOLATORS

6.5.1 MILLI VOLT DROP TESTS

The milli volt drop across the isolator is measured using DC current. The voltage drop gives a measure of resistance of current carrying part and contacts.

The DC current should be equal to or more than 100 A. The resistance of isolator should be measured at ambient air temperature. The temperature of specimen/environmental temperature should be recorded. The value of measured resistance should be converted to the value of temperature at which factory test results are taken. Temperature corrected value of resistance should be comparable to the factory value.

6.5.2 50 OPERATION TESTS

6.6 CHECKS/ TESTS APPLICABLE FOR SURGE ARRESTERS

6.6.1 MEASUREMENT OF THIRD HARMONIC RESISTIVE CURRENT FOR SURGE ARRESTERS

Testing Procedure

a. Make the connections as per the diagram given below (Fig.18)
b. The kit should be properly earthed.
c. Clamp On type CT should be placed above the surge monitor to pick up the total leakage current.
d. Carryout the measurements as per standard procedure supplied by the test kit manufacturer.
e. Note down the system voltage and ambient temperature along with the test current value.
f. Avoid measurement during monsoon.

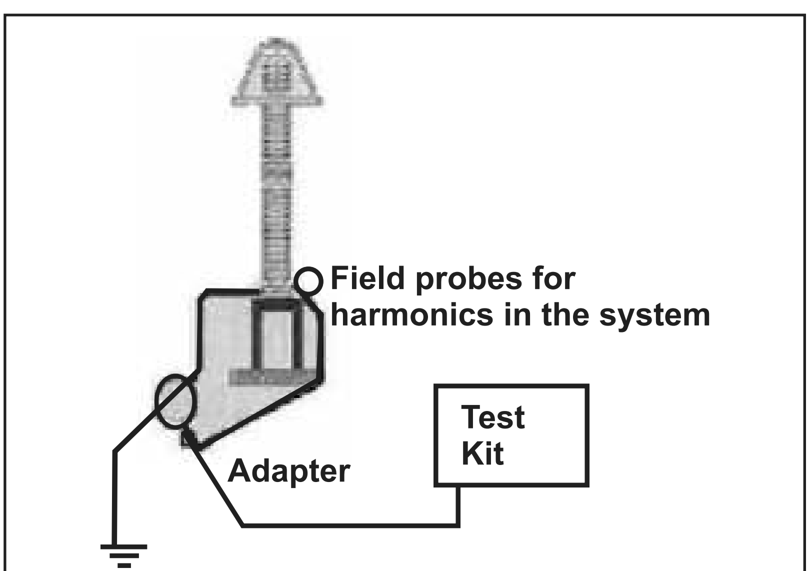


Figure- 18 Typical arrangement for THRCM Test

EVALUATION OF TEST RESULTS

A. ZnO Surge Arrester continuously conducts a small leakage current (Fig.19). The resistive component of this leakage current may increase with time due to different stresses causing ageing and finally cause arrester failure.

B. If Harmonics are present in the system voltage, it affects the value of measured third harmonic current. Compensating device provided to be used to nullify the effect. The value of Third Harmonic Resistive current shall be less than 30 μA

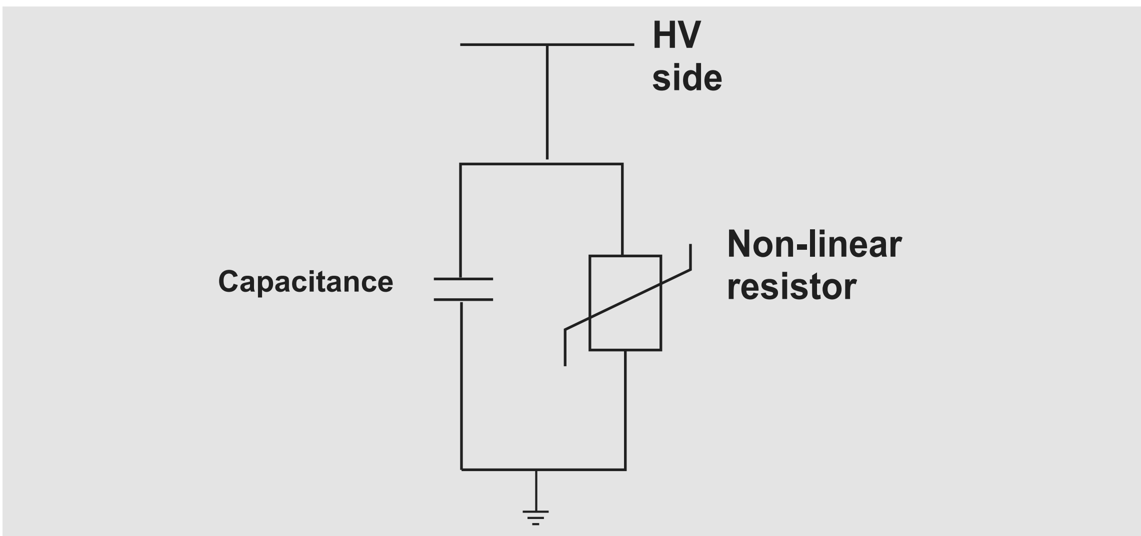


Figure-19 Arrester equivalent circuit

6.7 CHECKS/ TESTS FOR OTHER AREAS/ EQUIPMENTS

6.7.1 EARTH RESISTANCE MEASUREMENT

Normally Earth tester is used for measuring

(a) Soil resistivity

(b) Earth resistance

a. Prior to the testing of soil resistivity and earth resistance the operation manual of the testing instrument available at site may be referred for procedures to be adopted for measurement of soil resistivity and earth resistance.
A typical earth tester has 4 terminals. C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1, P1 and P2, C2. Then the handle is rotated or button is pressed and the reading of the resistance is read on the scale of the instrument. If R is the resistance measured then

Specific Resistivity = 2π a R

Where 'a' is the distance between the electrode

And R is the resistance in ohms measured on the earth tester.

b. In order to measure earth resistance of the electrode of the substation, it could be connected to C1 and the value of R could be read in the scale with the rotation of the handle of the Insulation tester. This will give the earth resistance. The value as far as possible should be around 1 ohm. To improve the value, water should be spread at the earth pit.

6.7.2 SECONDARY CURRENT INJECTION TEST SETS

The primary test is essential when commissioning and new installation as a test the whole protection system and will detect current transformers connected with incorrect polarity or relays that have been set in the wrong sequence in differential system. Secondary current injection sets are very useful for conducting these tests. The standard secondary current injection test equipment consists of a 1/5 A current injection set, separate wave form filter unit and a digital counter. The equipment is designed in a portable kit for on site testing of protecting devices, circuit breakers, trip coils, motor overloads, and similar apparatus. The filter unit should be used when testing saturating core type relays to ensure that the test current has a substantially sinusoidal waveform. The typical test setup is shown in fig. 20. Details of the testing will be elaborated in the relay testing.

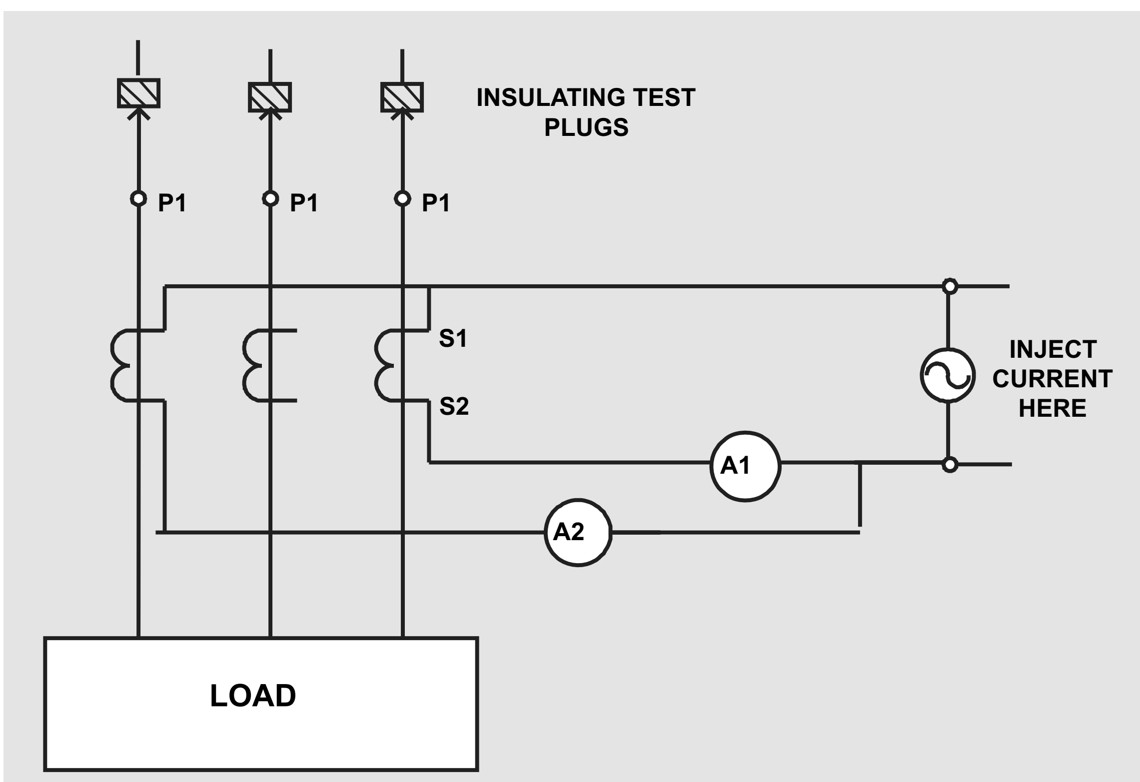


Figure - 20

6.7.3 CONTACT TIGHTNESS TEST OF BAY CONTACTS:

a. Isolate the Bay from Bus –Side and line side as shown in Fig.-21.

b. Ensure that all the secondary cores are connected or short if not in use.

c. Inject the Current at Point 1 (200A) from primary injection kit (w r t earth) and return current via earth point at 2 as shown in Fig.-21.

d. Check that we are able to inject current at point 1 and measure the current at point 2.

e. Injection of current is the indication of contact tightness.

f. Repeat the procedure for point 1 & 3

g. Repeat the procedure for point 1 & 4

Note: Above tests can be aborted if individual contact resistances are within satisfactory limit and physical phase checking is satisfactory.

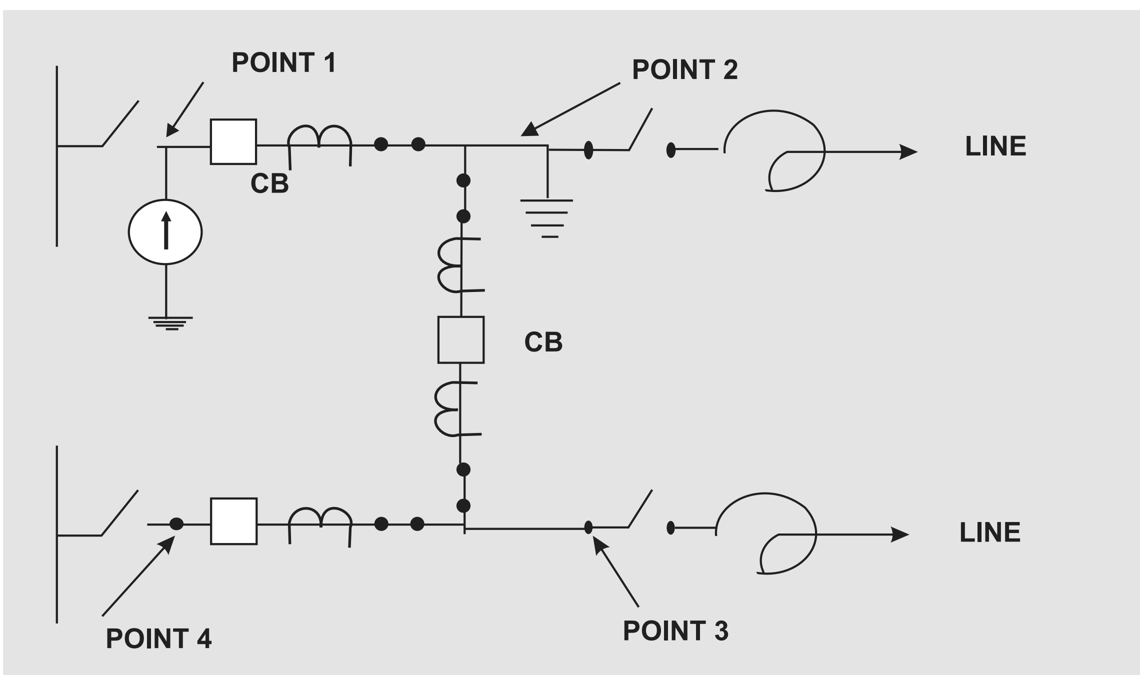


Figure-21 : Primary injection test to check contact tightness of Bay/ feeders

CHECKS/TESTS FOR BUS BAR PROTECTION

Types of bus bar protection

a) High impedance

b) Low impedance

7.1 High Impedance protection

The High-impedance protection scheme, is a good solution for single busbar arrangements, 1 ½ breaker systems or ring Busbars, provided that appropriate dedicated CT cores are available for this use alone.

Sensitive, stable and fast protection for single busbar arrangements and 1 ½ breaker systems.

Eg: RADHA (ABB), FAC 34 (EE), PBDCB (EE), PBLSB (EE)

7.1.1 Types of High impedance protection schemes

Two main protections with CT supervision feature

Main & check zone scheme

a) Two main protections

Generally used where direct measurement is possible without switching of the CT circuits

Trip command will be issued on operation of any one of the main protection.

b) Main & check zone scheme

Have highest degree of security in the form of check zone, generally used where CT switching is required through auxiliary contacts of isolator (like 220kV DMT scheme)

For a double busbar arrangement, two different high impedance units are required. In this case, the current must be switched between the two different measuring units by connecting auxiliary switches to the busbar isolator contacts.

In some cases the auxiliary switches did not operate correctly. This caused the busbar Protection to trip the busbar. For this reason, a safety precaution was introduced: An overall Check-Zone unit, fed from individual CT cores. This overall scheme does not include any switching of CT and therefore is more secure.

The TRIP command is only issued when both a discriminating and check-zone system Operates.

The relay coil will be designed as voltage measuring device consuming negligible current.

$V_f = I_f(Rct+2.Rl)$

$V_k=2V_f$

Paralleling CT current should be done at CT marshalling boxes.

7.1.2 CT requirements for High impedance protection system

- **Knee point voltage requirement of the CT will be high**
- CT core shall be dedicated to the High-impedance Busbar Protection Scheme (i.e. cannot be shared with other protection relays)
- CT Must have identical turns-ratio (CT Ratio) (Aux.CT for ratio corrections not acceptable)
- Shall have a low resistance of the secondary windings
- Shall have a minimum knee-point voltage of approx. 300-500V.
- Should have a low magnetising current (few milliamps)

7.1.3 Supervision of the CT circuits

Any interruption of CT currents up to the point of parallel connection can cause instability during external faults even though their degree of unbalance is with in the limits during normal operation. Hence supervision scheme for CT wire are required.

Supervision relay should be provided across each phase for each zone.

It will block the current passing through the differential relay by shorting the CT terminals

General setting of the CT supervision relay is 10% of the lowest circuit rating.

Calculation of typical settings for bus bar differential protection

CT ratio:	: 2000/1
CT resistance:	: 10 Ohms
Max. bus fault MVA	: 10000 MVA
Max. fault current	: $10000x10^6/1.732*400000 = 14434$ A
Fault current in secondary	: 7.217A
Voltage setting of the relay	: V_f or $V_S = I_f(R_{ct}+2R_L)$

Lead resistance of 1000m, 2.5sq.mm copper wire is 7.28 ohms

Assume 500m of lead length

Vs= 7.217* (10+2*7.28/2) =124.7V

Nearest available setting can be adopted for the relay

7.2 Low Impedance bus bar scheme

The most suitable protection scheme for Double and multiple busbar Systems (with or without transfer bus) with feeders being switched between sections of the busbar, which operates with full selectivity for all possible busbar configurations.

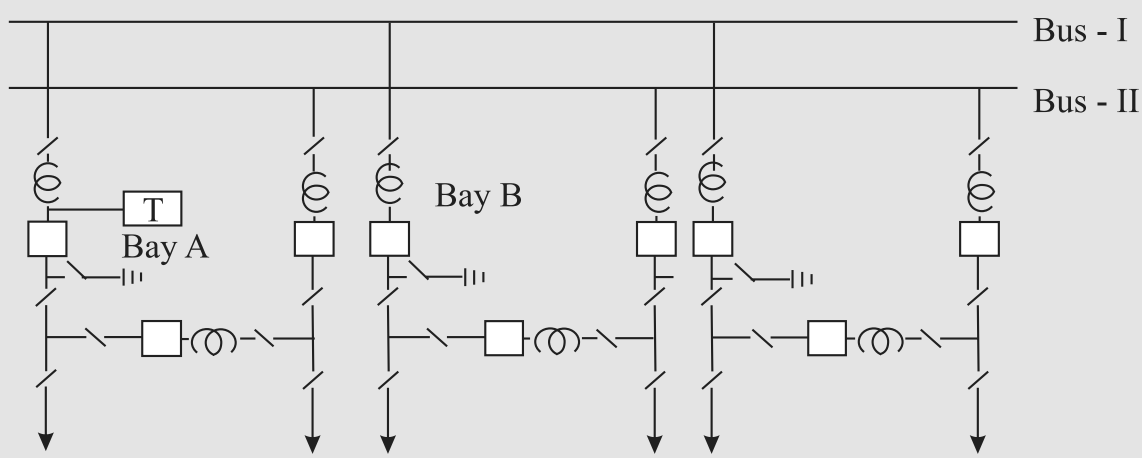
Free of any need for matched CT characteristic or ratios, low leakage reactance or resistance.

Other protective relays can be included in the same circuit.
Stable for infinite fault level.
Insensitive to CT saturation.

All the CT wiring will be routed to relay either directly or through aux. relay.

Eg: RADSS (ABB), MBCZ (EE)

7.3. Primary injection and bus bar differential stability test (New Substation)



T - Primary current injection text kit

1. Take one of the bays (A) as the reference

2. Select other bay (B) for testing the differential stability. Inhibit the tripping of the breaker in bay **B** from control room due to operation of distance or over current protection caused by primary current injection, if the earthing has been made after the breaker by using earth switch.

3. Earth the bus bar after CT using local earth or nearby earth switch on bay **B** to provide return path for the current.

4. Ensure bus bar is earthed only at bay **B**

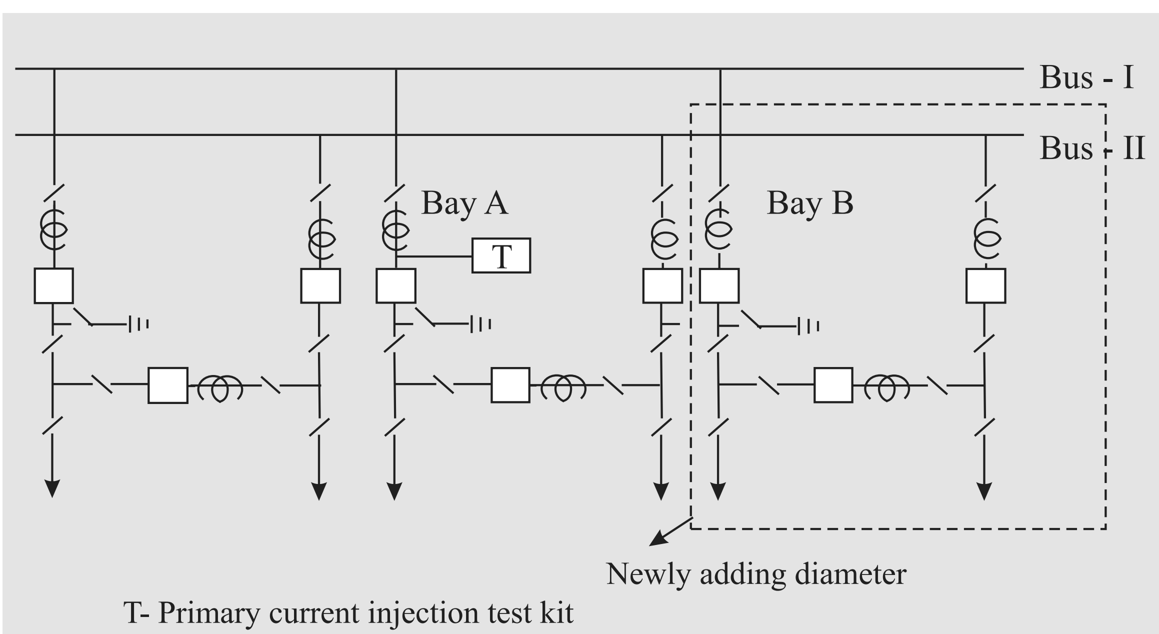
5. Inject primary current using primary current injection test kit across one phase (e.g.R Phase) and ground; don't use other phase as return path for the current.

6. Measure the current at both CT marshalling boxes and voltage across differential relay terminals incase of high impedance differential protection.

7. Measure currents before and after aux. CTs and at relay terminals, incase of low impedance differential protection is being installed.

8. The measured spill voltage/current at relay terminals should not be more than 2%.
9. If the spill voltage/current is more (almost twice the CT secondary current) at the relay terminals, stop injecting the primary current and then reverse the secondary terminals of CT at bay **B.**
10. Start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage magnitude less than 2%.
11. Stop injecting primary current and then create in-zone fault on primary side (by providing earthing between the two CTs) and start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current. (a pictorial example is attached herewith at Annexure)
12. After ensuring the above stop injecting the current. The CT connection should be as per polarity thus proved.
13. Repeat the test for other two phases.
14. Repeat the same procedure for other bays of the same bus bar by taking adjacent bus bar stability checked bay as the reference bay in order to inject max. possible current in the primary using primary injection test kit.
15. Repeat the above procedure for other bus bars also.
16. Above said procedure shall be carried out between Phase-Phase (R-Y &Y-B) by injecting in one phase and joining with other phase for using it as return path instead of earth return for one set of CTs (Two bays).

7.4. Primary injection and bus bar differential stability test (Bay Extension in the old substation):



1. Arrange the shutdown of the bus barunder test
2. Consider one of the existing bays (A) as the reference
3. Short the CT cores used for the other protections (like LBB, distance or differential or O/C or metering, etc), at CT MB itself, no CT core shall be in open condition.
4. Select one of new bays (B) for testing the differential stability and inhibit the tripping of the breaker from control room due to operation of distance or over current caused by primary current injection.
5. Earth the bus bar after CT using local earth or nearby earth switch on bay **B**.
6. Ensure bus bar is earthed only at bay **B**
7. Inject primary current using primary current injection testing kit across one phase (eg.R Phase) and ground; don't use other phase as return path for the current.
8. Measure the current at both CT marshalling boxes and voltage across differential relay terminals incase of high impedance differential protection.
9. Measure currents before and after aux. CTs and at relay terminals, incase of low impedance differential protection is being installed.
10. The measured spill voltage/current at relay terminals should not be more than 2%.
11. If the spill voltage/current is more (almost twice the CT secondary current) at the relay terminals, stop injecting the primary current and then reverse the secondary terminals of CT at bay **B.**
12. Start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/voltage magnitude less than 2%.
13. Stop injecting primary current and then create in-zone fault on primary side (by providing earthing between the two CTs) and start injecting primary current and measure the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current. (a pictorial example is attached herewith at Annexure)
14. After ensuring the above stop injecting the current. The CT connection should be as per polarity thus proved.
15. Repeat the test for other two phases.
16. Repeat the same procedure for other bays of the same bus bar by taking adjacent bay (whose stability check completed) as the reference in order to inject max. possible current in the primary using primary injection test kit.
17. Repeat the above procedure for other bus bars also.
18. Restore the system to normal conditions.

7.5 Scheme Checking of bus bar protection & DC trip logic. (New substation & Bay extension)

7.5.1 Two Main protection philosophy

1. Test the relay by secondary injection.
2. Check the tripping of the corresponding breakers and non tripping of other bus breakers and tie breakers.
3. Check initiation of LBB relays of the breakers corresponding to particular bus.
4. Check blocking of the bus bar protection on operation of CT supervision relay.
5. Ensure that operation of CT supervision relay should not initiate bus bar tripping.
6. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
7. a. Check the direct tripping scheme on operation of bus bar protection (only if tie breaker is in open condition)
   b. Direct trip signal should not go on operation of Bus bar protection if the Tie CB is in close condition.
8. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
9. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.

7.5.2 Main and Check zone philosophy

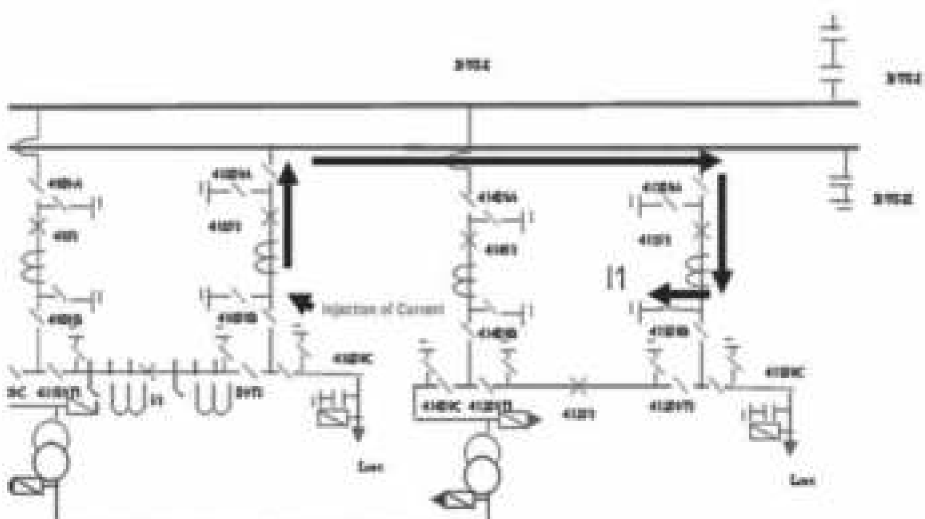
1. Test the both main and check zone relays by secondary injection.
2. Ensure bus bar should not initiate tripping for operation of either main or check zone alone.
3. For checking the tripping scheme, bypass the check zone contact.
4. Check the tripping of the corresponding breakers and non tripping of other bus breakers and tie breakers.
5. Check initiation of LBB relays of the breakers corresponding to particular bus.
6. Check blocking of the bus bar protection on operation of CT supervision relay.
7. Ensure operation of CT supervision relay should not initiate bus bar tripping.
8. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
9. a. Check the direct tripping scheme on operation of bus bar protection (only if tie breaker is in open condition)
   b. Direct trip signal should not go on operation of Bus bar protection if the Tie CB is in close condition.
10. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
11. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.
12. Repeat the above for check zone and CT supervision schemes.

7.6 AMP Testing of bus bar protection and scheme

1. Arrange bus bar shutdown for off line testing. Preferably the bus bar isolation should done through bus bar protection trip relay.
2. Insert the test block after shorting the incoming current terminals for on line testing.
3. Test the relays.
4. For off line testing:
   i. Check tripping scheme of bus bar (2 main/ main and check scheme), in case of main and check scheme, operation of one relay should not initiate bus bar trip.
   ii. Check initiation from LBB of corresponding bays of bus bar
   iii. Check initiation of LBB of corresponding bays of bus bar
   iv. Check annunciations and DR triggering as per the drawings
5. After completion of the above checks, normalise the connections and take bus bar into service.

CHECKING OF BUS BAR STABILITY

CONDITION 1- BUS –II EARTH SWITCH OPEN



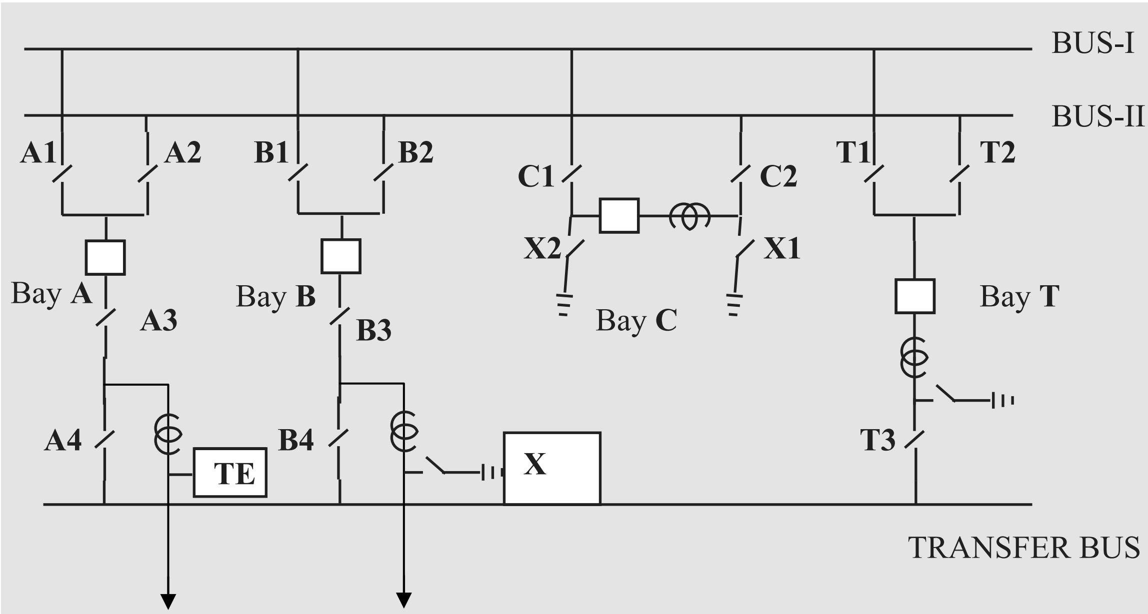
MEAUREMENT OF CURRENT

- Primary injected current = I 1(on single ph basis only)
- Secondary current for 410 CT for Ph & Neutral at
  - CT MB
- Secondary current for 412 CT for Ph & Neutral at
  - CT MB
- Relay diff current
  - As Summation of current is almost zero (Idiff= I1'-I1'),at relay current value should not more than spill

7.7 Double main transfer scheme (400kV/220kV):

For the double main transfer scheme, bus bar protection shall preferably be Main and check zone scheme because of dependency on CT switching between BUS-I & II bus bar protections.

7.7.1 Primary injection and bus bar differential stability test (New Substation):



TE – Testing Equipment
X – Temporary Earthing point

1. Take one of the bays (**A**) as the reference
2. Select other bay (**B**) for testing the differential stability. Inhibit the tripping of the breakers in bay **A** and **B** from control room due to operation of distance or over current protection caused by primary current injection.
3. Earth the bus bar after CT at X using earth rods on bay **B**.
4. Preferably connect the primary injection testing kit to the CT terminal pad of reference bay (A) after opening the jumper from line side.
5. Ensure that bus or line connected to bay B shall not be earthed other than at X.
6. Close the isolators A1 in bay A, B1 in bay B and Ensure that corresponding CT switching relays operated for checking the bus bar differential stability of BUS-1.
7. Close isolator A3 and breaker in bay A and isolator B3 and breaker in bay B.
8. Measure the resistance of the CT cores (used for main and check zone) towards CT in the CT switching cubicle and it shall be equal to the sum of resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.

9 Inject primary current using primary injection testing kit from bay **A**.

10. Measure the current at both CT marshalling boxes (both cores used for main and check zone) and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.

11. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).

12. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.

    a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay **'B'.**

    b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).

13. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs).

14. Start injecting primary current and Measures the current at both CT marshalling boxes (both cores used for main and check zone) and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

15. After ensuring the above stop injecting the current and normalize the system.

16. Open isolators A1 on bay A& isolator B1 on bay B and ensure that corresponding CT switching relay got resetted.

17. Close isolators A2 in bay A, B2 in bay B for connecting the feeder to bus-2 and ensure the operation of corresponding CT switching relay for checking the bus bar differential stability of BUS-2.

18. Repeat the above sequence from 9 to 16

19. Open isolators A2 on bay A& isolator B2 on bay B and ensure that corresponding CT switching relays got resetted.

20. Repeat the test for other two phases.

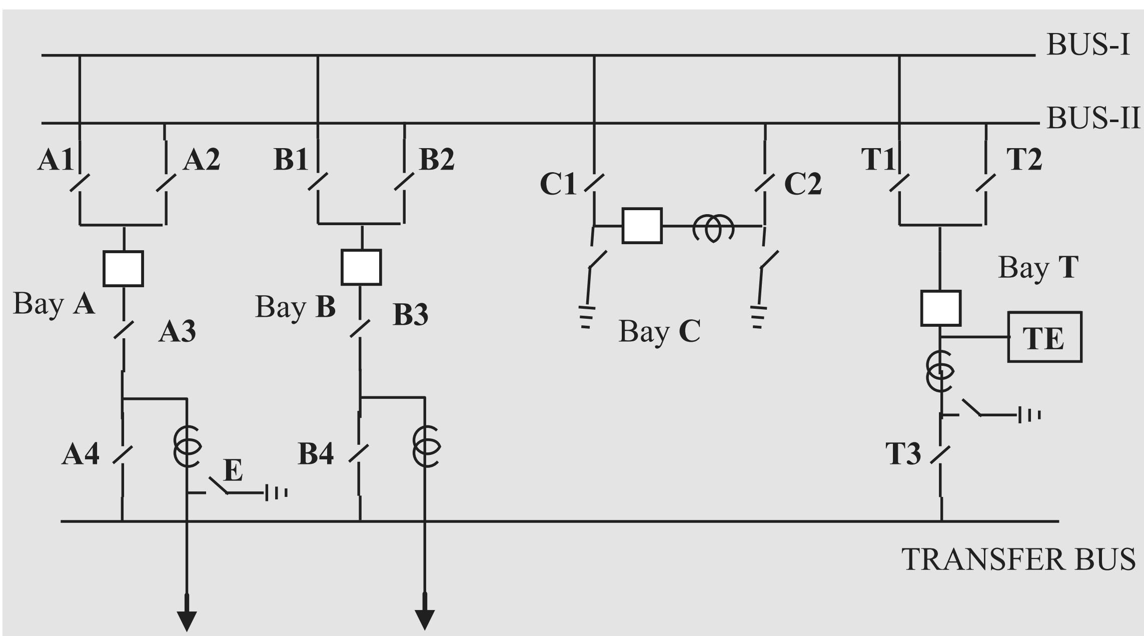
21. Above said procedure shall be carried out between Phase-Phase (R-Y &Y-B) by injecting in one phase and joining with other phase for using it as return path instead of earth return for one set of CTs (Two bays).

22. Repeat the same procedure for other bays including transfer bus coupler bay w.r.t Bus-I & II.

7.7.2 Checking of differential protection stability w.r.t bus coupler:

1. Take one of the bay A as the reference bay
2. Close isolator A1 in bay A to check differential stability of the bus coupler w.r.t Bus-1.
3. Close isolator C1 and breaker in bus coupler bay C and earth at X1 in bay C.
4. Adopt the same procedure as explained above for stability testing of normal bays.
5. Open breaker & isolators A1 in bay **A** and Open breaker & isolator C1 on bay C,
6. Close isolator A2 & breaker in bay **A** and isolator C2 & breaker on bay C to check differential stability of bus coupler CT w.r.t Bus - 2.
7. Earth bay C at X2.
8. Adopt the same procedure as explained above for stability testing of normal bays.
9. Open the breaker and isolator in bay A & bay C and open earthing on bay C and normalize the system.

7.7.3 Checking of differential protection stability w.r.t Transfer bus:



1. Before carrying out this test, ensure that differential protection stability with respect to Bus –I & Bus-II has been carried out on all bays including transfer bus coupler bay.
2. For checking the differential protection stability w.r.t to transfer bus, take one of the bays as reference bay and inject current from transfer bus coupler bay CT.
3. Close isolator T3 and breaker in transfer bus coupler bay T.
4. Close isolator A4 to check stability w.r.t transfer bus and ensure the operation corresponding CT switching relay.
5. Keep the normal/transfer switch of bay A in transfer mode.

6. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.

7. Inject primary current using primary injection testing kit from bay T.

8. Measure the current at both CT marshalling boxes and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.

9. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).

10. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.

    a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay **'T' only while testing first bay.**

    b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).

11. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs)

12. Start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

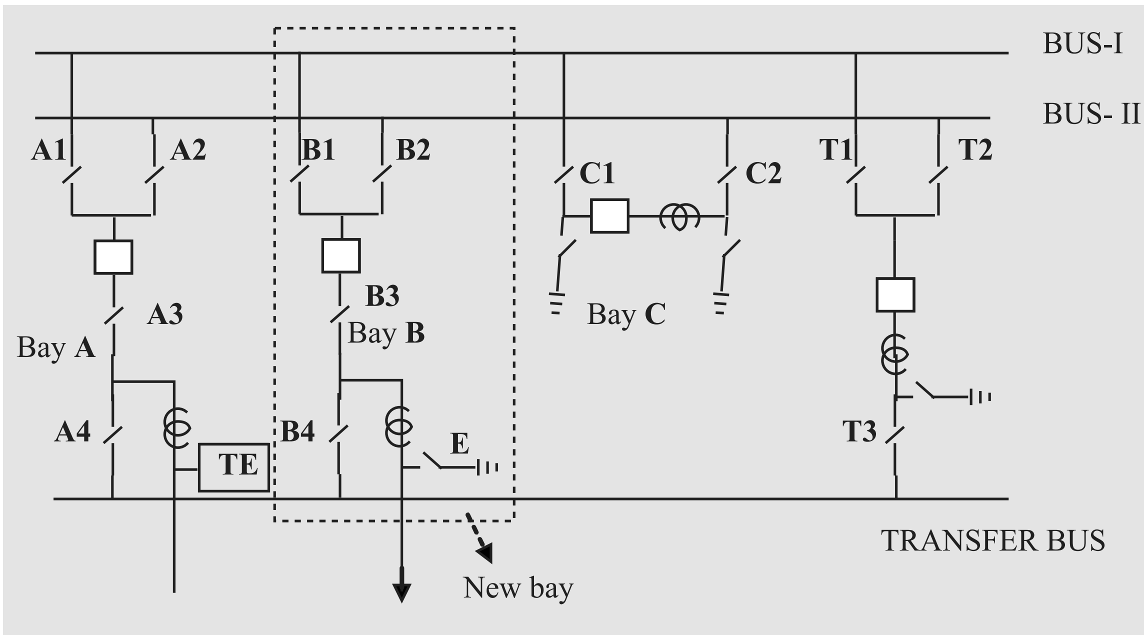
13. After ensuring the above stop injecting the current and normalize the system.

14. Open isolators and earthing which are closed for testing and keep N/T switches in normal position.

15. Repeat the test for other two phases.

16. Repeat the above procedure for other bays to ensure the operation of CT switch relay for transfer bus.

7.7.4 Primary injection and bus bar differential stability test for Bus-I (Bay extension in existing Substation)



1. Arrange the shutdown of the one of the existing feeder or take a bay which is already in out of service as reference bay (A).
2. Arrange shutdown of the bus bar (Bus-I).
3. Close the isolator of new bay B (B1) and ensure the operation of corresponding CT switching relay.
4. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.
5. Close the isolator B3 and breaker in bay B and isolators A1, A3 and breaker in bay A for connecting the CTs to Bus-I.
6. Inject primary current using primary injection testing kit from bay A.
7. Measure the current at both CT marshalling boxes (both cores used for main and check zone) and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.
8. The measured spill voltage/current at relay terminals shall be very less compared to the primary current/corresponding voltage (around 2%).
9. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals:

a. Stop injecting the primary current and check CT paralleling connections after the CT switching relay. If every thing is correct then reverse the secondary terminals of CT at bay '**B'.**

b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the primary current/corresponding voltage (around 2%).

10. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two Cts.

11. Start injecting primary current and Measures the current at both CT marshalling boxes (both cores used for main and check zone) and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.

12. After ensuring the above stop injecting the current and normalize the system.

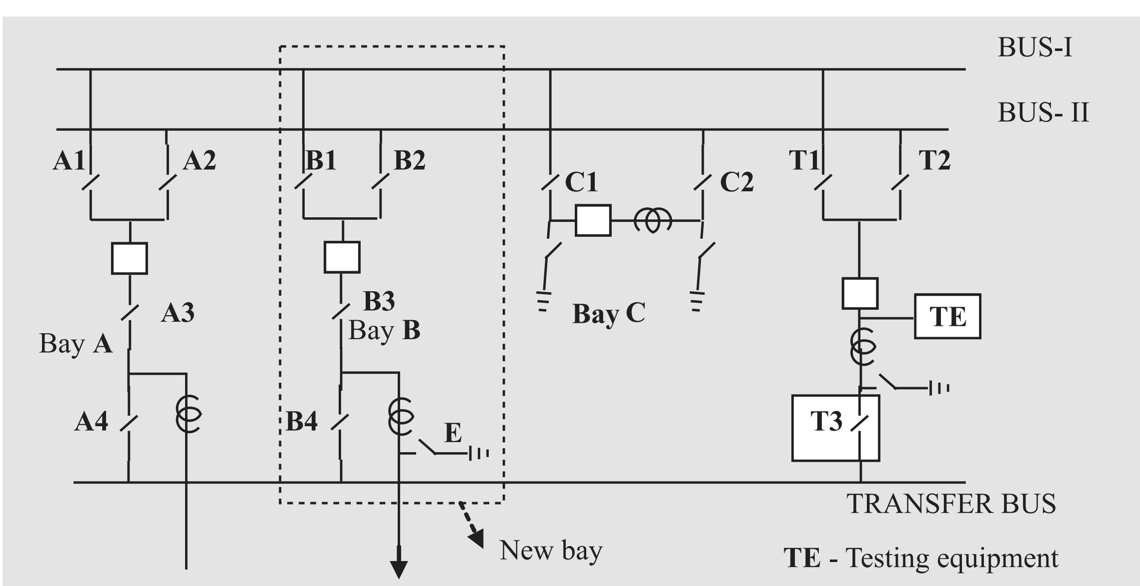
13. Open the breaker and isolator A1 in bay A and breaker and isolator B1 in bay B.

14. Repeat the above procedure for other phases.

15. Repeat the testing of the other newly adding bays (if any) taking this stability tested new bay (B) as the reference bay to avoid outage of old reference bay A for longer periods.

16. Repeat the above procedure of stability testing for new bay w.r.t. Bus-II by selecting of appropriate section (i.e. isolators A2 & B2) with Bus-II shutdown.

7.7.5 Primary injection and bus bar differential stability test w.r.t to transfer bus (Bay extension in existing Substation):



1. Arrange shutdown of transfer bus.
2. Take transfer bus T as reference bus.
3. Close isolator B4 and keep N/T switch in transfer position and ensure the operation of corresponding CT switching relay.
4. Measure the resistance of the CT cores towards CT in the CT switching cubicle and it shall be equal to the resistance of the CT core and lead resistance. If the resistance towards CT core is more, then check the CT circuit and corresponding CT switching relay.
5. Close isolator T3 and breaker in bay T.
6. Inject primary current using primary injection testing kit from bay T.
7. Measure the current at both CT marshalling boxes and relay terminals in the control room in case of low impedance protection or measure voltage across cores in CT MB and differential relay terminals incase of high impedance differential protection.
8. The measured spill voltage/current at relay terminals shall be very less compared to the set value (around 2%).
9. If Spill current/voltage is more (almost twice the CT secondary current) at the relay terminals.
   a. Stop injecting the primary current and Check CT paralleling connections after the CT switching relay.
   b. Start injecting primary current and Measures the current/voltage at both CT marshalling boxes and relay terminals at control room and observe the spill current/ voltage magnitude shall be very less compared to the set value (around 2%).
10. Stop injecting primary current and then create in-zone fault in primary side (by providing earthing between two CTs.
11. Start injecting primary current and Measures the current at both CT marshalling boxes and at the relay terminals at control room and observe the spill current/ voltage of considerable magnitude corresponding to the injected primary current.
12. After ensuring the above stop injecting the current and normalize the system.
13. Start injecting primary current and measure the current/voltage at relay terminals and ensure that its magnitude is very less compared to the primary current.
14. Open isolators and earthing which are closed for testing and keep N/T switches in normal position.
15. Repeat the test for other two phases.

7.8 Scheme checking of bus bar protection & DC trip logic. (New substation & Bay extension)

7.8.1 Two Main protection philosophy

1. Test the relay by secondary injection.
2. Check the tripping of the corresponding selected breakers and bus coupler breaker (in case of Bus-I & Bus-II only) and non tripping of other breakers.
3. Check initiation of LBB relays of the selected breakers corresponding to particular bus.
4. Check blocking of the bus bar protection on operation of CT supervision relay.
5. Ensure that operation of CT supervision relay should not initiate bus bar tripping.
6. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
7. Check the direct tripping scheme on operation of bus bar protection.
8. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
9. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.

7.8.2 Main and Check zone philosophy

1. Test the both main (i.e. Bus-I, Bus-II and Transfer Bus) and check zone relays by secondary injection.
2. Ensure bus bar should not initiate tripping for operation of either main or check zone alone.
3. For checking the tripping scheme, bypass the check zone contact.
4. Check the tripping of the corresponding selected breakers and bus coupler breaker (in case of Bus-I & Bus-II only) and non tripping of other breakers.
5. Check initiation of LBB relays of the breakers corresponding to particular bus.
6. Check blocking of the bus bar protection on operation of CT supervision relay.
7. Ensure operation of CT supervision relay should not initiate bus bar tripping.
8. Check initiation of bus bar tripping by operation of corresponding breaker LBB relays.(Back Trip feature)
9. Check the direct tripping scheme on operation of bus bar protection.
10. Test CT supervision relays and ensure for triggering control panel annunciation and event logger triggering as per approved scheme.
11. Check bus bar IN/OUT switch for correctness of wiring as per the drawing.
12. Repeat the above for check zone and CT supervision schemes.

7.9 AMP testing of bus bar protection and scheme

1. Arrange bus bar shutdown for off line testing and scheme checking.
2. While switching all the loads from one bus to other bus observe the operation and resetting of corresponding CT switching relays in accordance to the operation of isolators.
3. CT switching discrepancy alarm shall not appear in the control panel.
4. Check tripping scheme of bus bar (2 Main/ Main and check scheme), in case of main and check scheme, operation of one relay should not initiate bus bar trip.
5. Check annunciations and DR triggering as per the drawings
6. After completion of the above checks, normalise the connections and take bus bar into service.
7. Insert the test block after shorting the incoming current terminals for on line testing.
8. Test the relays.

PRE-COMMISSIONING FORMATS FOR TRANSFORMER

I. GENERAL DETAILS

DETAILS	
Region:	**Sub-Station:**
LOA No. :	**Make:**
Sr. No.:	**Type:**
Equipment identification: (For e.g. ICT-I-R phase)	
Year of Manufacture:	**Rating:**
Voltage Ratio :	**Cooling Type:**
Type of Neutral Grounding:	**Oil Make:**
Oil type:	**Oil quantity:**
Quantity of Radiator	**% Impedance details for all tap (To be enclosed in a separate sheet)**
Date of Receipt at site:	**Date of Starting of Erection:**
Date of Completion of Erection and Oil filling:	

II. CHECK LIST OF ELECTRICAL TESTS CARRIED OUT FOR TRANSFORMER

Sl. No.	Name Of Test	Testing Kit Details			Test Results (Ok/Not Ok)
		Make	Rating/ Measuring Range	Date Of Last Calibration	
1	Core Insulation Measurement (To be performed upon arrival)				
2	Insulation Resistance Measurements Of Bushing CTs				
3	Continuity Test Of Bushing CTs				
4	Secondary Winding Resistance Of Bushing CTs				
5	Polarity Test Of Bushing CTs				
6	Current Ratio Test				

Sl. No.	Name Of Test	Testing Kit Details			Test Results (Ok/Not Ok)
		Make	Rating/ Measuring Range	Date Of Last Calibration	
7	Magnetizing Curves Performance				
8	Measurement of Resistance of Earth Pit and Main Grid				
9	Frequency Response Analysis				
10	Magnetization Current of Windings				
11	Vector Group Test & Polarity Check				
12	Short Circuit Impedance Test				
13	Magnetic Balance Test (Not applicable for 1-ø)				
14	Floating Neutral Voltage Measurement				
15	Magnetization Current Test				
16	Voltage Ratio Test				
17	Core Insulation test after oil Circulation				
18	C & Tan δ Measurement Of Bushing				
19	C & Tan δ Measurement Of Windings				
20	Insulation Resistance Measurement of Winding				
21	Insulation Resistance Measurement of Cable				
22	Measurement of Winding Resistance				
23	Protection And Alarm Tests				
24	Stability Test Of Differential And REF Protection				
25	Contact Resistance Measurement				

Comments of Commissioning Team on test Results:

Comments of Corporate-OS on test Results (To be attached separately)

Manufacturer Recommendation on test Results (To be attached separately)

Signature:	**Signature:**	**Signature:**	**Signature:**
Name:	**Name:**	**Name:**	**Name:**
Desgn.:	**Desgn.:**	**Desgn.:**	**Desgn.:**
Organization: (Supplier Representative) (Wherev Applicable)	**(Erection Agency)**	**(POWERGRID Site I/C)**	**(POWERGRID Commg. Team) Members:**

III. CHECKS AFTER RECEIPT OF TRANSFORMER AT SITE :

A) *N2/ Dry Air Pressure & Dew Point Record*

Inspection Action	Date Of Meas.	N2/ Dry Air Pressure	Dew Point	Ambient Temperature	Remarks
During dispatch at factory					
After receipt at site					
Storage at site before commissioning					

Note:

i. Refer **graph 2.1.3 fig.1 in** POWERGRID doc no d-2-03-xx-01-01 rev-01 for maintaining N2/ Dry air pressure and dew point during storage(To be maintained in a separate sheet/ Register)

ii. Any noticeable drop in N2 during storage at site is observed, then matter to be referred to Manufacturer and CC-OS).

iii. If Transformer is received with zero N2 pressure then matter to be referred to Manufacturer and Corporate-OS prior to erection

B) *Impact Recorder Analysis*

No of Impact Recorder installed: ________________________________

Make of Impact Recorder(s) ________________________________

Type of Impact Recorder(s) ________________________________

Date of removal of impact recorder from equipment ________________________________

Sl.No.	Check Points	Status		Remarks
1	Functionality of Impact recorder at the time of dismantling from main unit	On	Off	
2	Joint data downloading carried out at site immediately after receipt	Yes	No	
3	Analysis of joint report received from manufacturer before charging	Yes	No	

Note:

i. Manufacturer to provide necessary software and downloading tools to respective sites so that data downloading can be carried out at site jointly by POWERGRID & Manufacturer

ii. Permissible limit for maximum shock in any direction shall be 3g.

iii. Impact Recorder should be switched off and detached from the Transformer when the main unit has been placed on its foundation.

C) *Core Insulation Test (Immediately after Receipt at Site)*

Shorting link between CC, CL & G to be removed and IR value to be taken between CC-G, CL-G & CC-CL by applying 1 kV DC

Terminals	Insulation Value	Terminals	Insulation Value
CC-G		CC-CL	
CL-G		Semi-shield –G (if provided) at 1 kV	

Note:

i. Permissible value > 500 MΩ
ii. In case core insulation values are less than the permissible limit matter to be referred to OEM for corrective measures and same to be checked during internal inspection for any abnormality
iii. Ensure shorting of CC-CL & G after the completion of the testing

D) ***Internal Inspection***

SL. No.	Internal Inspection	Status	
		Yes	No
1	Details photographs of all visible parts /components are taken during internal inspection.(refer procedure 2.3)		
2	In case of any abnormality observed during internal inspection, matter to be referred to manufacturer, CC-QA & I , CC-ENGG and CC-OS		

Details of abnormality observed during internal inspection (if noticed) ______________

____

____

IV. TRANSFORMER ERECTION

A) ***Checks / Precautions During Erection :***

Sl. No.	Description	Remarks
1	Total Exposure of Active part of Tr ansformer to atmosphere in hours (To be kept minimum)	
2	Dew point of dry air generator / dry air cylinders, during exposure of active part of Transformer	
3	Available of Oxygen in % before entering in Transformer tank	
4	N2/ Dry air pressure in PSI while Transformer is kept sealed in between different erection activities	
5	Ensure Leakage test of Air cell / bellow carried out	
6	Check Hermitically sealing is intact in all Bushings by OEM / Expert	
7	Storage of blanking plates	

B) ***Evacuating And Oil Filling***

a) Before filling oil, each drum has been physically checked for appearance and presence of water .

Yes	No

b) Details of oil filter machine (As per latest TS of Transformers)

Make ______________________ Capacity_________________________

Sl.No	Description Of Works	Remarks / Reading
1	Changing of Lubricating oil of vacuum pump	
2	Cleaning/ Replacement of Filter packs	
3	Flushing of whole filter machine and pipes with fresh oil	
4	Vacuum obtained without load (milli bar)	

c) Vacuum pump for evacuation of transformer

Sl.No	Description of Works	Remarks / Reading
1	Changing of Lubricating oil of vacuum pump	
2	Vacuum obtained without load (milli bar)	
3	Diameter of vacuum hose (50 mm minimum)	
4	Employ of Dry ice chamber	

d) Oil storage tank

Capacity______________________ Quantity__________________________

Sl.No	Description of Works	Remarks / Reading
1	Silica gel breather provided in the tank	
2	Any opening left uncovered	
3	Inside painted or not	
4	Cleanliness of inside of pipes/ hoses to the storage tank	
5	Healthiness of valves /flanges for pipe connection	

e) Exposure during erection

Sl.No	Description of Works	Remarks / Reading
1	First day exposure (in hrs)	
2	Second day exposure (in hrs)	
3	Third Day exposure (in hrs)	
4	N2 pressure applied after each days erection work (in PSI)	
5	Ambient Temperature (in degC)	
6	Average Relative Humidity	
7	Weather Condition(Rainy / Stormy / Cloudy / Sunny)	

Note:

i. Erection activities preferably to be carried out in sunny weather and RH<60%

f) N2/ Dry Air sealing in case of delay in oil filling
(Dry air shall be preferred for human safety)

Sl.No	Description of Works	Remarks / Reading
1	N2/ Dry air admitted from bottom valve	
2	Valve at diametrically opposite end at top kept open	
3	No. of Cylinders used for building up to 4- 5 psi(~0.3kg/cm^2)	

g) Leakage Test through pressure

Sl.No	Inspection Actions	Date	Time	Remarks / Reading
1	Fill dry N2/ dry air till pressure of 4- 5psi (~0.3kg/cm^2) achieved			
2	To be kept for 24 Hrs			
3	In case pressure remain same, check for dew point			
4	If dew point is achieved, proceed for evacuation			
5	**In case of drop in pressure, attend the leakages and repeat the pressure test**			
6	If dew point is not OK, dry air/ N2 cycle to be carried out till desired dew point is achieved			

h) Schedule for Vacuum & Tightness Test

Sl.No	Inspection Actions	Date	Time	Remarks / Reading
1	Starting of evacuation on complete unit			
2	Stopping of evacuation below the pressure of 5 kPa (50 mbar)			
3	Pressure P1 in kPa after 1 hour of stopping evacuation			
4	Pressure P2 in kPa after half an hour of reading pressure P1			
5	Leakage = (P2-P1) x V , V= Oil quantity in Cu mtr ***If leakage<3.6, continue evacuating** **If leakage > 3.6, attend leakage and repeat process as per Sr. No. 1 to 4.**			
6	Continue vacuum till 0.13kPa(1 Tor) or below achieved			
7	Break of vacuum *** Vacuum process to be continued after reaching fine vacuum for 24 hrs Up to 145 KV, 48 hrs for 220kV and 72 hrs for 420 kV and above**			

i) Record of drying out process (if carried out)

Sl.No	Activity	Date	Time	Remarks / Reading
1	**First Nitrogen/Dry air purging cycle**			
	Pressure of Nitrogen/Dry air 0.15 kg/cm2			
	Dew Point after 48 Hrs			
	Temperature with heaters on condition around the Transformer Tank(Refer procedure)			
2	**First Vacuum cycle**			
	Vacuum achieved			
	Rate of condensate collection(Hourly basis)			
	Duration of vacuum after achieving 1 to 5 torr			
3	**Second Nitrogen/Dry air purging cycle**			
	Pressure of Nitrogen/Dry air 0.15 kg/cm2			
	Temperature with heaters on condition around the Transformer Tank(Refer procedure)			
	Dew Point after 24 Hrs			

Note:

i. If dew point is within the permissible limit oil filling under vacuum may be started otherwise vacuum/ Nitrogen purging with heating cycle to be continued till desired dew point is achieved.

j) Schedule for Oil filling and Settling

Sl. No	INSPECTION ACTIONS	DATE	TIME	REMARKS / READING
1	Ensure measurement of Particle counts during oil filtration in oil tanks(If specified in the contracts)			
2	Oil Filling in Main Tank			
3	Oil filling in Conservator tank			
4	Oil filling in diverter switch			
5	Hot oil circulation (minimum 2 cycles or depending on oil parameters) at oil temperature 60-65 deg C.			
6	Start of oil settling			
7	End of oil settling *** Minimum settling time to be given 24 hrs for 145 KV , 48 hrs for 220kV and 420kV and 72 hrs for 765 kV & above**			

V. PRE-COMMISSIONING CHECKS:

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
1	ICT and its Auxiliaries are free from visible defects on physical Inspection			
2	All fittings as per out line General Arrangement Drawing			
3	Check Main Tank has been provided with double earthing			
4	Check neutral is grounded through separate connections. Ensure metallic requirements as per specification (e.g. Cu) in earthing strips used			
5	Check that Marshalling Box, T/C Driving Gear, Diverter, Radiator Bank Pump & Fan Motor etc. has been earthed			
6	All nuts and bolts are tightened correctly as per specified torque (as per manufacturers recommendation)			
7	Check tightness of Terminal Connectors			
8	Check leveling of Transformer and its accessories			
9	Erection Completion Certificate along with list of outstanding activities reviewed			
10	Any Paint removed / scratched in transit has been touched up			
11	Bushings are clean and free from physical damages			
12	Oil level is correct on all Bushings			
13	Check brazing of all Bushings Leads			
14	Check oil leakage through any Joints / Valves etc.			
15	Check oil drain valves are properly closed and locked			
16	Check oil level in Main / OLTC Conservator tank			
17	Check oil level at conservator matches with oil temperature of transformer			
18	Check Gear box oil level in OLTC (if applicable)			
19	Check OTI and WTI pockets and replenish the oil, if required			
20	Check all valves for their opening & closing sequence			
21	Check the colour of the breather silica gel			
22	Check availability of oil in the breather cup			
23	Check all rollers are locked and tack welded with rails (wherever applicable)			

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
24	Check tightness of bolt if main unit placed directly on foundation and not on rollers			
25	Check busing test tap is grounded			
26	Check the operation of flow sensitive shut off valve between main tank & conservator, if any			
27	Check the functioning of SPR (Sudden pressure relay) ,if any			
28	Check no debris, loose T & P and oil strains on and around the Transformer			
29	Check door seals of Marshalling Box is intact and all cable gland plates unused holes are sealed			
30	Check that pressure relief valve is correctly mounted			
31	Ensure unused secondary cores of Bushing CT's, if any, has been shorted			
32	Check CT star point has been formed properly and grounded at one end only as per scheme			
33	Check that permanent and adequate lighting arrangements are ready			
34	Check that labeling and identification is permanent and satisfactory			
35	Check that Buchholz Relay is correctly mounted with arrow pointing towards conservator			
36	Check cables are properly fixed and ensure cable entry at the bottom			
37	Ensure all Power and Control cable Terminals are tightened			
38	Check all cables and Ferrules are provided with Number as per Cable Schedule (Cross Ferruling to be checked)			
39	Check that all cables are correctly glanded			
40	Check external cabling from Junction Box to Relay / Control Panel completed			
41	Check that air has been released from the Radiators and their headers/OLTC Buchholz relay/Main tank/tank/Bushing turrets etc			
42	Check Fire Protection System & Emulsifier systems is adequate & ready			
43	Check that CC-CL & G are shorted			
44	Check that neutral connection has twin conductor in case of single phase unit			
45	Check insulation sleeves are provided in case of tertiary bus arrangement			
46	Check that all radiator bank valves on top and bottom headers are open			

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
47	Change over operation of ac supply from source- I to source-II checked			
48	Check the flanges of bushing & OLTC for any crack after fixing			
49	Calibration of OTI & WTI performed as per procedure			
50	Ensure RTCC is commissioned and kept in service			
51	Ensure Remote OTI and WTI data transfer to control room is taking place			
52	Ensure On-Line DGA is commissioned and kept "ON"			
53	Ensure On-Line Dry out system is commissioned and kept "ON"			
54	Check various interlocks provided with Fire Fighting as per the schematic Ref. Drg. No.____________________	Description of Interlocks		Checked

VI. MEASUREMENT OF EARTH RESISTANCE OF ELECTRODE

Location	Value
With Grid (Earth Pit -1)	
Without Grid (Earth Pit -1) (Neutral Earth)	
With Grid (Earth Pit -2)	
Without Grid (Earth Pit -2) (Neutral Earth)	

Note: Permissible limit $< 1\ \Omega$

VII. PRECOMMISSIONING TESTS AFTER READINESS OF THE TRANSFORMER

A) Frequency Response Analysis (FRA)

Sl.No	Description	Yes	No	Remarks
1	Carried out after completion of all commissioning activities			
2	Factory FRA test report in soft form available at site			
3	Interpretation of test results carried out			
4	Test results matching with the factory results			

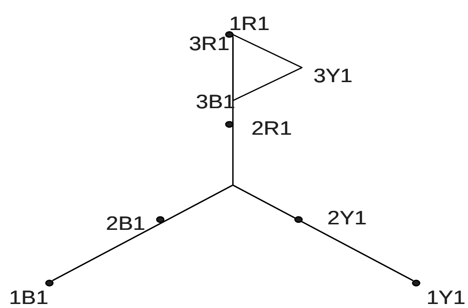
Note:- Measurement to be carried out at Minimum, Maximum and Nominal Tap for all combination of HV & IV and Nomenclature to be made similar as mentioned in the procedure documents

B) Vector Group Test & Polarity Checking

a) Vector Group Checks For 3Φ Transformer And Bank Of 1Φ Transformer After Tertiary Formation

Connect Neutral Point with earth, join 1 RI and 3 R1 Terminals and apply 415 V. 3-phase supply to HV Terminals

Terminals	Voltage Measured (Volts)	Terminals	Voltage Measured (Volts
1R1 – 1Y1		3R1- N	
1Y1 – 1B1		3Y1 – N	
1B1 – 1R1		3B1 – N	
3Y1 – 1B1		2R1- N	
3Y1 – 1Y1		2Y1 – N	
		2B1 – N	

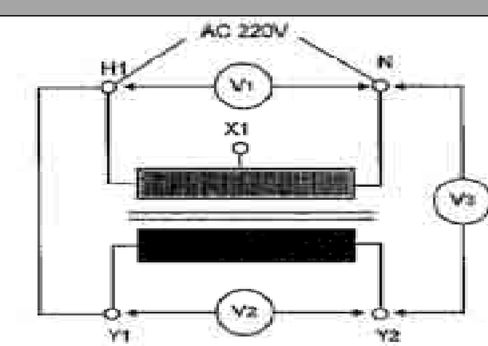


Vector group Ynaod11 is confirmed and polarity verified

If 2R1 – N = 2Y1 – N = 2B1 – N = constant
3R1 -N > 3Y1 - N > 3B1 - N
3Y1 - 1B1 >3Y1 - 1Y1

b) Polarity Checks for 1Ø unit

Apply 1-Ø supply to HV(1.1) and Neutral(2) Terminals

Terminals	Voltage Measured (Volts)	Remarks
HV-N, V1		
LV1(Y1)-LV2(Y2) ,V2		
LV2(Y2)-N,V3		
Remarks :If V1> V3= Subtractive,V1<V3= Additive		

C) Magnetic Balance Test (Not Applicable For Single Phase Units)

Apply single phase 230 V across one phase of HV winding terminal and neutral then measure voltage in other two HV terminals across neutral. Repeat the test for each of the three phases.

Apply 1- 230v Ac Across (1)	Voltage Measured In Volts		Remarks
	Between (2)	Between (3)	
2R1 – N:	2Y1 – N:	2B1 – N:	
2Y1 – N:	2R1 – N:	2B1 – N:	
2B1 – N:	2Y1 – N:	2R1 – N:	

Note:
i. (1)= (2) + (3), Approx.
ii. When outer phase is excited, voltage induced in the center phase shall be 50 to 90% of the applied voltage. However, when the center phase is excited then the voltage induced in the outer phases shall be 30 to 70% of the applied voltage.

D) Floating Neutral Voltage Measurement

a) Disconnect the Transformer neutral from the ground and apply 3 phase 415 Volts to the high voltage winding and make the measurement in the IV winding with respect to neutral and neutral point to ground

Tap Position	HV Winding	Voltage Applied	IV Winding	Voltage Measured	Remarks, If Any
Normal (__)	1R – N		2R – N		
Normal (__)	1Y – N		2Y – N		
Normal (__)	1B – N		2B – N		
			N – Earth		

b) Apply 3 phase 415 Volts to the Intermediate voltage winding and make the measurement in the Tertiary winding with respect to neutral and neutral point to ground

IV Winding	Voltage Applied	LV Winding	Voltage Measured	Remarks, If Any
2R – N		3R – N		
2Y – N		3Y – N		
2B – N		3B – N		
		N – Earth		

Note: Neutral to be reconnected to the ground after the test