TECHNICAL SPECIFICATION
SECTION-GENERAL TECHNICAL REQUIREMENTS

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SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

Contents

1.0 FOREWORD 2
2.0 GENERAL REQUIREMENT 2
3.0 STANDARDS 3
4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED 3
5.0 ENGINEERING DATA AND DRAWINGS 6
6.0 MATERIAL/ WORKMANSHIP 8
7.0 DESIGN IMPROVEMENTS / COORDINATION 11
8.0 QUALITY ASSURANCE PROGRAMME 11
9.0 TYPE TESTING & CLEARANCE CERTIFICATE 17
10.0 TESTS 18
11.0 PACKAGING & PROTECTION 19
12.0 FINISHING OF METAL SURFACES 20
12.3 PAINTING 20
13.0 HANDLING, STORING AND INSTALLATION 22
14.0 TOOLS 23
15.0 AUXILIARY SUPPLY 24
16.0 SUPPORT STRUCTURE 24
17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS 25
18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES MARSHALLING BOXES 26
FOR OUTDOOR EQUIPMENT 26
19.0 DISPOSAL OF PACKING MATERIAL & WASTE FROM CONSTRUCTION SITE 27
20.0 TERMINAL BLOCKS AND WIRING 27
21.0 LAMPS & SOCKETS 28
22.0 BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS: 29
23.0 MOTORS 30
24.0 TECHNICAL REQUIREMENT OF EQUIPMENTS 31

Annexure-A : Corona and Radio Interface Voltage (RIV) Test

Annexure-B: Seismic Withstand Test Procedure

Annexure-C: List of General Standards and codes
Annexure-D: List of General Standard/Document for second advance
Annexure-E: Comprehensive List of Drawings
Annexure-F: Assessment report from Main Contractor for proposed sub vendor's-List of Enclosure
Annexure-G: MQP & Inspection Level Requirement
Annexure-H: Specification of RTV coating on porcelain insulators
Annexure-I: Standard Drawing for open platform
Annexure-J: List of make for which type test reports are not required to be submitted
Annexure-K: List of Equipment's to be supplied from domestic manufacturer only
Annexure-L: Major Changes in GTR rev 15

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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)

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

(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-contracted x 1.5 / 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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

ANNEXURE-C

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

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 (Part-I)	Classification of hazardous areas for electrical 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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

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	

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

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

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

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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

Annexure-G

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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:

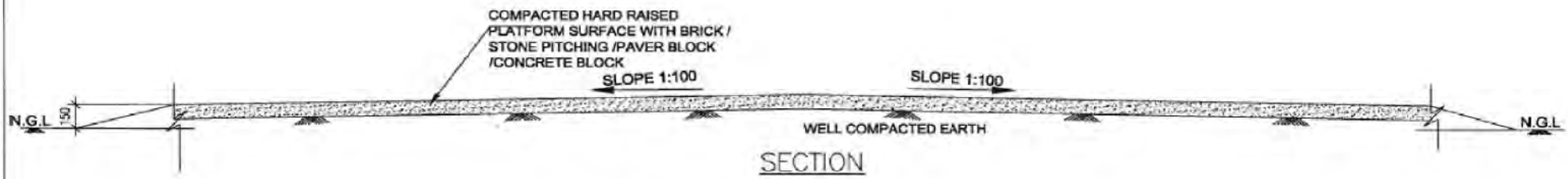
A power water wash test shall be performed at site on 5% sample in accordance with IEEE Std 957 to demonstrate that the RTV coated insulators can be power washed without any damage to RTV coating. The test shall be a water spray of a solid stream through a 6mm diameter nozzle at 3800 kPa for a period 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.

1401648/2023/TBG-TB_HVDC

Annexure-I



SECTION

INDICATIVE DRAWING ONLY
(SIZE SHALL BE AS PER WORK REQUIREMENT)

11/8/16				11/8/16	POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise)
ACM(ENGG CIVIL)	CDM(ENGG CIVIL)	REVD. BY AGM(ENGG CIVIL)	APVD. BY GM(ENGG CIVIL)	DATE	PROJECT: STANDARD DRAWING FOR OPEN PLATFORM
					TITLE: INDICATIVE DRAWINGS FOR OPEN STORAGE PLATFORM
					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.

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

SECTION-GENERAL TECHNICAL REQUIREMENTS (GTR)

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.

Major Changes in Section GTR (Rev 15)

			(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>
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<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>
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</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

Major Changes in Section GTR (Rev 15)

<table>
<tr>
<td></td>
<td></td>
<td>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</td>
<td>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.

<table>
<tr><th>S. No</th><th>Name of Equipment</th><th>Validity of type test(in years)</th></tr>
<tr><td>1</td><td>Power Transformer</td><td>5</td></tr>
<tr><td>2</td><td>LT Transformer</td><td>5</td></tr>
<tr><td>3</td><td>Shunt Reactor</td><td>5</td></tr>
<tr><td>4</td><td>OLTC</td><td>10</td></tr>
<tr><td>5</td><td>Bushing of Power Transformers/Reactors</td><td>7</td></tr>
<tr><td>6</td><td>Fittings and accessories for Power transformers & Reactors</td><td>10</td></tr>
<tr><td>7</td><td>Circuit Breaker</td><td>10</td></tr>
<tr><td>8</td><td>Isolator</td><td>10</td></tr>
<tr><td>9</td><td>Lighting Arrester</td><td>10</td></tr>
<tr><td>10</td><td>Wave Trap</td><td>10</td></tr>
<tr><td>11</td><td>Instrument transformer</td><td>7</td></tr>
<tr><td>12</td><td>GIS & Hybrid GIS</td><td>10</td></tr>
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</table>

Major Changes in Section GTR (Rev 15)

			<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	
15.	**Clause no. 9.5**	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).	The list of makes of various items, for which Type test reports are not required to be submitted are specified ~~in Compendium of Vendor (COV)~~ **at Annex-J**	
16.	**Clause 12.2**	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-**	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~~ if defined in Section Project) ~~or as specified in Section Project~~**. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For	

Major Changes in Section GTR (Rev 15)

<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>

Major Changes in Section GTR (Rev 15)

<table>
<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><th>Sl. No.</th><th>Description</th><th>Materials</th></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>
</table>

Major Changes in Section GTR (Rev 15)

		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	

Major Changes in Section GTR (Rev 15)

		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.	

Major Changes in Section GTR (Rev 15)

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

Major Changes in Section GTR (Rev 15)

			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	

Major Changes in Section GTR (Rev 15)

		(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.	

Major Changes in Section GTR (Rev 15)

		(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	

Major Changes in Section GTR (Rev 15)

		~~(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)	

Major Changes in Section GTR (Rev 15)

		~~(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:	

Major Changes in Section GTR (Rev 15)

		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	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	

Major Changes in Section GTR (Rev 15)

		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:	

Major Changes in Section GTR (Rev 15)

		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	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 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	

Major Changes in Section GTR (Rev 15)

		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	

Major Changes in Section GTR (Rev 15)

		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.	

		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**	

Major Changes in Section GTR (Rev 15)

		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.	

Major Changes in Section GTR (Rev 15)

		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 Technical Requirement for 400kV GIS Equipment**	New Clause added

Major Changes in Section GTR (Rev 15)

			(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.	

Major Changes in Section GTR (Rev 15)

			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

Major Changes in Section GTR (Rev 15)

			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:	

<table>
<tr><td></td><td></td><td></td><td>Minimum Average Annual Turnover (MAAT) = Cost of the work to be contractedx1.5/Completion period years**

**The completion period shall be considered as 1 year even if the same is less than 1 year.</td><td></td></tr>
<tr><td>40.</td><td></td><td></td><td>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.

<table>
<tr><th>S. no</th><th>Voltage class of GIS Package</th><th>Minimum Voltage class Circuit Breaker Equipped of Bay(**)</th></tr>
<tr><td>1</td><td>765kV & 400kV GIS</td><td>345kV</td></tr>
<tr><td>2</td><td>220kV</td><td>220kV</td></tr>
<tr><td>3</td><td>132kV</td><td>110kV</td></tr>
<tr><td>4</td><td>66kV</td><td>66kV</td></tr>
</table>
</td><td>New Clause added</td></tr>
</table>

Major Changes in Section GTR (Rev 15)

			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

CONTENTS

Clause No	Particulars	Page No.
1.0	General	1
2.0	String Insulators & Hardware	1
3.0	AAC/ACSR Conductor	12
4.0	Galvanised Steel Earth Wire	15
5.0	Aluminium Tube	17
6.0	Earthing Conductors	18
7.0	Spacers	19
8.0	Bus Post Insulators	20
9.0	Earthing	23
10.0	Bus Bars	28
11.0	Bay Equipment	28
12.0	Lightning Protection	30
13.0	Equipment Erection Details	30
14.0	Storage	31
15.0	Cabling Material	31
16.0	Directly Buried Cables	33
17.0	Installation Of Cables	33
18.0	Junction Box	38
19.0	Testing And Commissioning	38
Annexure-A	Testing Procedure for ACSR MOOSE conductor	40
Annexure-B	Testing Procedure for Galvanised Steel Earthwire	42
Annexure-C	Corona and Radio Interference Voltage (RIV) Test	44
Annexure-D	Short Circuit Forces And Spacer Span for Gantry Str.	46
Annexure-E	Standard Technical Data Sheets for Conductors, Earthwire and Aluminium pipe	48

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. Tension Insulator String

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. Suspension Insulator String

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.

SECTION - (SE)
SWITCHYARD ERECTION

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 ~~-o~~pen 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.

SECTION - (SE)
SWITCHYARD ERECTION

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.	
b)	Corona extinction voltage test (dry)	As per Annexure-A
(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	
c)	Check for lay ratios of various layers	-do-
d)	Galvanising test on steel strands	
e)	Torsion and Elongation test on steel strands	
f)	Breaking load test on steel and aluminium strands	
g)	Wrap test on steel and aluminium strands	As per IEC:60888 & 60889
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	)	IS:398 (Part-III) - 1976
h)	DC resistance test	)	
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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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 ~~-S~~tandard 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 ~~c~~lass 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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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.

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

ANNEXURE-E

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	$23.0x10^{-6}$	$23.0x10^{-6}$
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	

SECTION - (SE)
SWITCHYARD ERECTION

ANNEXURE-E

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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

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	$21.5x10^{-6}$	$19.3x10^{-6}$
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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

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

SECTION - (SE)
SWITCHYARD ERECTION

ANNEXURE-E

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

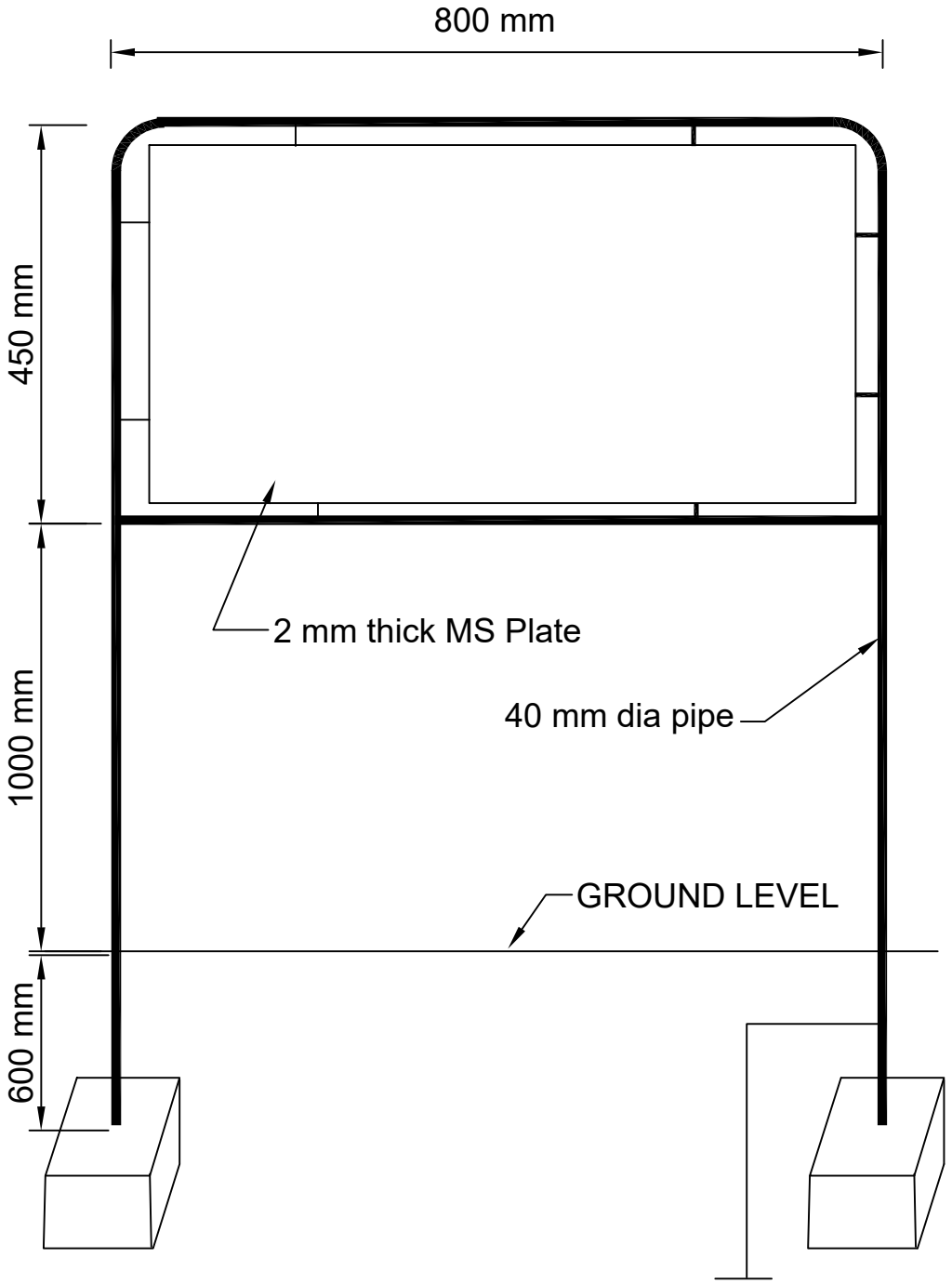
B. GTP for 4.5" IPS & 5" IPS AL. TUBE

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

1401648/2023/TBG-TB_HVDC



NOTE : DIMENSIONS ARE INDICATIVE ONLY.
IT MAY VARY AS PER SITE REQUIREMENT.

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- STANDARD

TITLE:- STANDARD BAY NAME PLATE

KKParkar	KKParkar	18 / 02 / 2008	Drawing No.: C/ENG/STD/BAY NAME PLATE	Rev. 00
CKD BY	PRPD BY	Date		

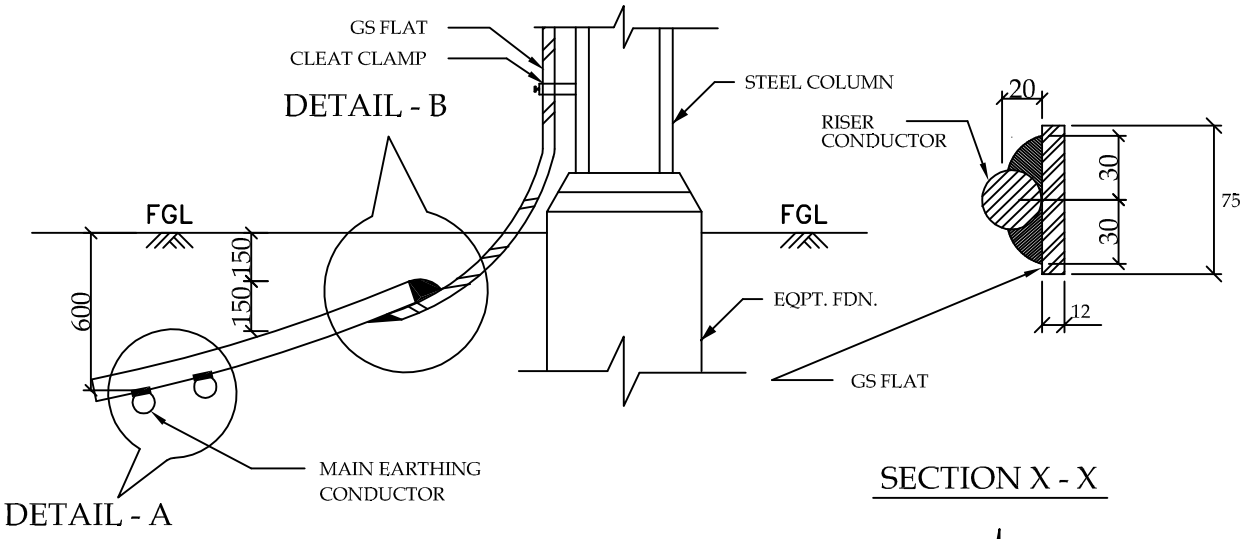
GENERAL INSTRUCTION FOR EARTHING:

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

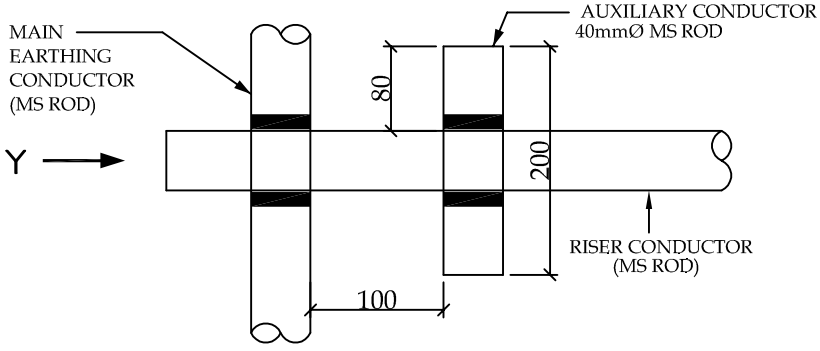
POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 1
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

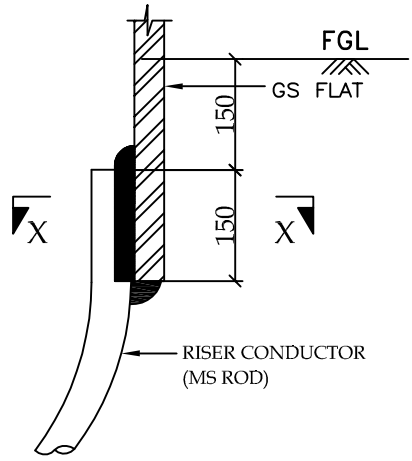


SECTION X - X

TYPICAL DETAILS OF RISER

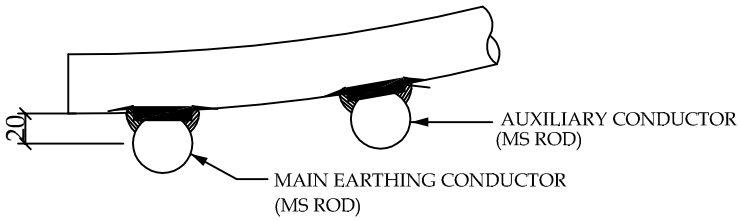


PLAN



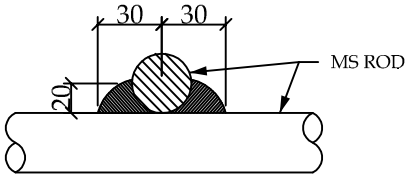
ELEVATION

DETAIL - B



ELEVATION

DETAIL - A

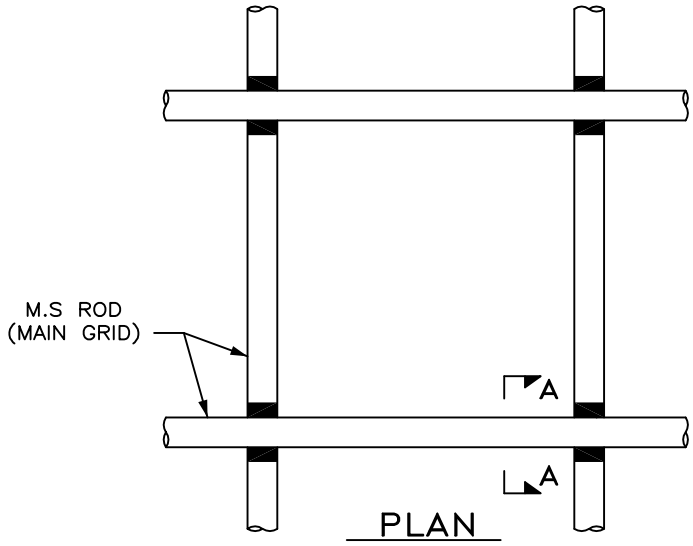


VIEW - Y

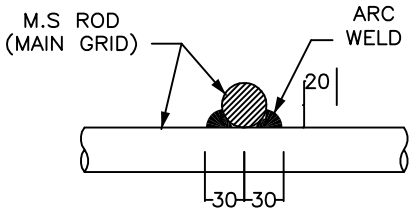
RELEASED FOR CONTRUCTION

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 SHEET # 2
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

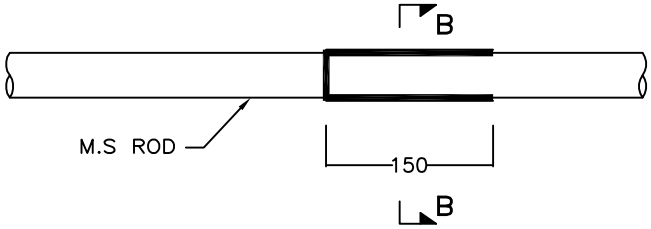


PLAN



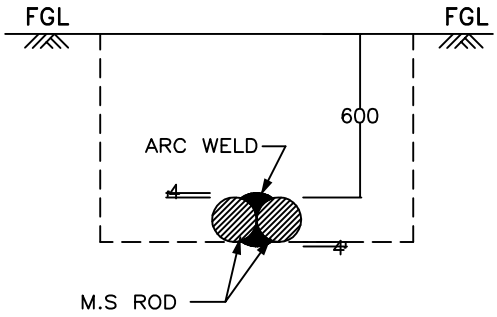
SECTION A – A

DETAIL OF CROSS JOINT

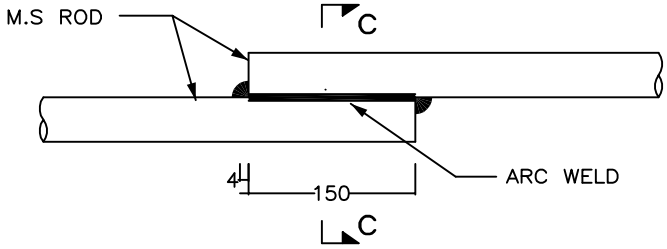


ELEVATION

(CONDUCTORS KEPT ON SIDES)

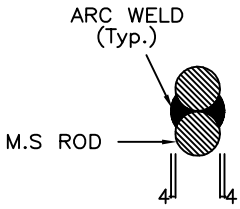


SECTION B – B



ELEVATION

(CONDUCTORS ONE ABOVE THE OTHER)

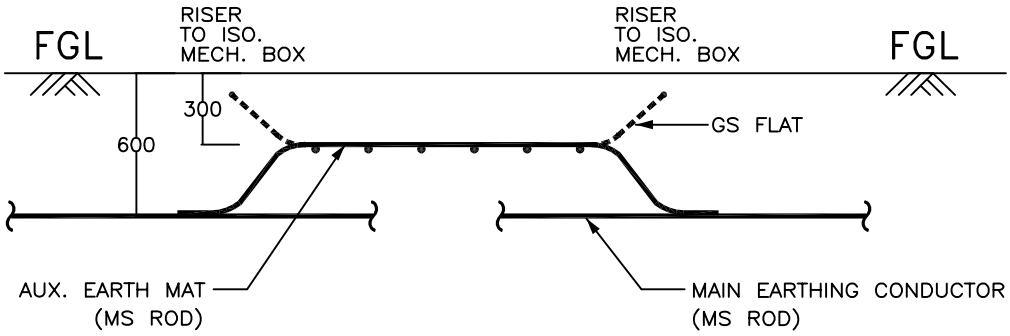


SECTION C – C

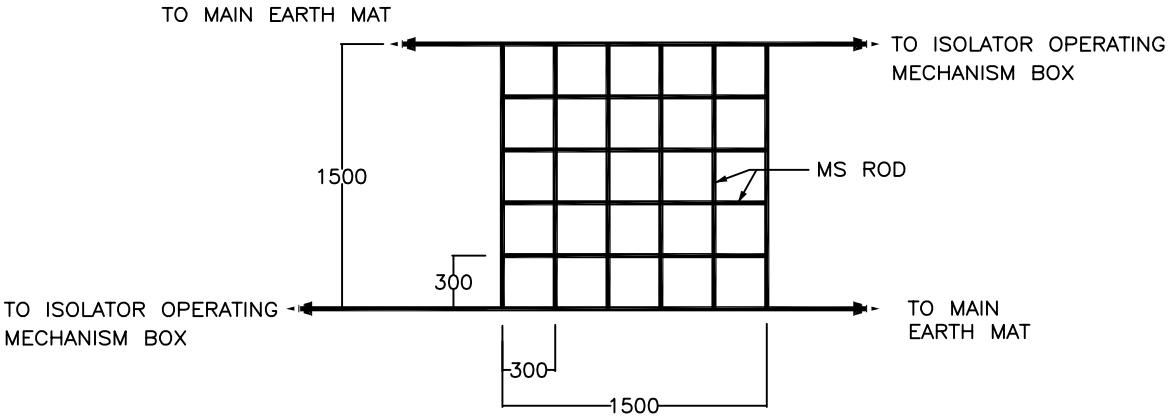
DETAIL OF LAP JOINT

RELEASED FOR CONTRUCTION

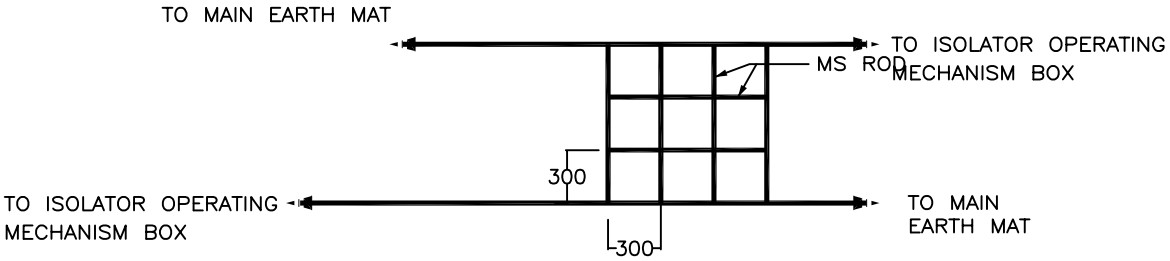
POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 3
CKD BY	PRPD BY	Date	



ELEVATION



PLAN (For 220kV & above class isolators)



PLAN (For 132kV & below class isolators)

RELEASED FOR CONTRUCTION

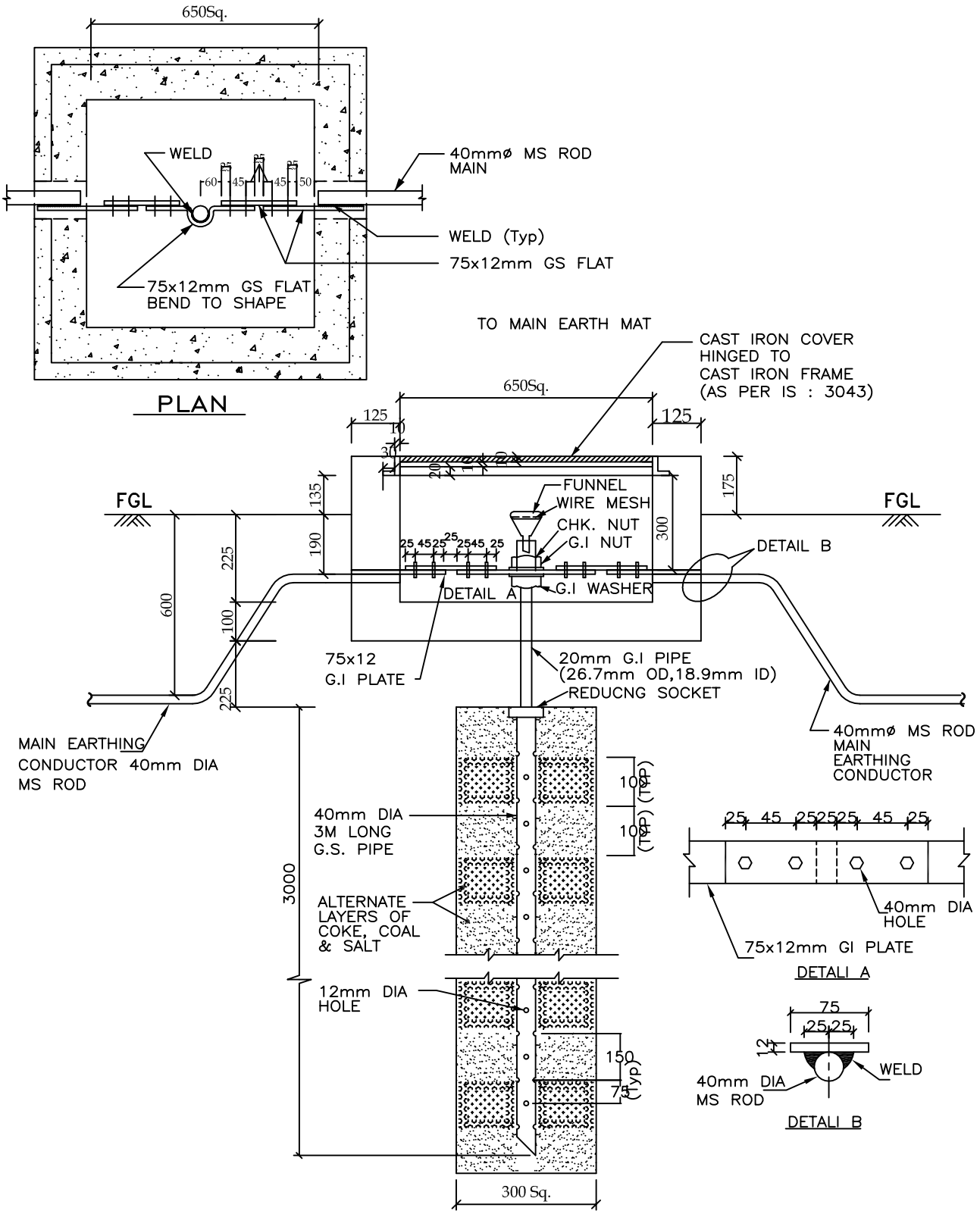
POWER GRID CORPORATION
OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-
SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 4
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC



RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

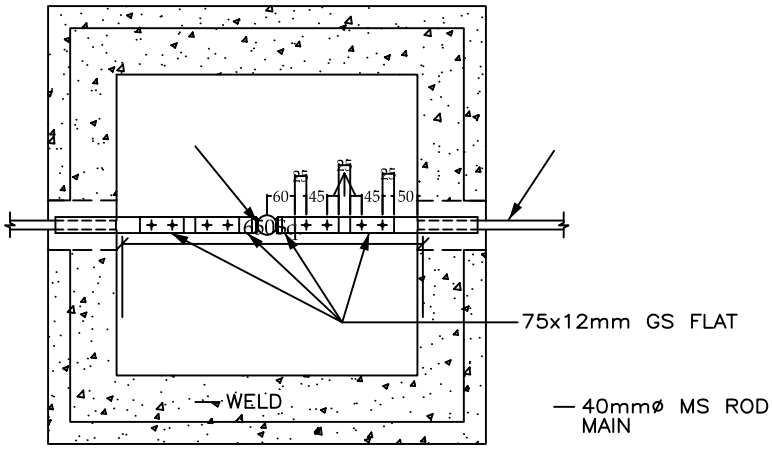
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

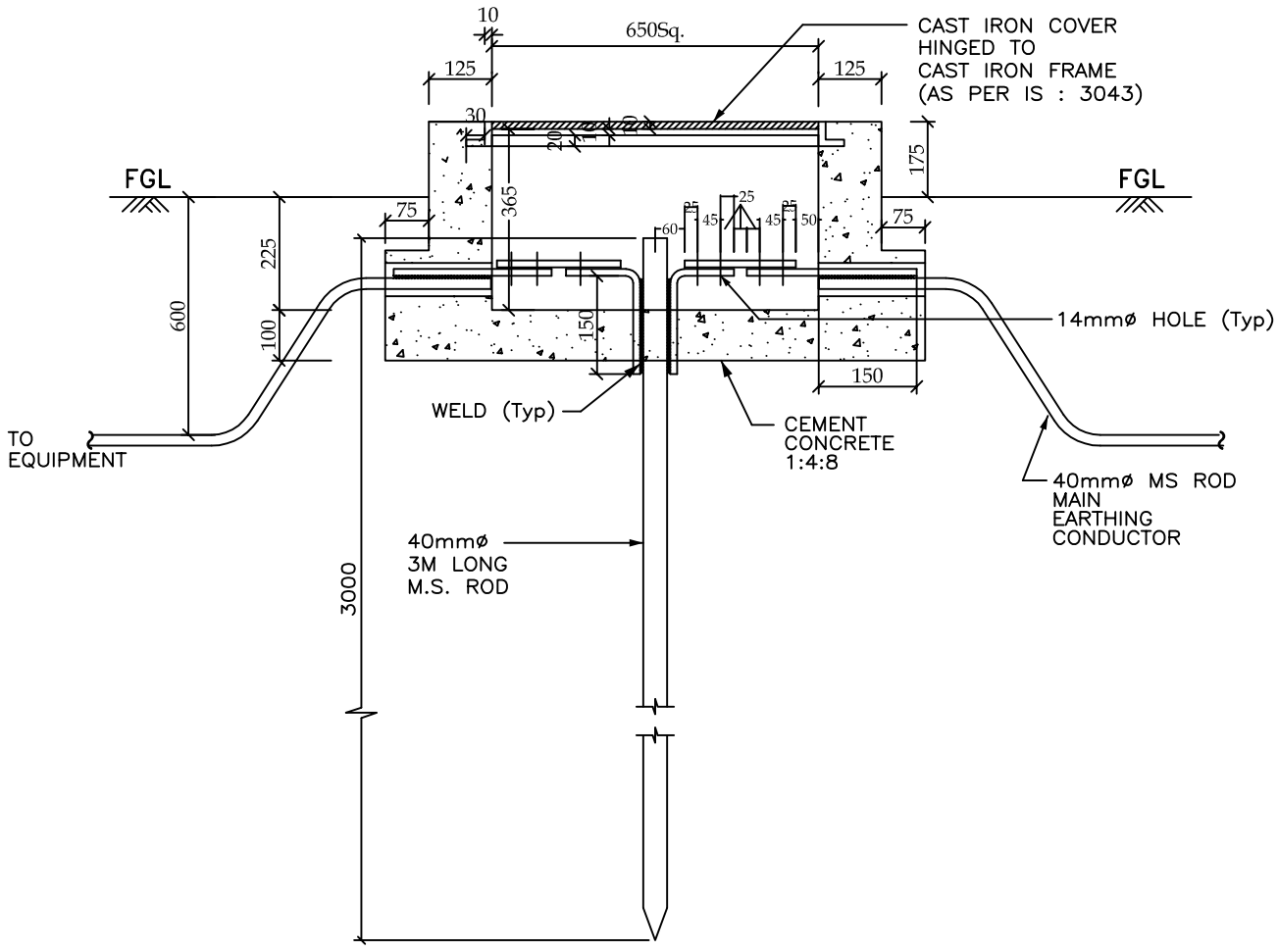
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 5

1401648/2023/TBG-TB_HVDC

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

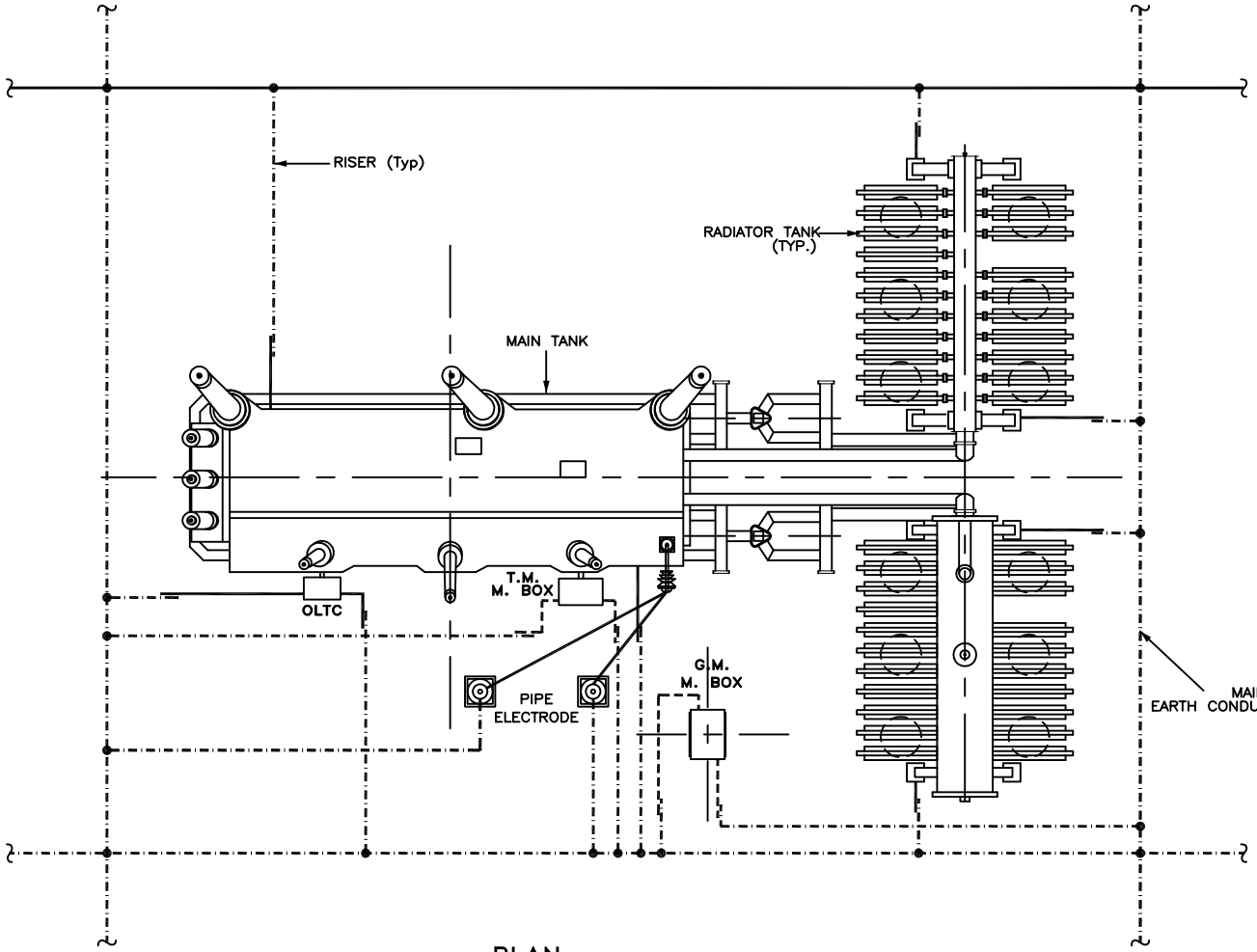
TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 6

260/811

1401648/2023/TBG-TB_HVDC

EARTHING OF TRANSFORMER/ REACTOR



PLAN

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

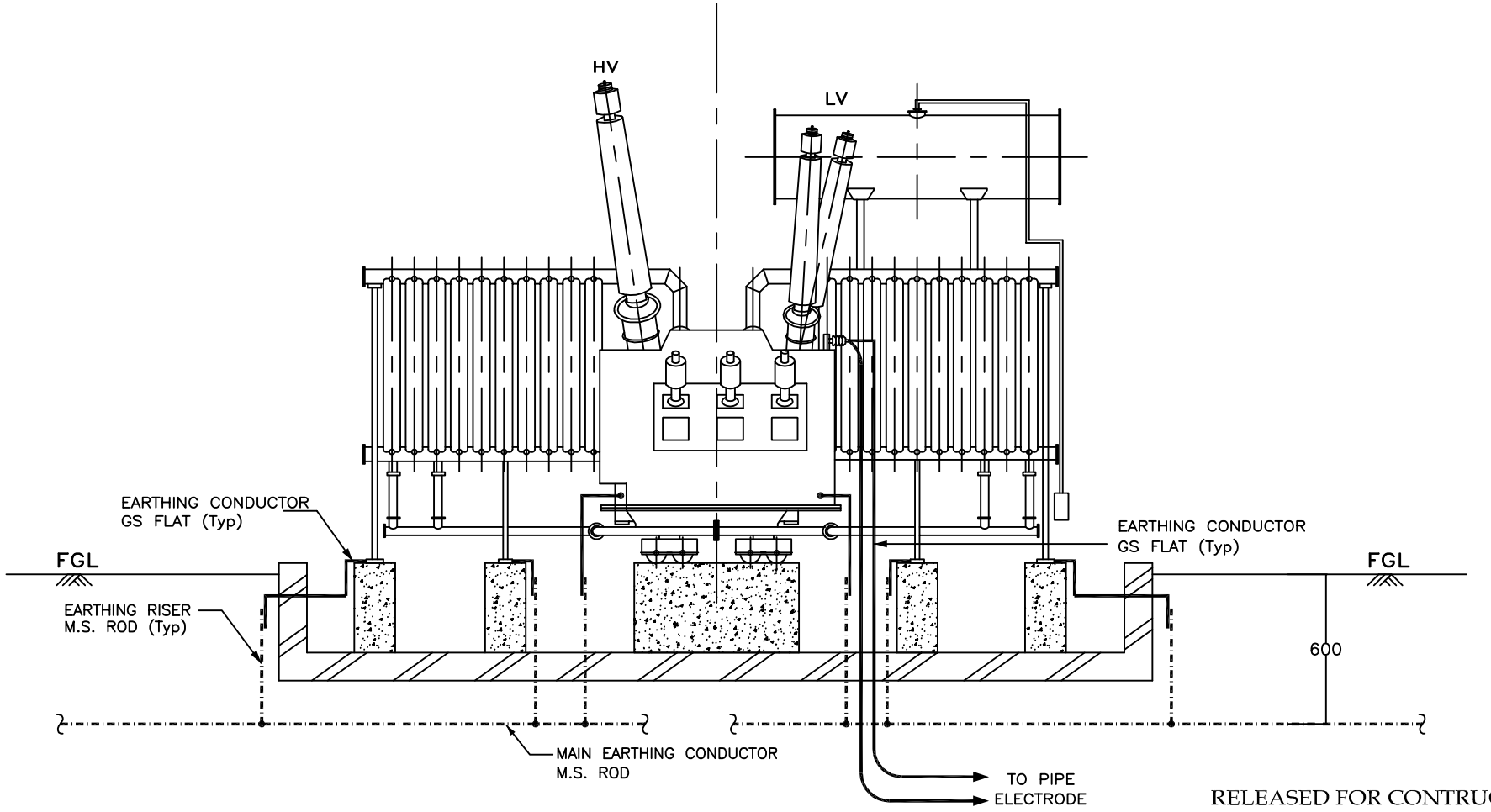
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise) पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 7
CKD BY	PRPD BY	Date	

EARTHING OF TRANSFORMER/ REACTOR



RELEASED FOR CONTRUCTION

LEGEND

- 40mmø MS ROD
- 75 x 12 mm GS FLAT
- 50 x 6 mm GS FLAT

END VIEW

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

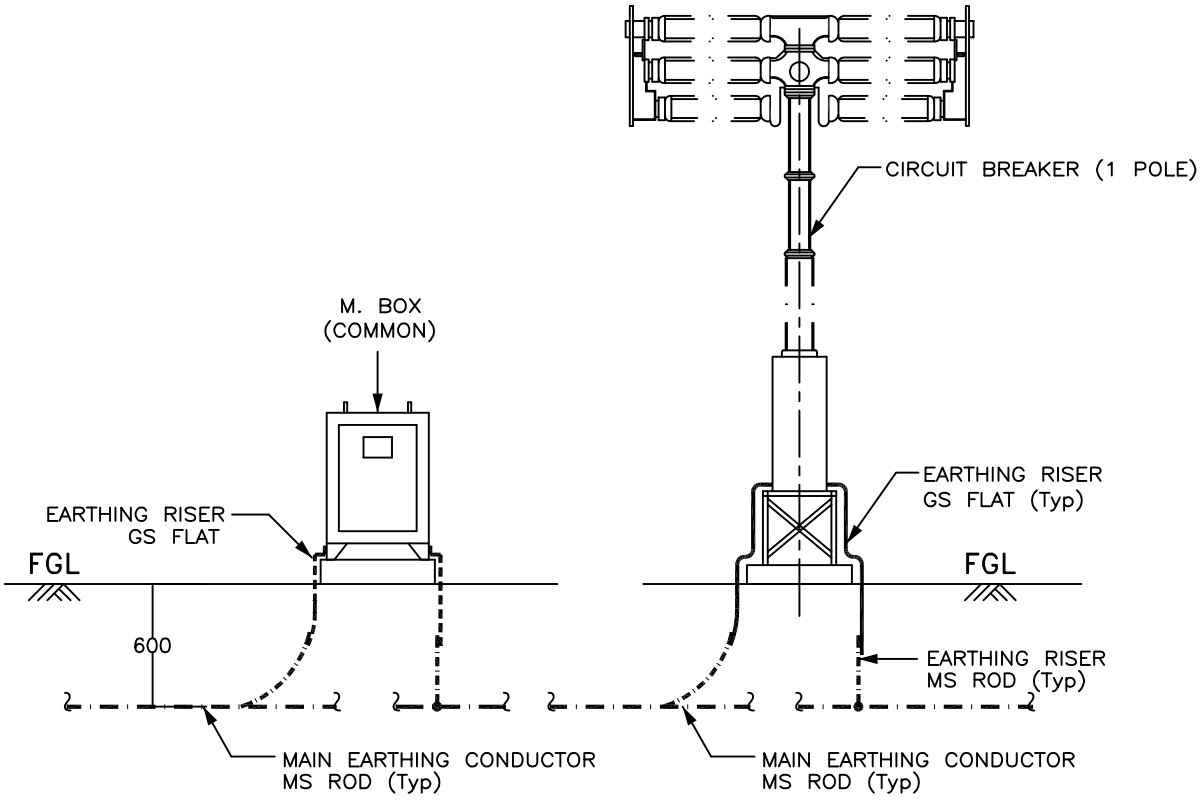
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

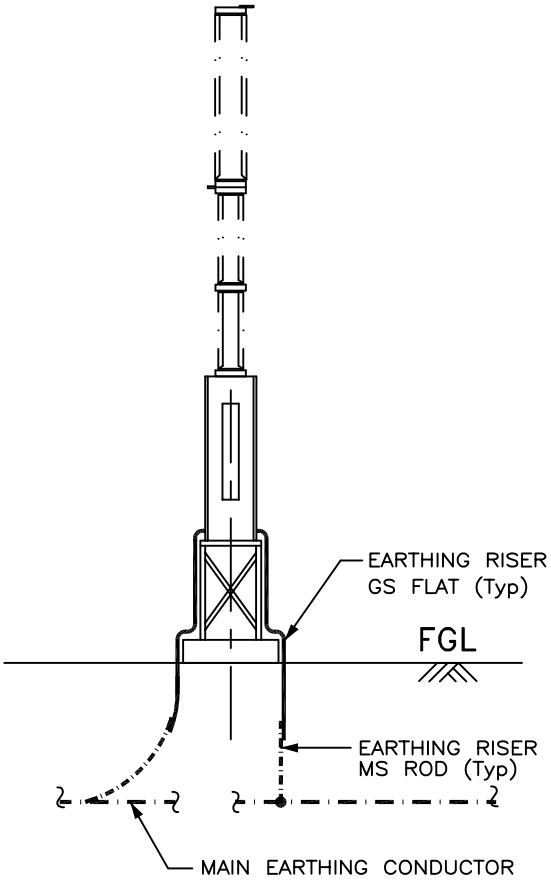
CKD BY	PRPD BY	Date	Drawing No.:
KKSarkar	KKSarkar	Dec-2013	C/ENG/STD/EARTHINGS/09 SHEET # 8

1401648/2023/TBG-TB_HVDC

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

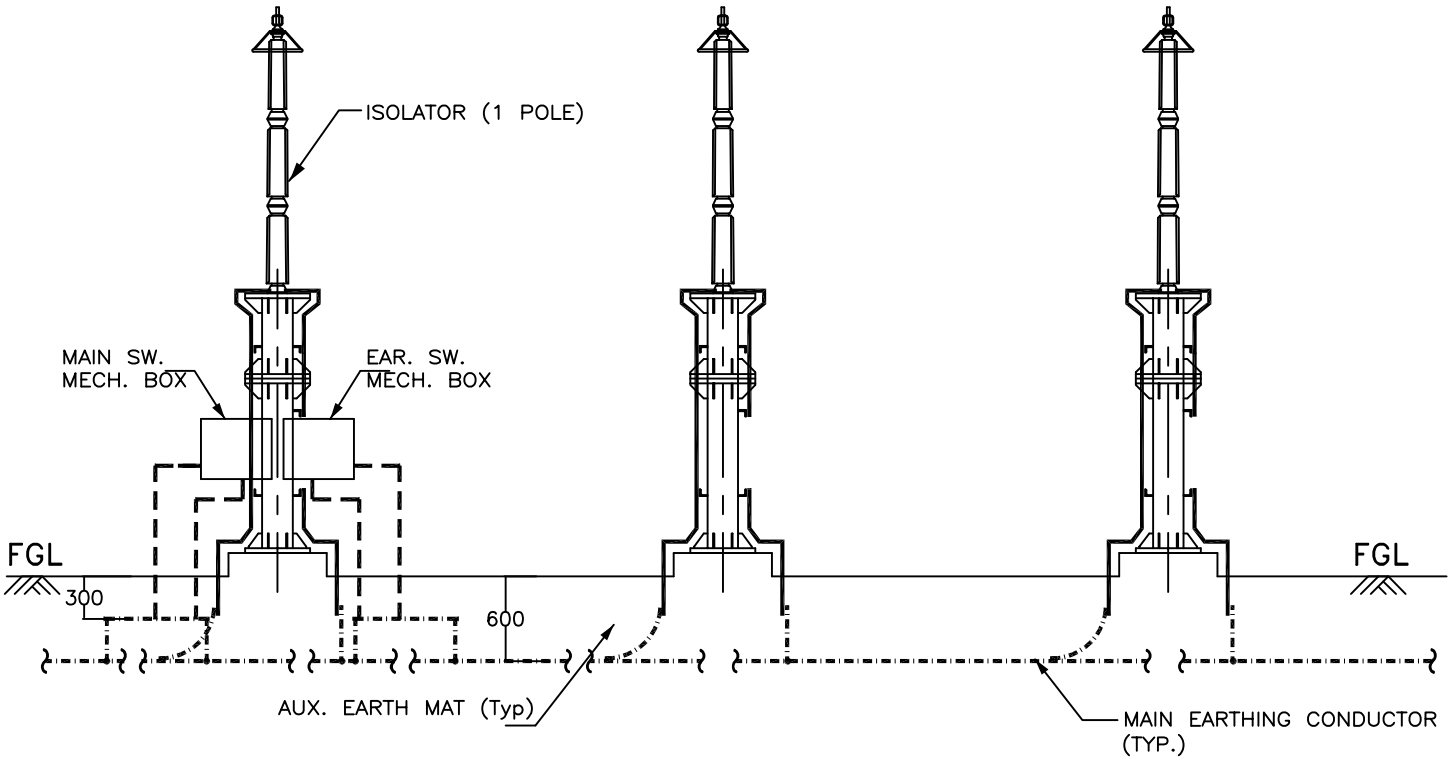
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

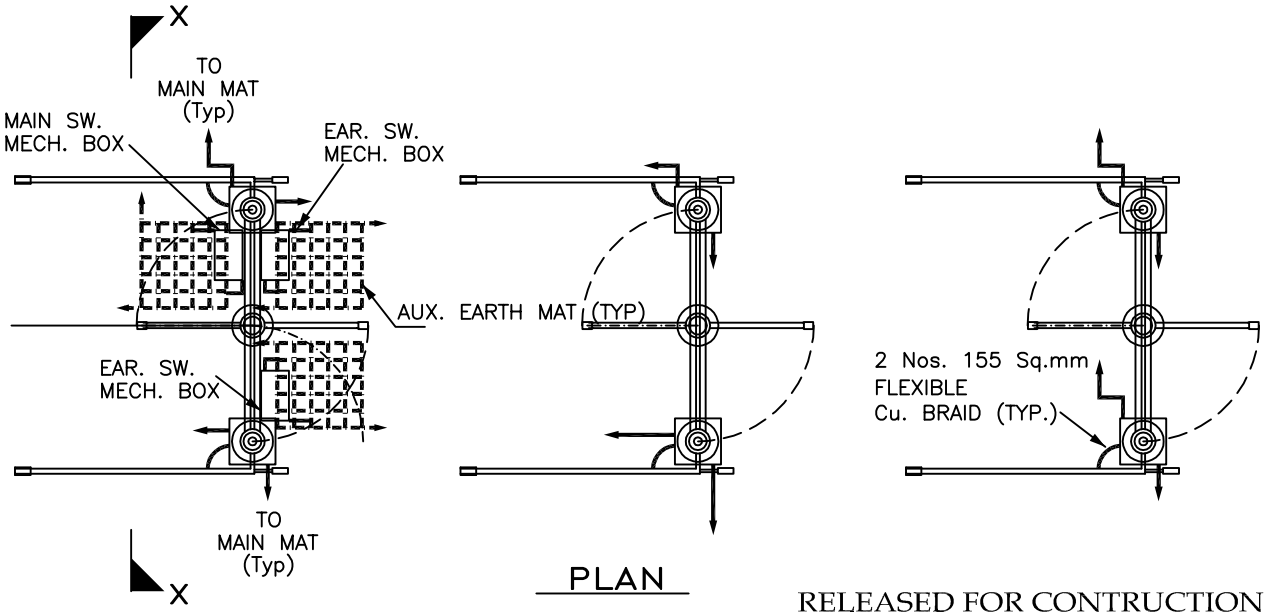
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 9

1401648/2023/TBG-TB_HVDC

EARTHING OF ISOLATOR



ELEVATION



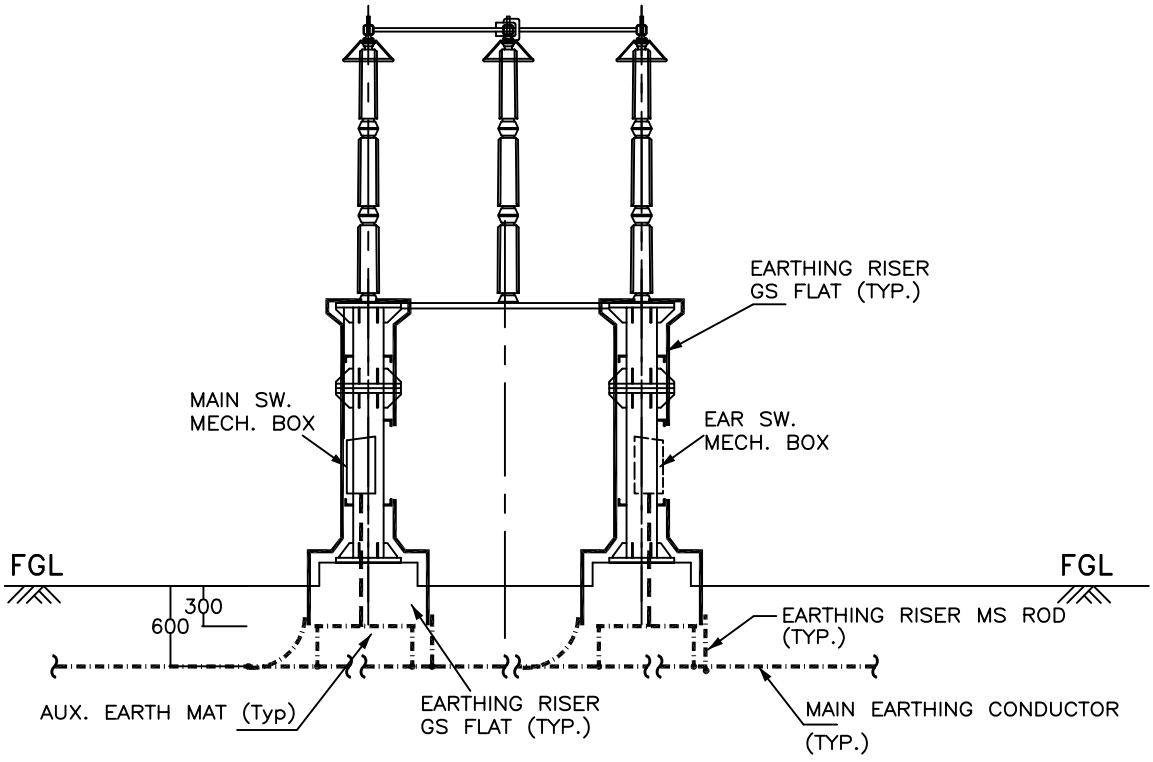
PLAN

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 10
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

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.

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

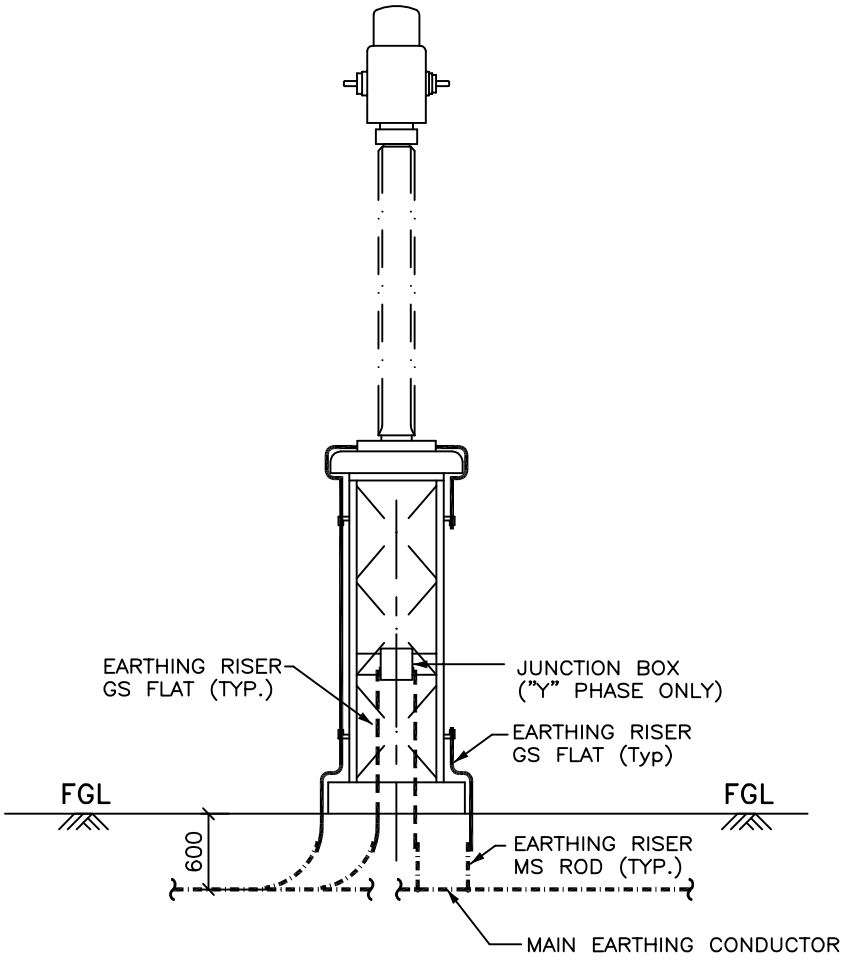
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 11

1401648/2023/TBG-TB_HVDC

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.

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

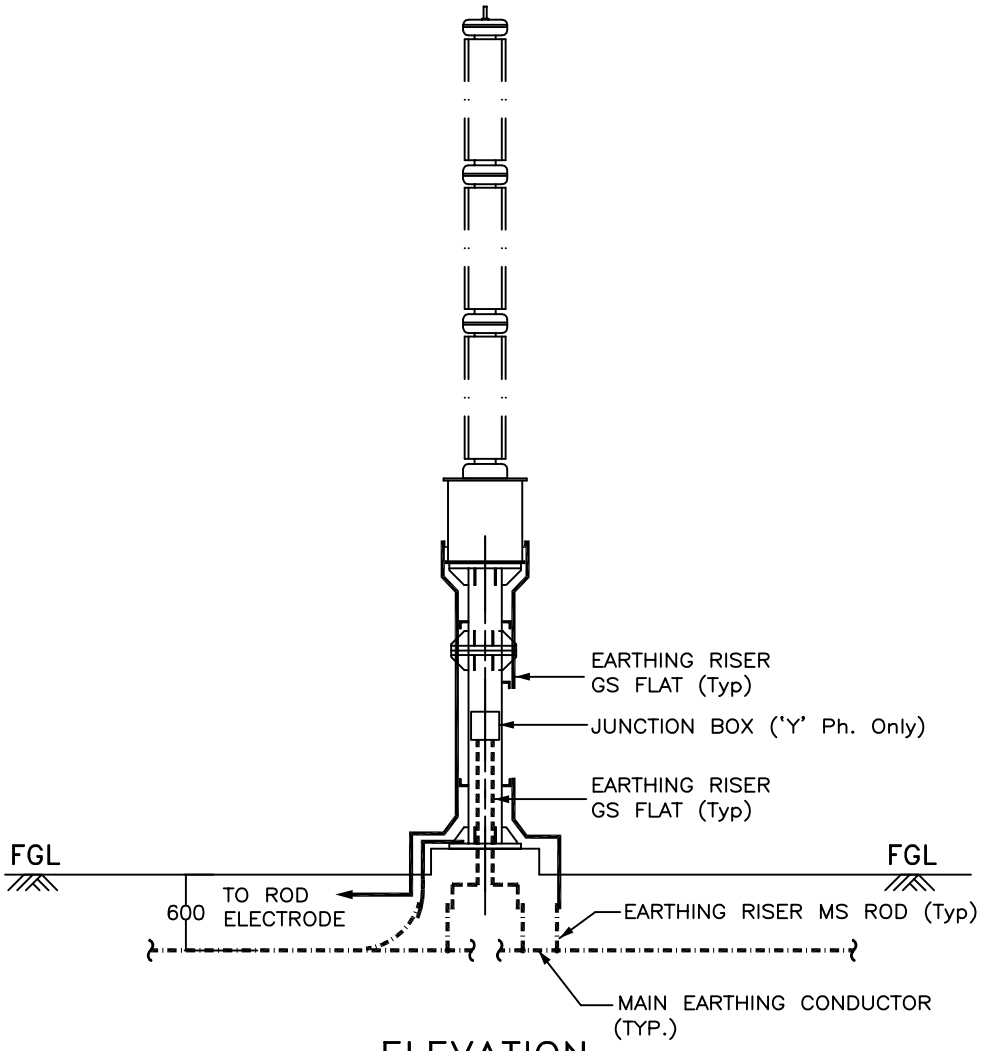
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 12
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

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

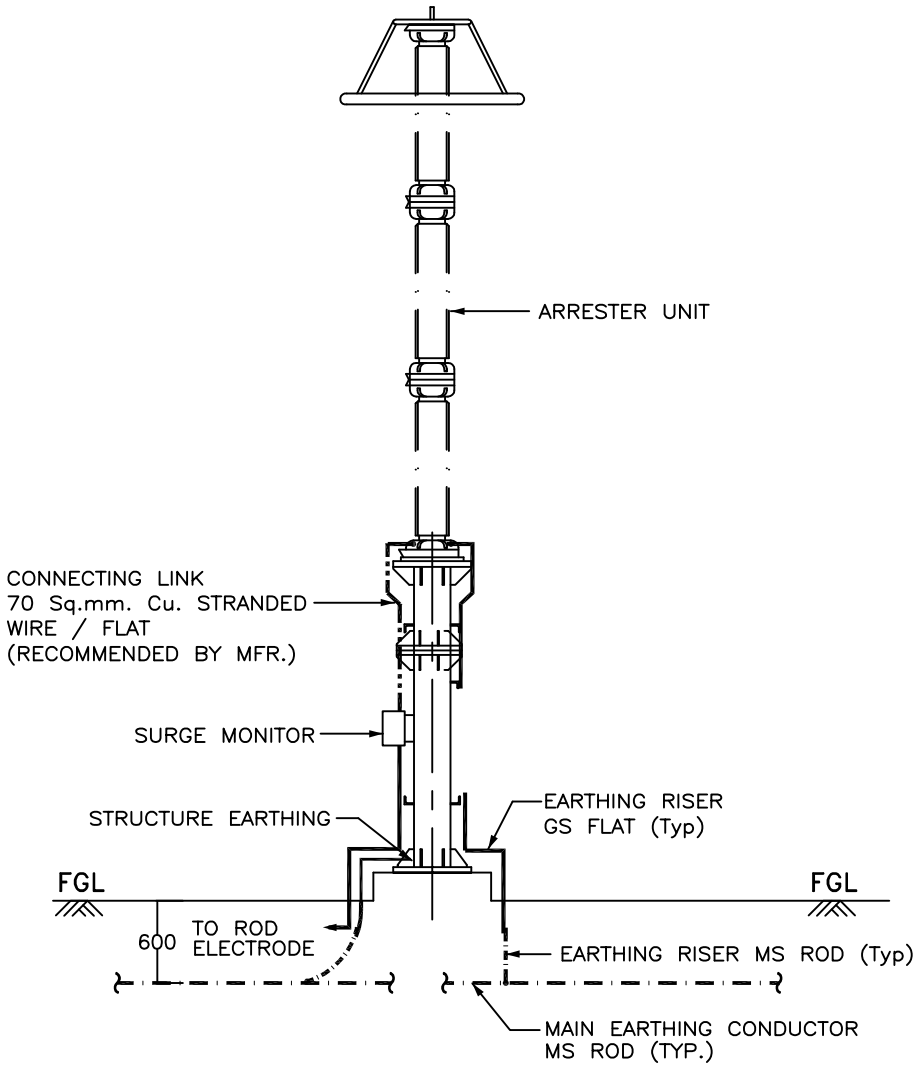
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 13

1401648/2023/TBG-TB_HVDC

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
(A Government of India Enterprise)
पावरग्रिड

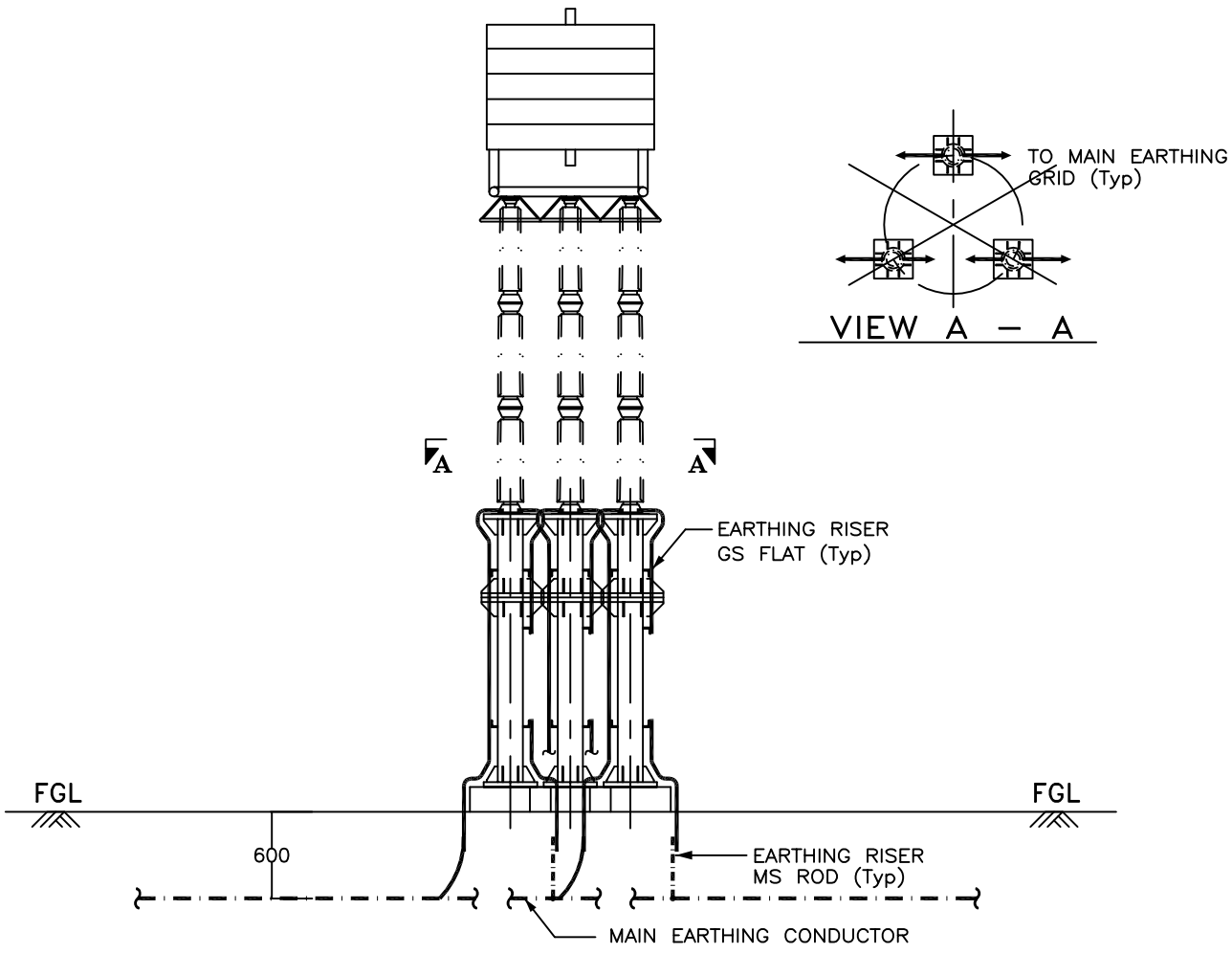
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 14

1401648/2023/TBG-TB_HVDC

EARTHING OF WAVE TRAP (1PH)



ELEVATION

LEGEND

40mmø MS ROD

75 x 12 mm GS FLAT

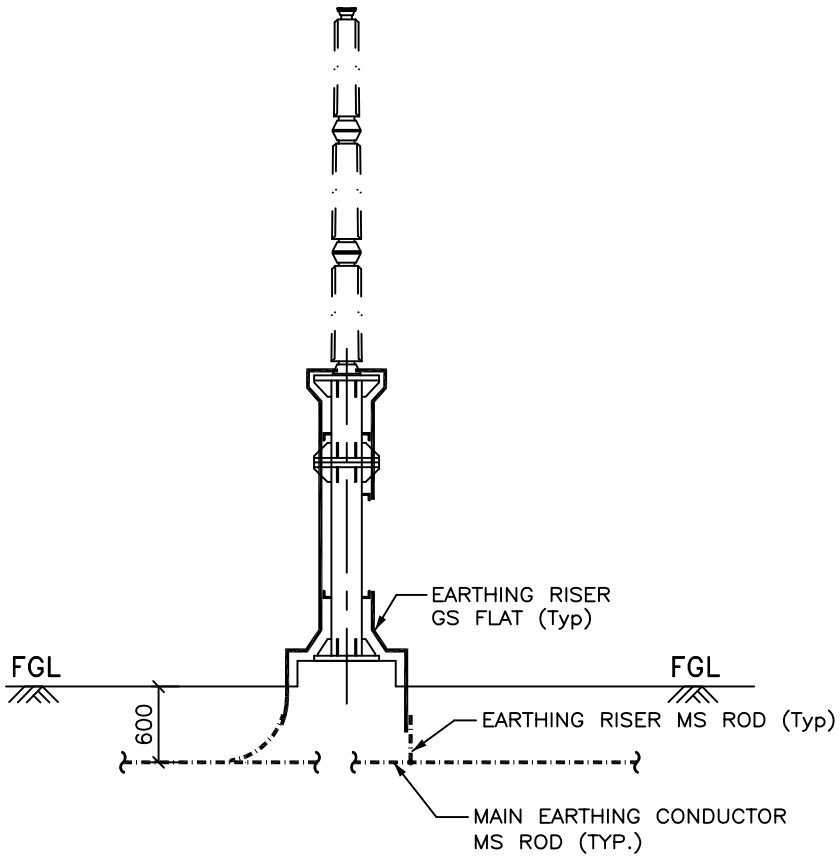
NOTE :–

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 (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 SHEET # 15
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

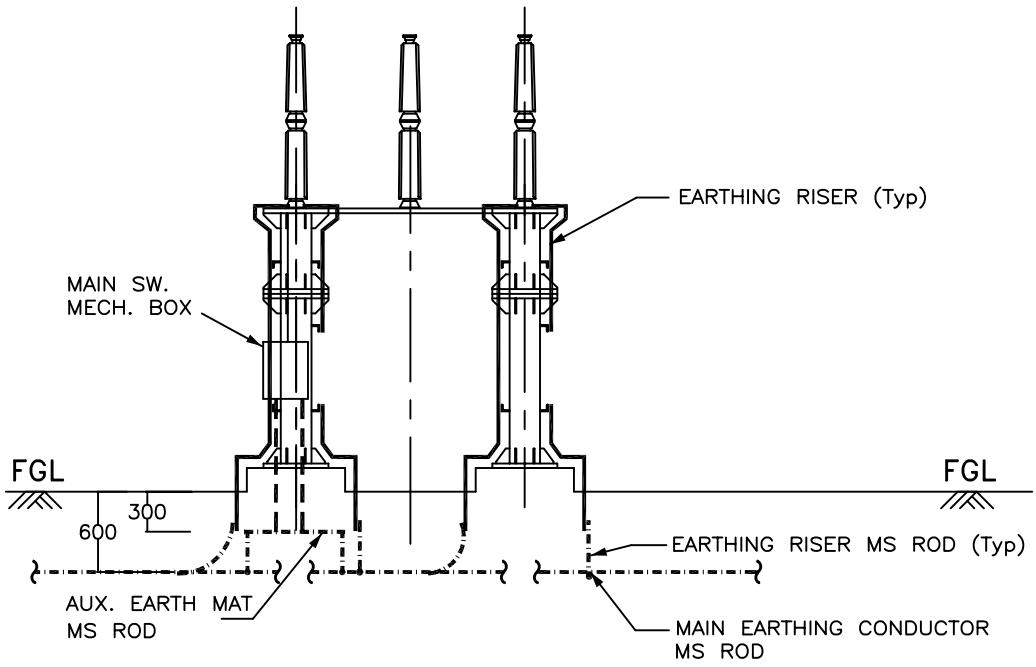
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

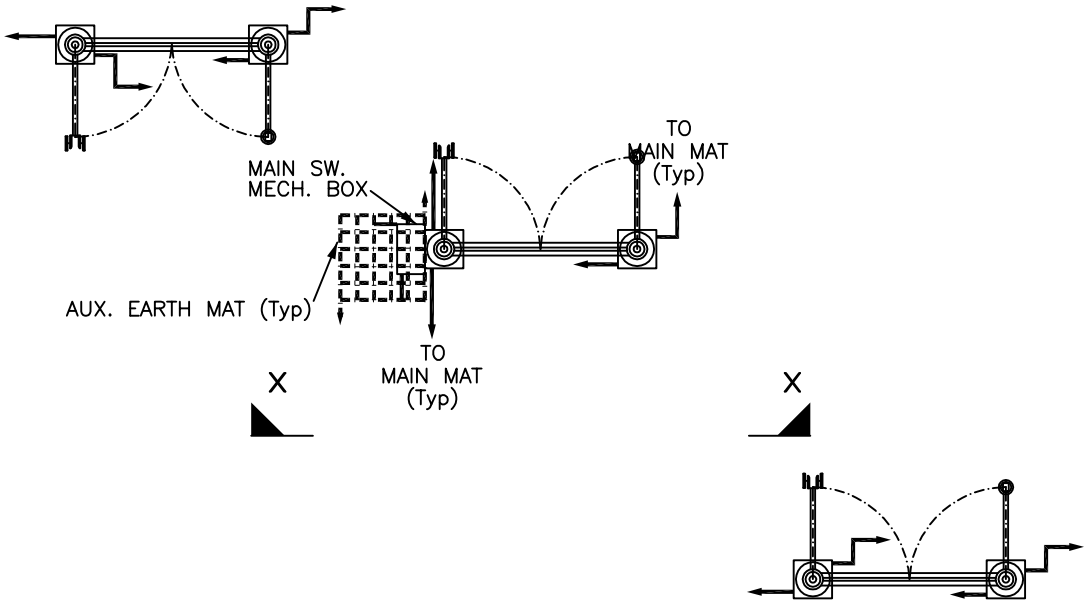
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 16

1401648/2023/TBG-TB_HVDC

TANDEM ISOLATOR



VIEW – X X



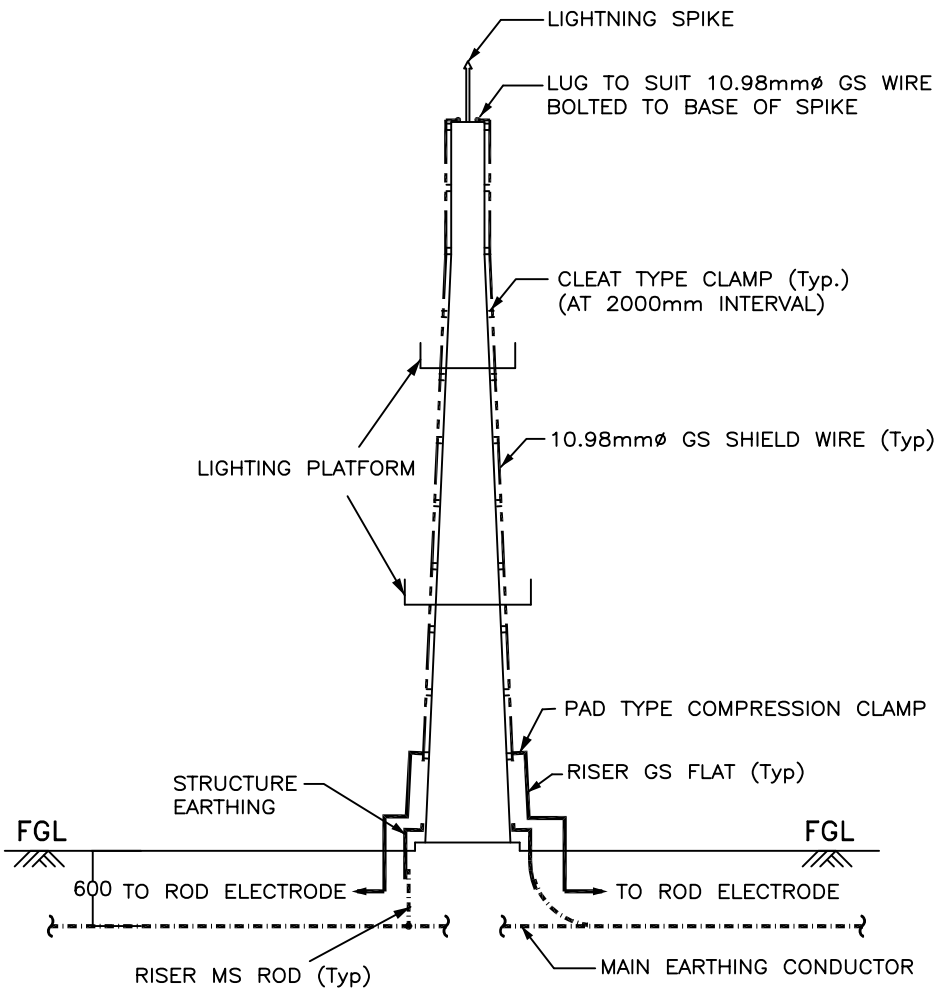
PLAN

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 17
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

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

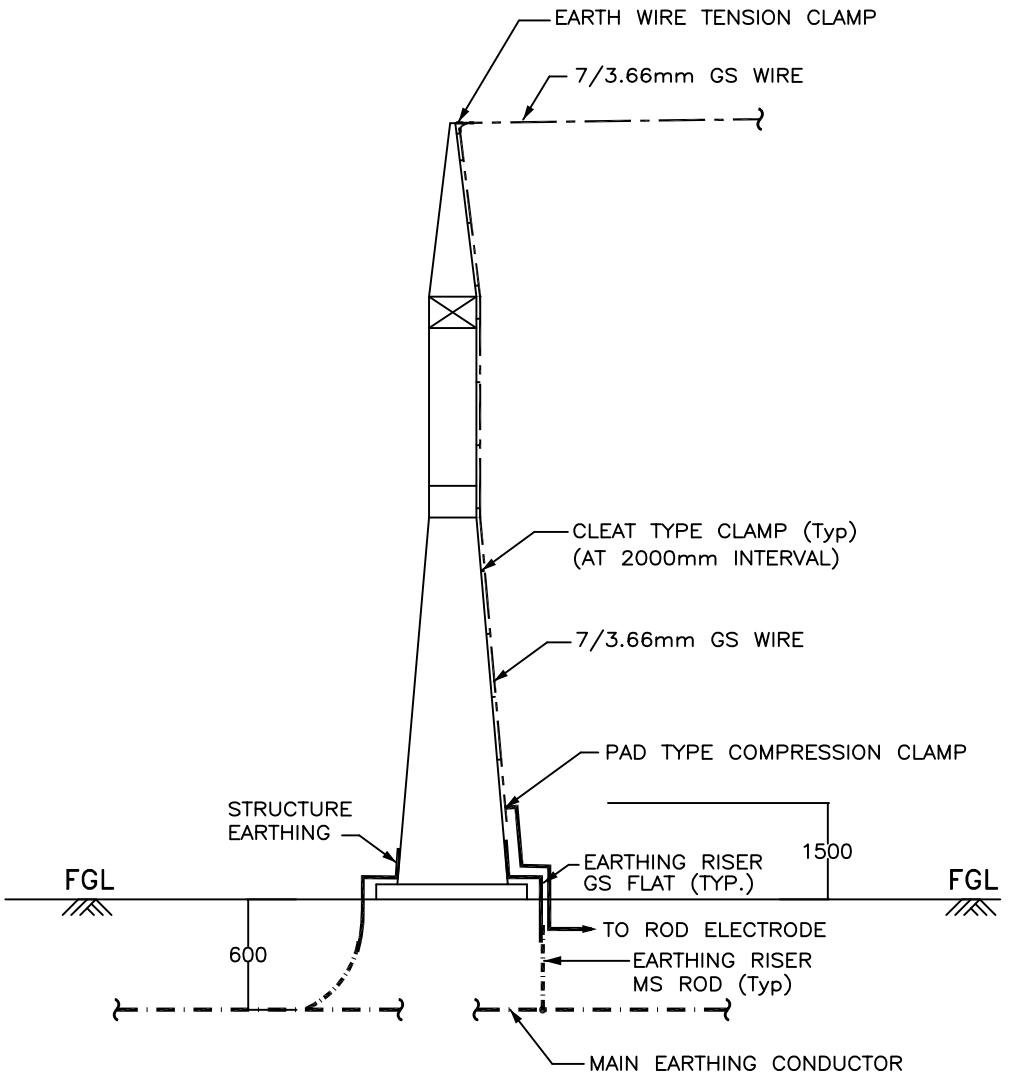
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 18

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

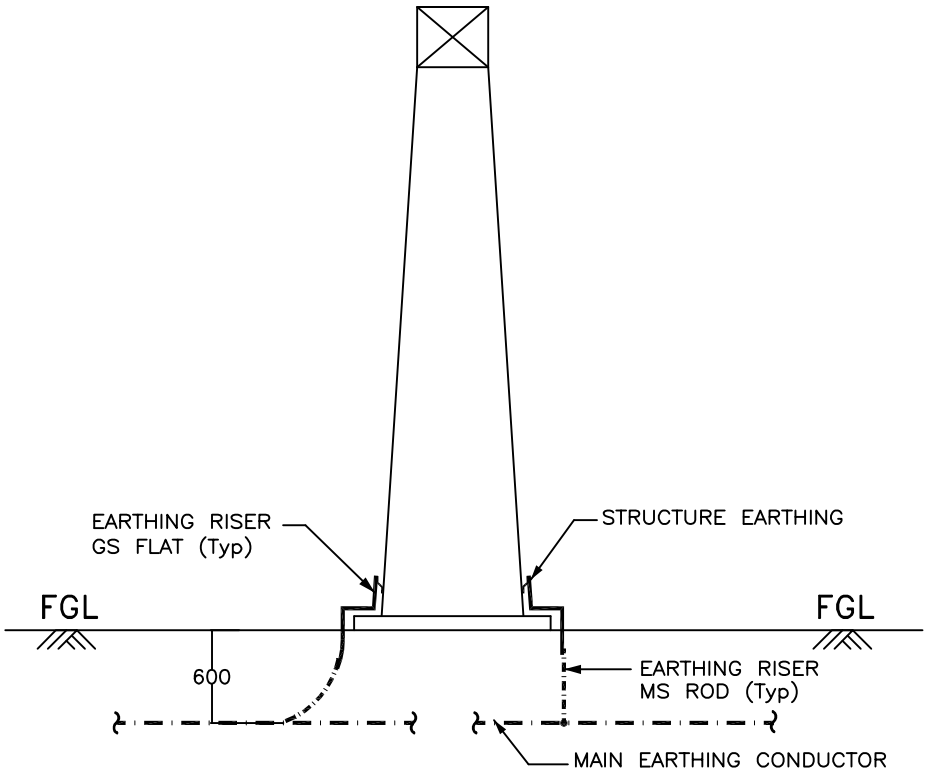
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	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

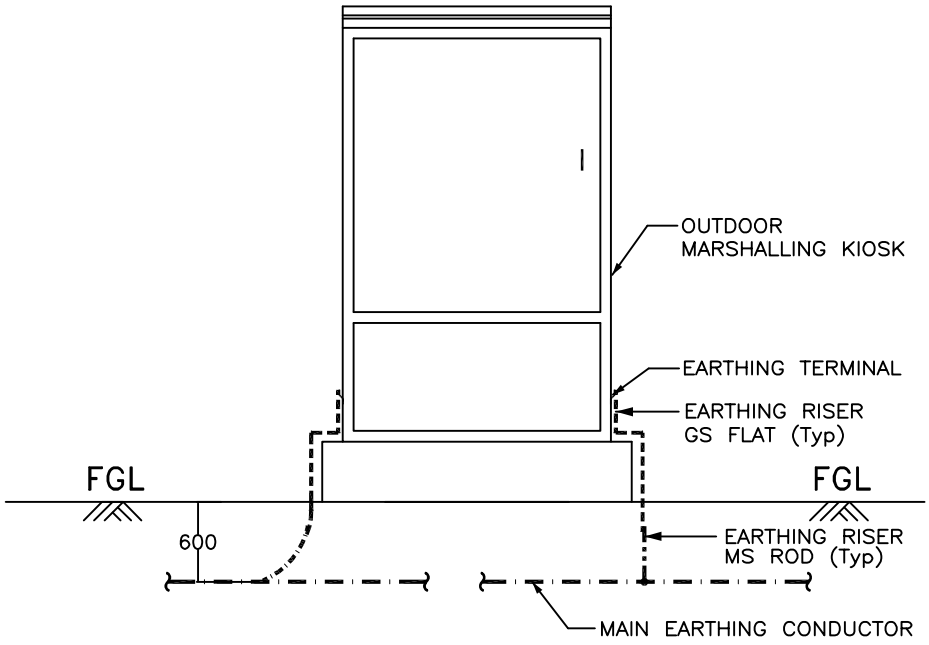
NOTES :–

1. No. OF RISERS = 2 Nos.

RELEASED FOR CONTRUCTION

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 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.

RELEASED FOR CONTRUCTION

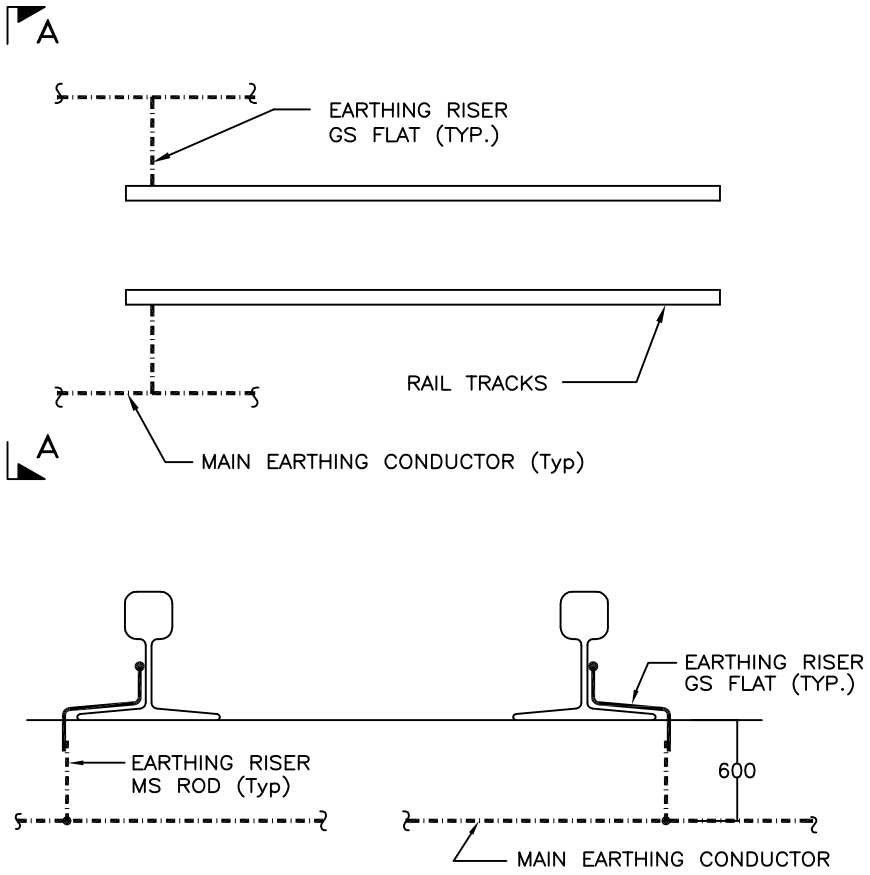
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 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 :–

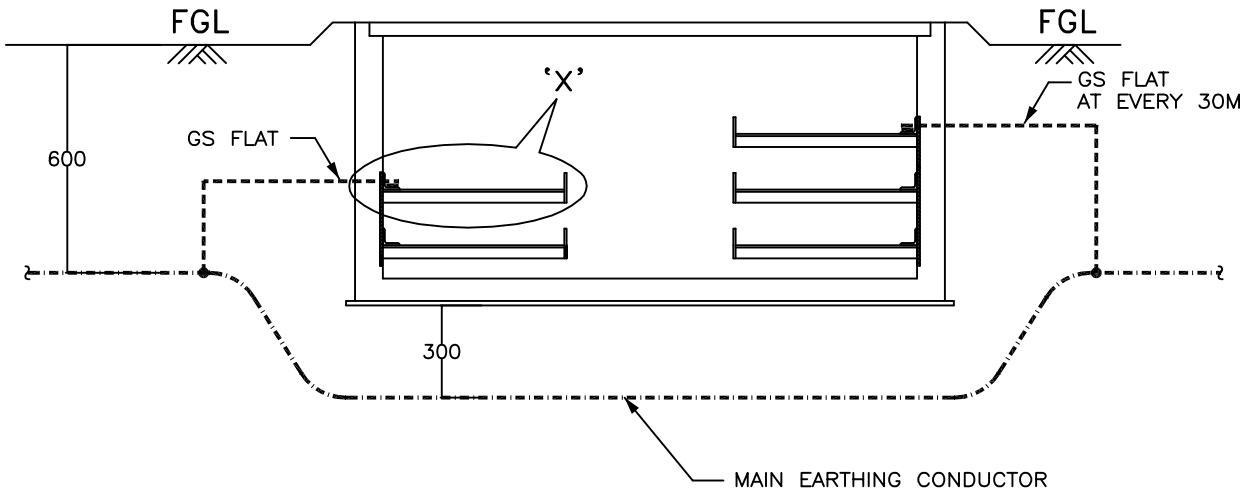
1. EACH RAIL SHALL BE EARTHED AT 30M INTERVAL AND ALSO AT BOTH ENDS.

RELEASED FOR CONTRUCTION

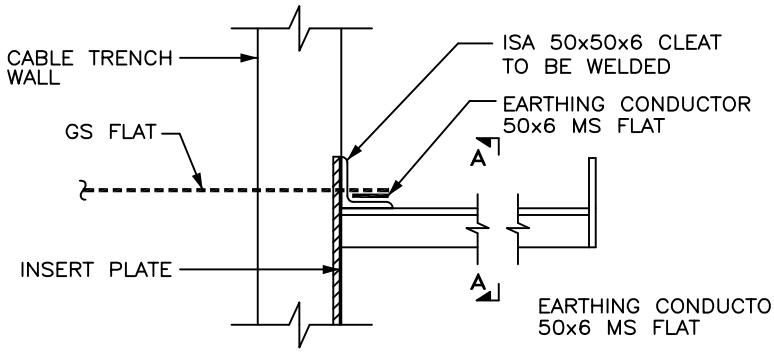
POWER GRID CORPORATION OF INDIA LIMITED (A Government of India Enterprise) पावरग्रिड			
PROJECT :- TECHNICAL SPECIFICATION- SWITCHYARD ERECTION			
TITLE:- STANDARD EARTHING DETAILS			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 22
CKD BY	PRPD BY	Date	

1401648/2023/TBG-TB_HVDC

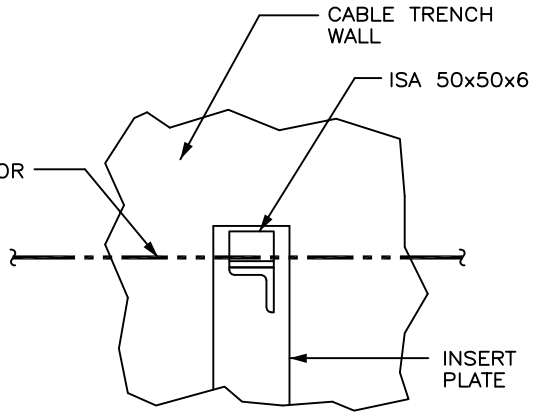
EARTHING OF CABLE TRENCH



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.

RELEASED FOR CONTRUCTION

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

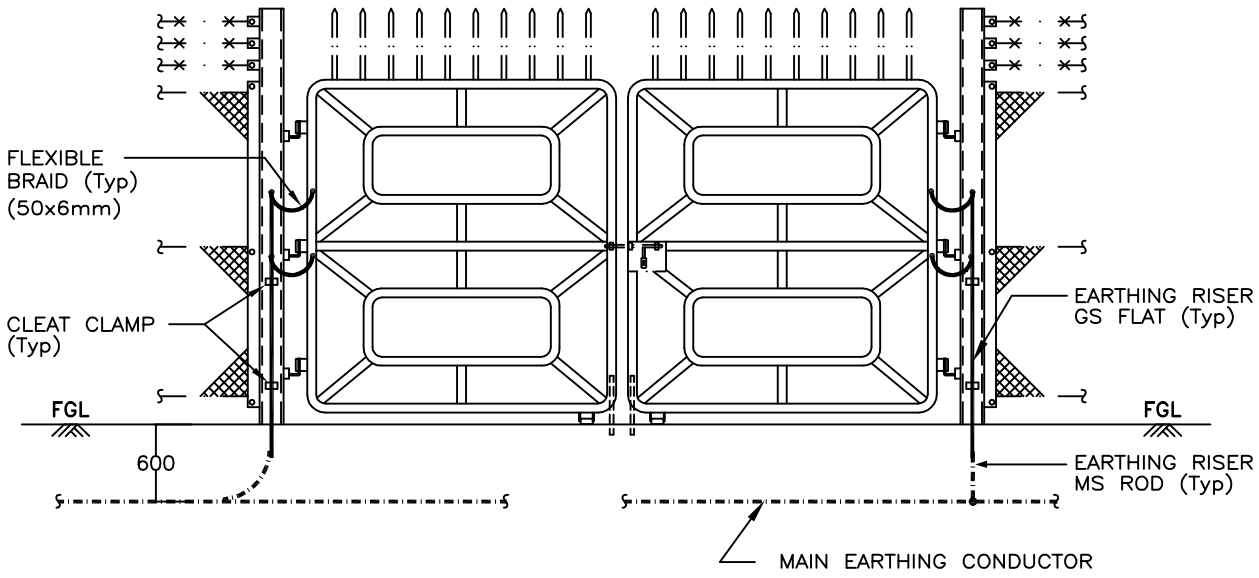
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 23

1401648/2023/TBG-TB_HVDC

EARTHING OF GATES



MAIN GATE

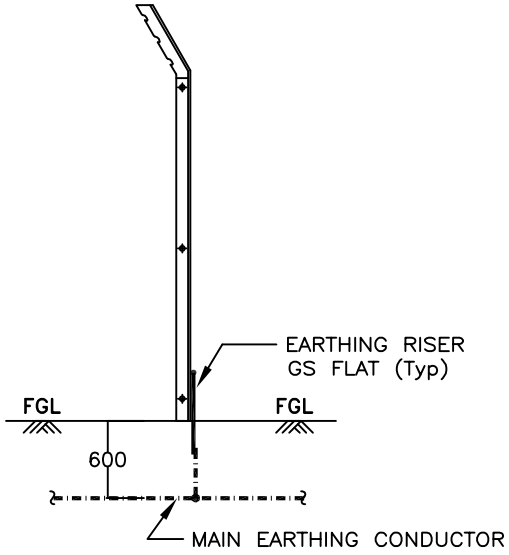
LEGEND

- 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.



FENCE POST
(ALTERNATE FENCE POST)

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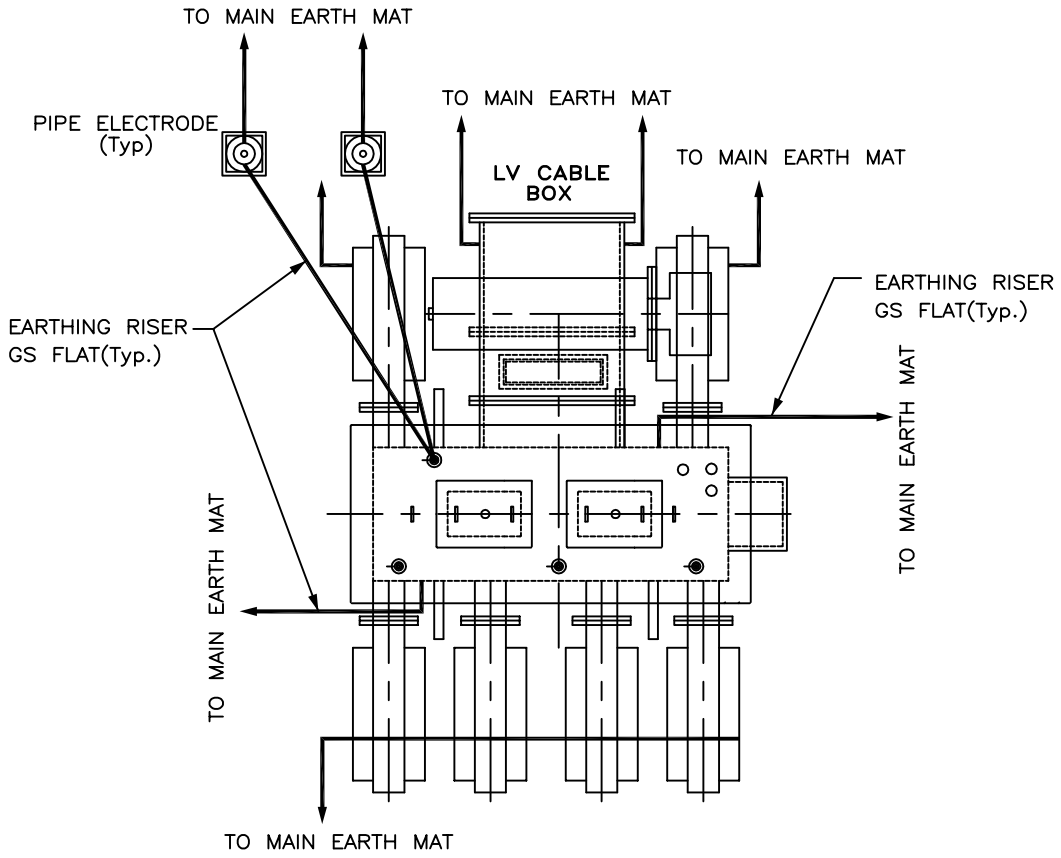
TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 24

1401648/2023/TBG-TB_HVDC

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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पावरग्रिड

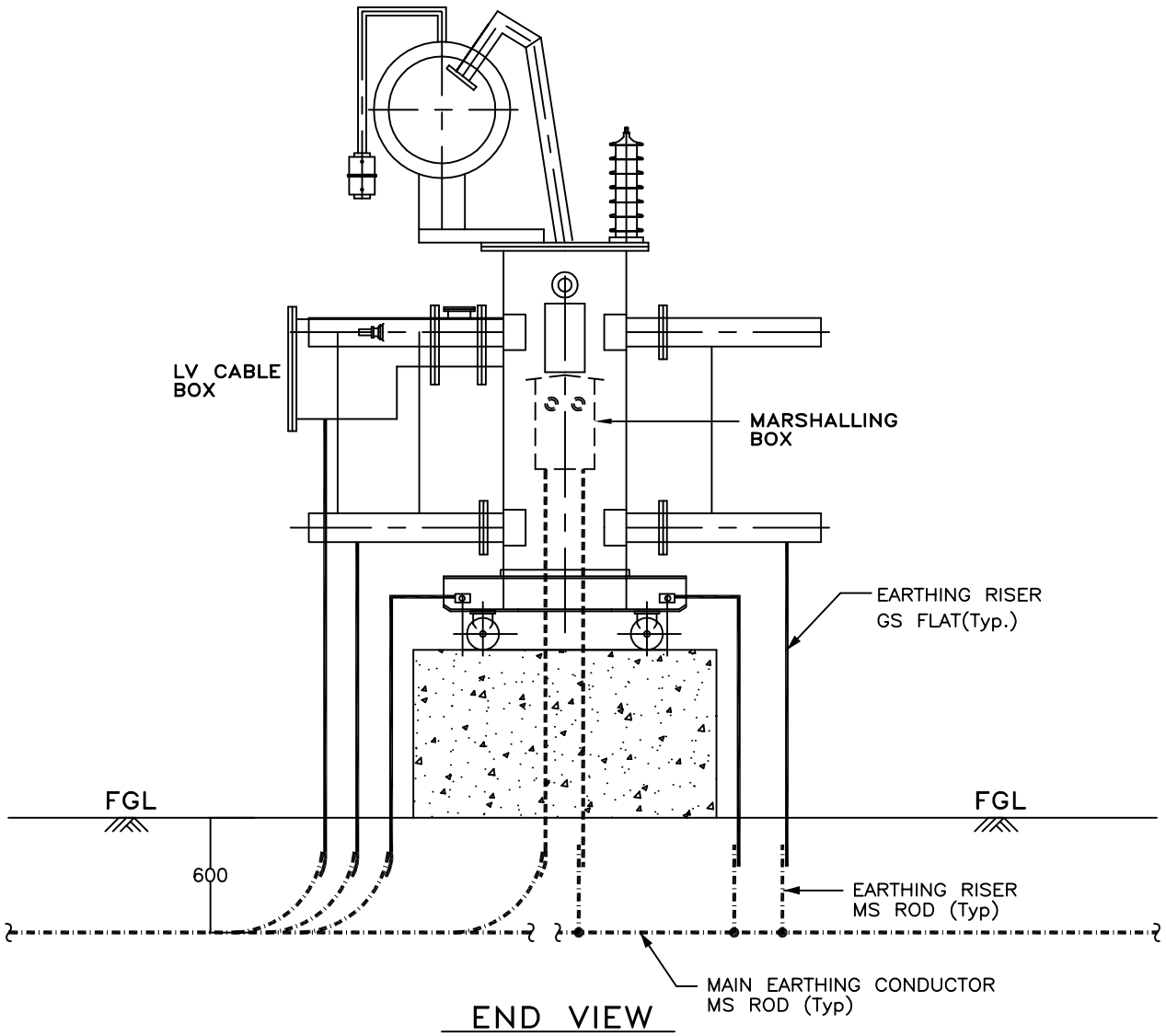
PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 25

1401648/2023/TBG-TB_HVDC

EARTHING OF LT TRANSFORMER



END VIEW

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पावरग्रिड

PROJECT :- TECHNICAL SPECIFICATION-SWITCHYARD ERECTION

TITLE:- STANDARD EARTHING DETAILS

KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09 SHEET # 26
CKD BY	PRPD BY	Date	

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.

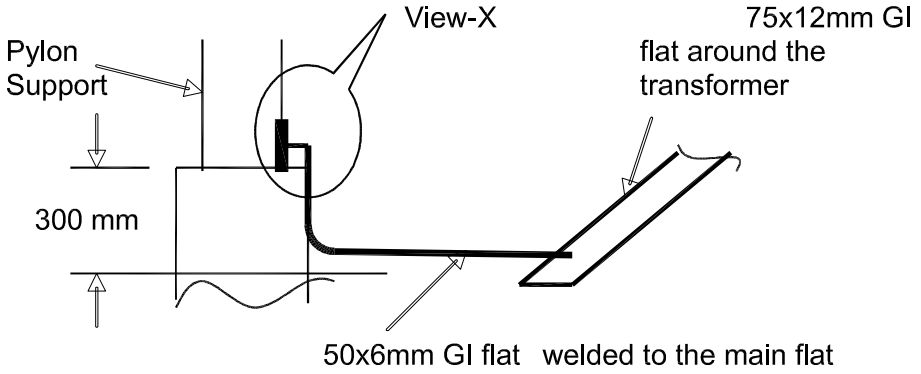

Fig.- Elevation (Earthing of Pylon Supports)

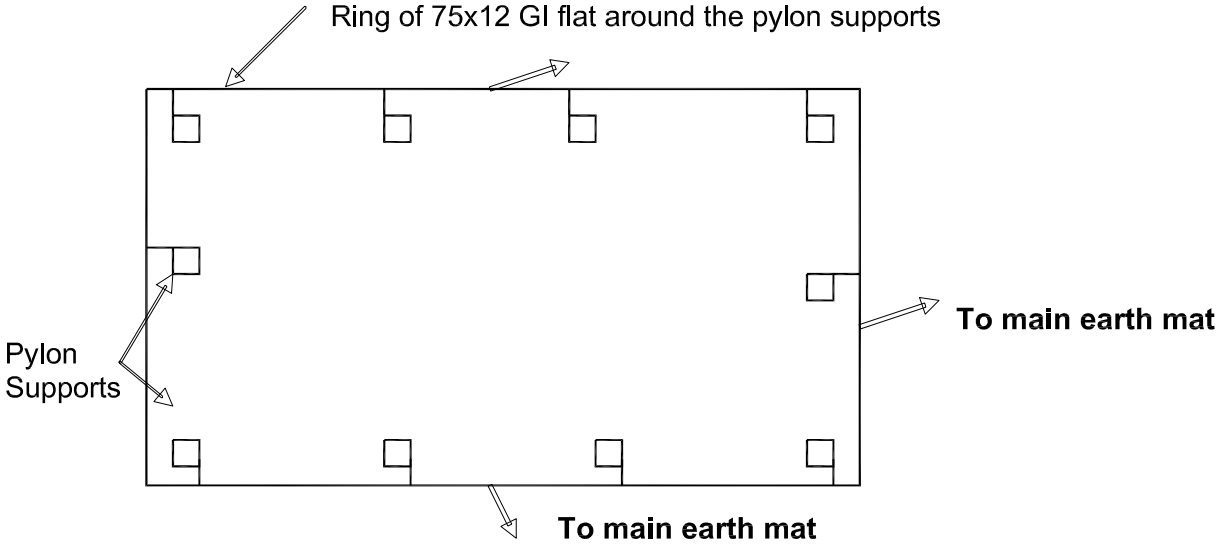

Fig.- Layout (Earthing of Pylon Supports)

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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			
KKSarkar	KKSarkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 27

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.

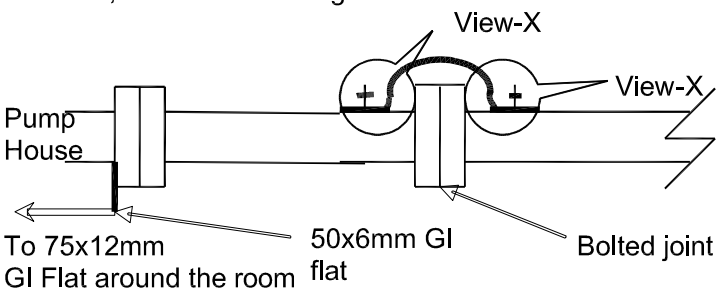

Fig.-Earthing of Hydrant / HVW Spray Piping

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.

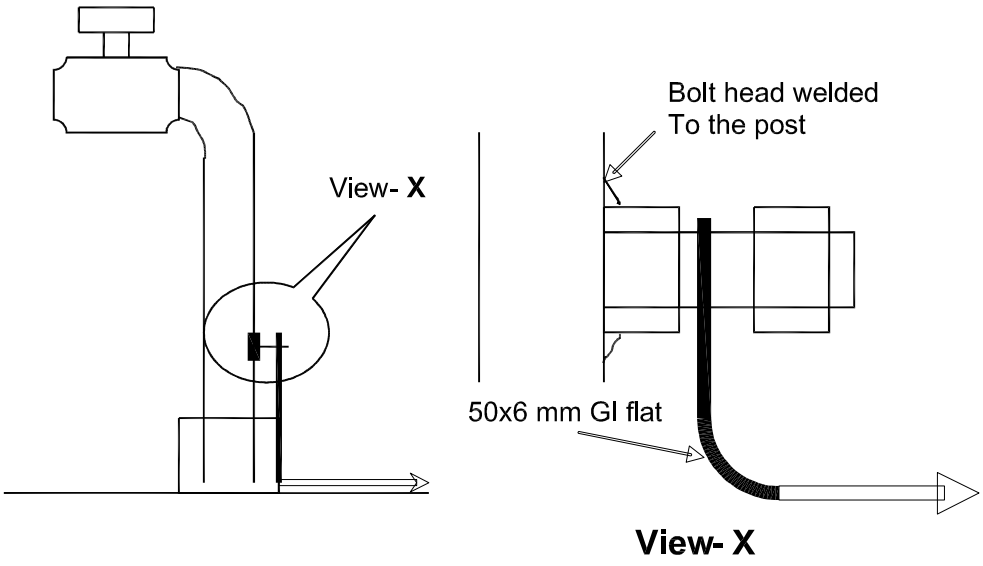

Fig.- Earthing of hydrant box / hose box

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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			
KKParkar	KKParkar	Dec-2013	Drawing No.: C/ENG/STD/EARTHINGS/09
CKD BY	PRPD BY	Date	SHEET # 28

Section -LIGHTING SYSTEM (Rev.07)

Sl. No.	Description	Page No.
1.	GENERAL	1
2.	GENERAL DESIGN CRITERIA	1
3.	SOLAR PV POWER PLANT	2
4.	LIGHTING SYSTEM DESCRIPTION	2
5.	LIGHTING SYSTEM INSTALLATION WORKS	18

.

Annexure-I Bill of Quantity
Annexure-II Details of Lighting Fixture
Annexure-III Drawing of Portable Flood Light Panel (PFL)
Annexure-IV Drawing of Lighting Pole
Annexure-V Single Line Diagram(C/ENGG/TS/STD/ILLU/TOWNSHIP/01)

Major Changes in Technical Specification Lighting System (Rev.07 w.r.t. Rev.06):-

1. For Indoor Lighting, LED fixtures to be supplied as per Quantity specified in Technical Specification.
2. For Outdoor Lighting & GIS Building, LED fixtures have been envisaged in place of Conventional Sodium Vapor Lamps (Quantity to be supplied as per BPS).
3. Firewall mounted Flood Lights have been envisaged for Transformer & Reactors (to be supplied as per BPS).
4. Portable Flood Light Panel for Maintenance purpose has been specified. Typical Drawing is also enclosed (to be supplied as per BPS).
5. Bidder shall be required to submit LM-79 & LM-80 reports for LED Luminaries.
6. Roof top Solar Grid System **with battery** has been replaced by Roof Top Solar Grid System of 50kW, 30kW & 20kW for 765kV, 400kV & 220kV Substation respectively (without Battery) to be integrated in ACDB. (to be supplied as per BPS).
7. Considering maintenance issue of Pole mounted battery, **Solar Panel along with battery** used for Street Lighting System has been deleted and Street Lighting using LED Luminaries is retained.
8. AC Emergency Lighting in GIS building, SPR, DG Area and LT Transformer Area has been specified.
9. Use of Occupancy Sensor has been deleted.
10. Lighting System for Township & Transit Camp included in line with Rev.05.
11. **Stainless steel** Panels/Junction Boxes of thickness 1.5 mm for Outdoor application has been specified.
12. Indoor Lighting Panels Bus Bar has been changed from Copper to Copper/**Aluminum Alloy**.
13. Technical Specification for Receptacle RQ-1 (250A) & RQ-2 (400A), 415V, 3-phase has been included for Oil filtration purpose.
14. All concealed Conduit shall be PVC type and all surface mounted conduit shall be of Galvanized steel.
15. Lighting Steel tubular Poles **painting changed** to hot deep galvanizing with PU (Polyurethane) coating in Suzuki Silver color.
16. Fixtures Model and Vendor names have been deleted and general technical parameters of LED fixtures have been included for Indoor as well as Outdoor Fixtures.
17. Bottom of Outdoor Lighting Panels mounting height shall be 1000mm from FGL.

Note : Above are major changes made in the Model TS, however Bidder is advised to refer Technical Specification in detail for other changes in the specification.

Section -LIGHTING SYSTEM (Rev.07)

1 GENERAL

The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of various lighting fixtures complete with lamps, supports and accessories, ceiling fans with electronic regulators, exhaust fans with accessories, lighting panels, Sub-Lighting Panels, lighting poles with distribution boxes, PVC conduits, lighting wires, G.I. earth wire, receptacles, tag block & telephone socket, switchboards, modular switches, junction boxes, pull out boxes, aluminum ladders for maintenance, **solar grid system** complete with accessories.

The following specific areas are included in the scope of lighting as applicable (as per BPS):

i) Indoor Lighting

a) Control Room cum administrative building
b) Firefighting pump house
c) Switchyard panel rooms
d) GIS Building
e) Township & Transit Camp
f) Other Buildings

ii) Outdoor Lighting

a) Switchyard Area including DG Set & LT Transformer area
b) Street Lighting
c) Open Store

2 General Design Criteria

The illumination system shall be designed on the basis of best engineering practice and shall ensure uniform, reliable, aesthetically pleasing and glare free illumination. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection. The diffusers/ louvers used in the lighting fixtures shall be made of impact resistant polystyrene sheet and shall have no yellowing property over a prolonged period Illumination. The type of Lighting Fixture to be used in different areas shall be as per **Annexure-I**.

For Indoor and Outdoor Illumination, detailed drawings showing the lighting layout and electrical distribution diagram shall be prepared by the Contractor and submitted for approval. Conduiting shall be done as per approved Lighting Layout and no separate drawings for the same shall be submitted for approval. The above layout drawings will include disposition and location of lighting fixtures, receptacles, lighting panels etc. While finalizing the detailed layout of lighting fixtures, the position/location and layout of equipment should be taken into account

to have adequate illumination at desired locations. In false Ceiling, surface wiring is permissible but all down run conduit will be concealed in wall below the false Ceiling.

2.1 **Indoor Illumination**

Indoor illumination shall be done by LED Luminaries as per the requirement of false ceiling and non-false ceiling of buildings.

2.2 **Outdoor Illumination**

Outdoor illumination shall be done by LED luminaries as per the requirement. For Outdoor Switchyard area, LED fixtures shall be installed at gantry structures (For 400kV & below voltage level) & available lightning masts (if any). However for 765kV Switchyard, LED fixtures will be installed at 28 meter height on the towers. For other outdoor areas, Street Lighting, lighting poles & nearby buildings (if any) shall be used for installation of LED fixtures. Additional firewall mounted Flood Lights have to be provided for Transformer & Reactors as specified in the BPS. Mounting structure /Accessories for Mounting of LED Lighting Fixtures will be prefabricated and will be hot dip galvanized.

Portable Flood Light Panel (PFLP): Portable Flood Light Panel along with fixture is to be supplied as per BPS for maintenance purpose of the Substation. The detailed drawing for the PFLP shall be as per the drawing attached in the specification (Annexure-IV). Fixture shall be FL-2 type on PFLP.

3 **Grid Interactive Solar PV Power Plant:**

Solar Grid System shall be supplied as specified in BPS. Solar PV Power Plant of PV array Capacity shall be 50kWp for 765kV Substation, 30kWp for 400kV Substation and 20kWp for 220kV & below Substation.

3.1 **General**

Grid Interactive Solar PV Power Plant of PV array shall be provided over Control Room building. This installation shall be a supplement source to Substation ACDB bus, to save on conventional energy supply from the grid during solar energy generation from the plant. The equipment and materials shall include but not limited to the following:

a) PV Modules (Crystalline)
b) Module Mounting Structure and frames
c) Array Terminal Box
d) Grid Interactive Inverters
e) Solar AC Panel
f) Cable & Wires
g) Earthing system

h) Civil works for Foundation of PV Array

All civil works associated with the installation & commissioning of PV Array shall be done by the Contractor including necessary structural work, cost of the same shall be deemed included in the erection work.

The Solar PV Module will be installed over the Control Room Building while the Inverters, Grid interfacing LT Panels etc. will be placed in Substation ACDB Room of Control Room Building. The Contractor shall specify and submit detail GA drawing indicating indoor equipment as well as PV Array. Contractor shall provide necessary supporting documents to the employer including typical solar PV module electrical characteristics including current-voltage (I-V) performance curves and temperature coefficients of power, voltage and current of the proposed PV Module (s).

3.2 Solar PV Modules

Solar PV module shall include but not limited to the following**:**

- PV Module shall be mono or poly crystalline high power silicon cells.
- The solar cells shall have anti-reflective surface coating to help to absorb more light in all weather conditions.
- The PV modules shall comply the relevant standards.
- Each module shall have superior light transmission, tampered & textured glass with antireflective coating. It shall also have tough multi-layered polymer back sheet for environmental protection against moisture & to provide high voltage electrical insulation.
- Solar PV module shall be highly reliable, light weight and shall be designed to have a long service life.
- Major technical parameters for PV module shall be as under:-

Type	Mono or Poly Crystalline silicon
Efficiency	>= 16%
Fill factor	>=70%
Module frame	Non-corrosive and electrolytic ally compatible with the mounting structure material
Array Termination box	Thermo-plastic, IP 65, UV resistant
Module Rated power	The nominal power of a single PV module shall not be less than 300Wp. The rated output of any supplied module shall not vary by more than 3% from average power rating.
Environmental Conditions	It shall perform satisfactorily in relative humidity up to 95% and temperature between 0-85 deg. C.

Applicable standards	IEC 61215 IEC 61730 Part 1 and 2
Salt Mist Corrosion Test	As per IEC 61701

3.3 **Module Mounting Structure and frames**

- Entire system shall be installed by providing necessary steel structures. The array structure and its legs shall be made of hot dip galvanized MS angles or galvanized MS tubular frame. The structure shall be designed for simple mechanical and electrical installation. It shall support PV modules at a given orientation, absorb and transfer the mechanical loads to the ground properly. The minimum thickness of the galvanization shall be as per Section-GTR.
- The array structure shall be so designed that it will occupy minimum space without sacrificing the output from SPV panels. The structure shall be designed to allow easy replacement of any module & shall be in line with the site requirement. Array structure shall also have tilt arrangement to adjust the plane of the array for optimum tilt during erection.
- Minimum Ground Clearance of the lowest part of the module structure should be at least 700mm.
- All fasteners for supporting conduits, Nut & Bolts shall be of stainless steel (SS-304 Grade).
- The array structure shall be grounded properly.

3.4 **Array foundation**

Foundation is to be made above the surface and no grouting to be done. If any grouting is done on the concrete foundation, necessary modification shall be done to avoid any seepage to the Ceiling. The base plate arrangement may be made on RCC blocks. Grade of concrete for all RCC blocks shall be 1:1.5:3 mix.

3.5 **Grid Interacting Inverter**

The inverter shall be pure sine wave inverter of high efficiency. Inverters shall have display to show its own parameters along with the parameters of PV array connected to the Inverter. The inverter shall be compatible as On Grid Connected Mode (Synchronization with grid). The inverter shall include but not limited to the following**:**

- The inverter shall be highly efficient based on Maximum Power Point Tracking (MPPT) control providing a fixed DC input voltage to inverter. MPPT must be able to extract maximum energy from Solar array and produce 415 V, 3-ph, 50Hz AC to synchronize with the grid through Substation ACDB panel.
- The Inverter shall not produce Electromagnetic interference (EMI) which may cause malfunctioning of electronic and electrical

instruments including communication equipment, which are located within the facility in which the inverter is housed

- Inverter shall have facility to display basic parameters of the system through LED/LCD display.

Display
- Voltage & Frequency
- Power
- Energy

Indications
- DC Input Line Status
- Inverter under voltage/ over voltage
- Inverter over load

Protections
- Over voltage both at input & output
- Over current both at input & output
- Over/ under grid frequency
- Reverse Polarity Protection
- Reverse current to PV array protection
- Short circuit
- Protection against lightning
- Protection against Surge voltage induced at output due to external source

Major Technical Parameters for Inverter shall be as follows:-

Inverter Capacity	50kW/30kW/20kW
Input DC voltage range	As required for the solar grid
Operation AC voltage	3-phase, 415V±10%
Total Harmonic Distortions on AC side	THD<3%
Operating Frequency range	50Hz ± 3%
Power factor of the inverter	>0.98 at rated power
Operating ambient temperature	-20ºC to +60ºC
Humidity	0 – 95% Rh
Inverter efficiency	>=96%
Inverter weighted (EURO) efficiency	>=95%
Protection degree	As per GTR
Communication interface	IEC 61850 Protocol or through IEC 61850
Safety compliance	IEC 62103, IEC 62109
Display type	LCD / LED

The manufacturer shall facilitate for smooth interfacing of Inverter (Alarm & Analog measured Values) with Substation SAS.

3.6 Solar AC Panel

AC Power output of Inverters shall be fed to the Solar AC Panel through suitably rated MCCBs. Output of Solar AC panel shall be connected to Substation ACDB bus through available MCCB in ACDB Panel.

3.7 Provision for Module Cleaning

For cleaning of the PV Modules, necessary plumbing & piping work shall be done by tapping from the existing pipeline available at the roof top so that water is easily available near the PV modules.

4 LIGHTING SYSTEM DESCRIPTION

The lighting system shall comprise of the following:

4.1 AC Normal Lighting System

All the Lighting fixtures connected to the AC Normal Lighting system in different areas will be fed from the 415 V main lighting distribution board through Lighting Panel & Sub-lighting panels (SLP).

4.2 AC Emergency Lighting System

The lighting panels of this system will be connected to the 415 V Emergency lighting distribution board (ELDB) which is fed from diesel generator during the emergency. This system will be provided in Control Room building, GIS Building, Switchyard Panel Room, Firefighting pump house, Switchyard Area including DG Set & LT Transformer Area. AC Emergency lighting load will be connected to this system which will be normally 'ON'. Approximate 25 % of lighting fixtures (distributed over all above areas) shall be connected on AC emergency lighting system.

4.3 D.C. Emergency lighting System

DC emergency LED lighting fixtures of 8W DC Input Down Lighter shall be operated on the 220/110V DC system (as per available Station DC Supply) and will be provided in the strategic locations in Control Room Building, Fire Fighting Pump House and GIS Building .

The supply to the DC lighting panels shall be automatically switched ON in case of loss of Normal & Emergency AC supply at station or when under voltage occurs in the AC MLDB. The DC supply will be automatically switched OFF after about 3 minutes following the restoration of supply to normal AC or emergency AC lighting system.

Exit Lightings Signage are to be provided in the all rooms of Control Room Building, Fire Fighting pump house & GIS Building including

Corridors & Staircase so that the operating personnel can safely find their way even during emergency of total AC failure.

5 LIGHTING SYSTEM DESCRIPTION- TOWHSHIP & TRANSIT CAMP

The scope of work comprises of design, engineering, testing, supply, installation, testing and commissioning of 415V, 400Amp, Main Township Distribution board/Energy meter Boards/Flat DBs etc. as per single line diagram (C/ENGG/TS/STD/ILLU/TOWNSHIP/01), Power and Control cables, various lighting fixtures complete with lamps, supports and accessories, ceiling fans complete with electronic regulators, exhaust fans for toilets and pantry & accessories, lighting panels, lighting poles complete with distribution boxes, galvanized rigid steel/PVC conduits, lighting wires, G.I. Earthwire, receptacles, tag block & telephone socket, bells, boxes for telephone/television & Air-conditioners points, switchboards, switches, junction boxes, pull out boxes complete with accessories as outlined in electrical drawings enclosed with tender documents for various type of quarters, parking, pump house, recreation centre and transit camp associated with township.

The township lighting system shall comprise of the following:

5.1 EXTERNAL ELECTRIFICATION WORKS

The entire External Electrification work including connection to various quarters, recreation centers & transit camp associated with township including street lighting of township shall be in the scope of the contractor. 415V, 400A Main Township distribution board shall be fed from 415V, 1000A Main switchboard (being supplied under LT switchgear package) located in ACDB/DCDB Room of main Switchyard through 2-3 ½ x300 sq.mm XLPE insulated power cable from each source. **Supply of Main Township DB & associated 3 ½ x300 sq.mm XLPE cable along with its interconnection, installation etc. shall be as per BPS.**

Further typical distribution from 415V Main Township DB is indicated in the drawings. The entire external electrification work comprising of feeder pillars, Cables and associated glands and lugs, steel tubular poles, street lights, MS junction boxes, GI pipes for cable protection, danger plates, Hume pipes, fire extinguishers, cable route markers etc. as required shall be in the scope of the contractor. The exact location of quarters, recreation center, transit camp, streets etc. shall be intimated to successful bidder during detailed engineering.

5.2 INTERNAL ELECTRIFICATION WORKS

The bidder shall quote for each type of quarters, recreation center and transit camp separately as per BPS, including entire scope pertaining to lighting system, earthing and lightning protection.

The scope shall broadly consist of entire concealed conduit work, wiring for lights/power/fans/telephones/cables & air-conditioners, supply and fixing of metal boxes, plates, switches, sockets, call bells, buzzers,

exhaust fans, ceiling fans, MCBs, MCCBs, light fittings, energy meters boards & flat DBs etc. as per the requirements of various quarters, recreation centers and transit camps.

In addition to above complete earthing (through separate earth pit) and lightning protection for each type of quarters, recreation center and transit camp shall be provided as per standard guidelines given in relevant Indian standards and code of practices. The complete drawing for earthing and lightning protection shall be submitted to owner for approval. The loop earthing inside the buildings shall be carried out with minimum 1Cx1.5 sq.mm PVC stranded Copper wire. All materials required or earthing and lightning protection of township buildings shall be in the scope of contractor.

Any item not specifically outlined in the layouts and specifications enclosed herein shall necessarily be included by the contractor as per applicable buildings codes, statutory electricity rules and code of practices for the completion of scope.

6 DESCRIPTION OF ITEMS

The Contractor shall supply and install the following equipment and accessories in accordance with the specification and applicable standards:

6.1 LED LUMINAIRES

LED Luminaries shall be used for the lighting of all the indoor and outdoor areas. In false ceiling area, LED luminaries shall be recessed mounting type & in non-false ceiling area, the LED luminaries shall be surface mounting type.

Suitable heat sink with proper thermal management shall be provided in the luminaries. All LED Luminaries shall be POWERGRID approved make. The marking on luminaries & safety requirements of luminaries shall be as per IS standards.

Necessary Care shall be taken so that there is no water stagnation anywhere in the Luminaries. The entire housing shall be dust and water proof protection as per IS 12063.

Parameters of outdoor & indoor Lighting fixtures are detailed in **Annexure-II**.

6.2 LIGHTING PANELS

6.2.1 CONSTRUCTIONAL FEATURES OF LIGHTINNG PANELS

i) The Lighting panels shall conform to IS-8623.

ii) All Outdoor Lighting Panels shall be **Stainless sheet steel** of Grade 304 and shall be dust, weather and vermin proof. Panels shall be of

thickness not less than 1.5 mm smoothly finished, leveled and free from flaws. Stiffeners shall be provided wherever necessary.

iii) The panels shall be of front single door hinged construction, suitable for either floor mounting on channels, sills or on walls/columns by suitable M.S. brackets. Indoor Lighting panels shall be modular flush mounted and wall embedded of slim depth.

iv) All panels shall have a dead front assembly provided with hinged door(s) and with suitable locking arrangement.

v) All Outdoor panel's removable covers and doors shall be gasketed all around with neoprene/EPDM gaskets/ puff arrangement.

vi) The outdoor panels shall be suitable for cable/conduit entry from the bottom. Suitable removable cable gland-plate shall be provided in the bottom of panels. For indoor lighting panels the provision of cable/conduit entry shall be from both top and bottom side with suitable removable gland plate. The thickness of the gland plate shall be 3 mm. Necessary number of double compression brass type cable gland shall be supplied, fitted on to these gland plates.

vii) The panels shall be so constructed as to permit free access to connection of terminals and easy replacement of parts.

viii) Each panel shall have a caution notice fixed on it.

ix) Each panel will be provided with laminated as built circuit diagram suitably pasted in the panel.

x) Main Bus Bars

Bus bars shall be of **Copper/aluminum alloy** conforming to IS: 5082 and shall have adequate cross-section to carry the rated continuous current and withstand short circuit currents. Maximum operating temperature of the bus bars shall not exceed 85 deg. C. The bus bars shall be able to withstand a fault level of 9 kA for 1 sec. for AC panels and 4 kA for 1 sec. for DC panels.

xi) All Outdoor Lighting Panels shall be erected such that a minimum height of 1000mm is maintained between FGL & bottom of the Lighting Panel. Size of Outdoor Lighting panels shall be such that cables are properly terminated and wires are dressed with provision of loops.

6.2.2 CONFIGURATION OF INDOOR AND OUTDOOR LIGHTING PANELS (AS PER BPS).

Type of Panel	Description	Detail Of Feeders
ACP 1	Indoor AC	**Bus Bars:** 415V, 63A, 3 phase 4

	Lighting panel	wire bus bars with Colored LED indication lamps with fuse for each phase. **Incomer:** One no. 415V, 63A TPN MCB with 300mA 63A Four Pole RCCB. **Outgoings:** 12 nos. 230V, 16A Single Pole MCB and 1 no. 5/15A Switch with Socket. **Mounting:** The indoor ACP shall be of slim depth suitable for embedding in the wall and will be flush mounted.
ACP 2	Outdoor-Switchyard AC Lighting panel	**Bus Bars:** 415V, 63A, 3 phase 4 wire bus bars with Colored LED indication lamps with fuse for each phase. **Incomer:** One no. 415V, 63A TPN MCB & Contactor with suitable Photo-sensitive automatic switching system. **Outgoings:** 6 nos., 230V, 20A Single Pole MCB and 3 Nos. 230V, 32A TPN MCB and 1 no. 5/15A Switch with Socket. **Mounting:** Suitable for Outdoor applications**.**
ACP 3	Outdoor - Street AC Lighting Panel	**Bus Bars:** 415V, 63A, 3 phase 4 wire bus bars with Colored LED indication lamps with fuse for each phase. **Incomer:** One no. 415V, 63A TPN MCB & Contactor with suitable Photo- sensitive automatic switching system. **Outgoings:** 3 nos. 32A TPN MCB and 1 no. 5/15A Switch with Socket. **Mounting:** Suitable for Outdoor applications**.**

DCP	Indoor DC Lighting panel	**Bus Bars:** 220/110V DC (as applicable) 32A two wire Bus Bar. **Incomers:** 220/110V DC (as applicable) with one 32A DP Contactor (for AC fail Logic) backed up by 32A double pole MCB with DC test push button. **Outgoings:** 6 nos.16 A Double Pole MCB **Mounting:** The indoor DCP shall be of slim depth suitable for embedding in the wall and will be flush mounted
SLP	Outdoor AC Sub-lighting panel	**Incomers:** 415V, 32A TPN MCB **Outgoings:** 8 nos. terminal blocks suitable for cable upto 16 sq. mm cable. **Mounting:** Suitable for Outdoor applications with Loop in and Loop out facility.
Sub-DB	Indoor AC Sub Distribution Box	**Incomers:** 415V, 32A TPN MCB. **Outgoings:** 6 nos. 230V, 16A Single Phase feeder with Single Pole MCB. **Mounting:** The Sub-Distribution Box shall be of slim depth suitable for embedding in the wall and will be flush mounted/surface mounted as per site requirement.

6.2.3 AUXLIARY ITEMS FOR LIGHTING PANELS

(i) TERMINAL BLOCKS

Each terminal shall be suitable for termination of suitable size of Cable/Wire Conductors without any damage to the conductors or any looseness of connections.

(ii) RESIDUAL CURRENT CIRCUIT BREAKERSS (RCCB)

For indoor panels (ACP 1), 63A, 4pole 300 mA RCCB conforming IS 12640 will be provided along with incomer.

(iii) **MINIATURE CIRCUIT BREAKER (MCB)**

a) The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCBs shall also be trip free. MCB of Type C tripping characteristics as per IS 8828 will be used for Illumination purposes.

b) The MCBs and MLDB panel MCCBs together shall be rated for full fault level. In case the MCB rating is less than the specified fault level the Contactor shall co-ordinate these breaker characteristics with the backup MCCB in such a way that if fault current is higher than breaker rating, the MCCB should blow earlier than the MCB. If the fault current is less than MCB breaking capacity, MCB shall operate first and not the incomer MCCB.

c) The MCBs shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper/Al wire connection at both the incoming and outgoing side by copper/Al lugs or for bus bar connection on the incoming side.

d) The terminals of the MCBs and the 'open/trip' and 'close' conditions shall be clearly and indelibly marked.

(iv) **CONTACTORS**

Contactors shall be of the full voltage, direct-on line air break, single throw, electro-magnetic type. They shall be provided with at least 2'NC' and 2'NO' auxiliary contacts. 3-Phase Contactor shall be provided with the three elements, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable settings to suit the rated current. Hand reset button shall be flush with the front of the cabinet and suitable for resetting with starter compartment door closed. The Contactor shall check the adequacy of the Contactors rating, wires with respect to lighting load.

(v) **PUSH BUTTONS**

All push buttons shall be of push to actuate type having 2 'NO' and 2 'NC' self-reset contacts. They shall be provided with integral escutcheon plates engraved with their functions. Push buttons shall be of reputed make.

(vi) **LABELS**

a) Designation labels shall be provided on the front of lighting Panels. The panel designation labels shall be of 3 mm thick plastic plate. The letter shall be black engraved on white back ground.

b) All incoming and outgoing circuits shall be provided with labels.

Labels shall be made of non-rusting metal or 3 ply lamicoid. Labels shall have white letters on black or dark blue background.

(vii) **EARTHING TERMINALS**

Outdoor Panels shall be provided with two separate and distinct earthing terminals suitable to receive the earthing conductors of size 50x6 G.S. Flat.

6.3 EARTHING & LIGHTNING PROTECTION FOR CONTROL ROOM BUILDING, GIS BUILDING , TRANSIT CAMP & TOWNSHIP

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) Indian Electricity Rules 1956 with latest amendments.

Lighting Fixtures & Miscellaneous Items For Township Lighting:-
Please refer Annexure-I

6.4 POWER AND CONTROL CABLES:-

Power and Control cables required under township lighting shall conform to standard technical specification, Section-Power and Control cables.

6.5 RECEPTACLES (AS PER BPS).

All receptacles shall be of heavy duty type, suitable for fixing on wall/column and complete with individual switch. The outdoor Receptacles shall have IP 55 protection. The receptacles shall be of following types:

Type RO : 20A, 240V, 3 pin type (third pin grounded) plug and socket with body earthing arrangement with Single Pole MCB, metal clad with gasket having cable gland entry suitable for 2Cx6 sq.mm. PVC/aluminum armoured cable and a spring loaded cover suitable for installation in moist outdoor location. Receptacles shall be housed in a box made out of 1.5 mm thick Stainless Steel of Grade 304 with hinged doors with suitable locking arrangements. Door shall be lined with good quality gasketing.

Type RP - 63A, 3ph, 415V AC receptacles shall be provided for welding purposes in GIS Halls and near major equipments in switchyard.63A, 415V, 3 phase, 4 pin interlocked plug and socket with

body earthing arrangement with TPN MCB. Receptacles shall be housed in a box made out of 1.5 mm thick Stainless Steel of Grade 304, with hinged door with suitable locking arrangement The receptacle shall be suitable for 3.5C x 35/3.5Cx70 sq.mm and suitable for installation in moist outdoor location. Aluminum conductor cable entry and shall also be suitable for loop-in and loop out connection of cables of similar size. . Door shall be lined with good quality gasketing.

Type RQ-1 (250A)/ Type RQ-2(400A):- 250A/400A Receptacle shall be provided for oil filtration purpose near alternate Transformer/Reactor. 250A/400A, 415V, 3 phase, 4 pin, Switch Box with body earthing arrangement with TPN MCB, suitable for outdoor application. The enclosure shall be made out of 1.5 mm thick Stainless Steel of Grade 304, with hinged door with suitable arrangement and having cable gland entry suitable for 3.5C X 300 sq.mm XLPE armoured cable. The bus bar shall have adequate cross-section to carry the rated continuous current and withstand short circuit currents. The receptacle shall be suitable for loop-in and loop out connection of cables of similar size. Door shall be lined with good quality gasketing.

6.6 LIGHTING ACCESSORIES

Various accessories mentioned below shall be supplied as per site requirement and cost of the same shall be deemed to be included in overall Lighting System cost.

(i) JUNCTION BOXES

a) The Indoor junction boxes shall be provided with 4 way knockouts suitable for two numbers 10 sq. mm. wire/ Cable. These junction boxes shall be concealed type for indoor lighting.

b) The outdoor junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips. The junction boxes shall be suitable for termination of Cable glands of required size. The junction boxes shall be provided with 4 way knockouts suitable for street lighting/switchyard lighting terminals suitable for 2 numbers 4C x 16 Sq.mm Al. cable or as per requirement. All Outdoor Junction boxes shall be of Stainless Steel of thickness 1.5mm of grade 304. Outdoor Junction Boxes shall be suitable for mounting on columns, structures etc for Outdoor Lighting. The outdoor Junction shall have IP 55 protection.

c) The junction boxes shall have the following indelible markings
   (i) Circuit Nos. on the top.
   (ii) Circuit Nos. with ferrules (inside) as per drawings.
   (iii) DANGER sign in case of 415 volt junction box.

(ii) SWITCH AND SWITCHBOARD

a) All Switch board/boxes and electronic fan regulators located in office/building areas shall be modular flush mounted type.

b) Switch boards/boxes shall have conduit knock outs on all the sides.

c) The exact number of Switches including regulator for fans and layout of the same in the switchboard shall be suitable as per the requirement during installation.

d) The maximum number of luminaries controlled by one no. 6 Amp Switch shall be 8 nos. However each Switchboard shall have minimum 2 Nos. of 6A Switches to control the Luminaries. For DC fixtures there will be no switch and the same shall be directly controlled from DCP.

e) The Luminaries shall be wired in such a fashion that luminaries on each phase are evenly distributed all over the room.

f) 6/16A, 240V AC modular flush mounted socket with switch outlet shall be provided in indoor areas like offices, cabins, Security Room, Control Room, Switchyard Panel Room etc.

g) 25A, 240V AC modular flush mounted socket with switch shall be provided at strategic locations in GIS Halls, ACDB/Switchgear room etc.

(iii) **CONDUITS & CONDUIT ACCESSORIES**

a) The conduits shall be Rigid PVC conduits of 20/25 /32 mm diameter for Lighting, Telephone wiring & LAN Cabling and shall be ISI marked.

b) Flexible conduits wherever required shall be PVC type.

c) All conduits accessories shall be ISI marked.

d) Galvanized Steel Conduits for Surface Conductor (e.g. GIS Hall).

(iv) **PULL OUT BOXES**

a) The pull out boxes shall be concealed type for indoor lighting and suitable for mounting on column, structures etc., for outdoor lighting.

b) The pull out boxes shall be circular of minimum 16 SWG sheet steel and shall have cover with good quality gasket lining.

c) The pull out boxes shall be completed with conduit knock outs/threaded hubs and provided at approximately 3 meters intervals in a conduit run.

(v) **CEILING, WALL MOUNTED & EXAUST FANS AND REGULATORS**

a) The Contactor shall supply and install 1400 mm sweep ceiling fans complete with electronic regulator and board for mounting switch, suspension rod, canopy and accessories. The electronic regulator for Ceiling fans will be housed in common switchboard for lighting and shall be of similar make and model as that of modular switches. The wall mounted fans shall be of 400 mm sweep. Exhaust fans shall be of 300mm size.

b) Winding of the fans shall have Class-E insulating material. Winding shall be of copper wire.

(vi) **LIGHTING WIRES**

a) Wiring from Lighting/Sub-Lighting Panels to junction boxes / Switchboards/ fixtures etc. is covered under Lighting Wires. The wiring used for lighting shall be standard products.

b) The wires shall be of 630V grade (Phase to ground), PVC insulated products.

c) The conductor sizes for wires used for point wiring shall be 1.5 sq.mm, 2.5 sq.mm, 4 sq.mm and 6 sq.mm stranded copper wire as required.

d) The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two fixtures shall be single core copper stranded conductor, 630V grade (Phase to ground) flexible PVC insulated cords, unsheathed, conforming to IS:694 with nominal conductor cross sectional areas of 2.5 sq. mm.

e) The wires shall be colour coded as follows:

Red for R - Phase
Yellow for Y - Phase
Blue for B - Phase
Black for Neutral
White for DC (Positive)
Grey for DC (Negative)
Green for Earth

6.7 **LIGHTING POLES (AS PER BPS).**

(i) The Contactor shall supply, store and install the following types of galvanized steel tubular lighting poles required for street lighting and decorative lighting, as per the attached drawing of poles.

(i) Type L1 Street Lighting Pole of 6 meter - for SL-L1 type fixture
(ii) Type D1 Post top lantern pole of 4 meter - for Sl-D1 type fixture

(ii) “L1” type poles shall be used for street lighting. “D1” type (Decorative

post top lantern) poles and Bollards shall be installed In front of control room building, Fire Fighting Buildings as finalized during detailed engineering.

(iii) Lighting poles shall be complete with fixing brackets. Cable termination box will be built inside the pole itself as per drawing enclosed.

(iv) Poles and its Cable termination box shall be hot dip galvanized and PU (Polyurethane) coated in Suzuki silver color and inside with bituminous paint.

(v) Terminal strips provided in street - lighting poles shall be suitable for terminating up to 2 nos. 4C x 16 sq. mm aluminum cables.

(vi) Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done through 2.5 sq. mm Copper wire laid inside the tubular pole.

(vii) Distance of center of pole from street edge should be approximately 1000 to 1200 mm or as per site conditions.

(viii) Earthing of the poles should be connected to the switchyard main earth mat wherever it is available, else, the same should be earthed through 3M long, 20 mm dia, earth electrode.

6.8 LADDER(AS PER BPS).

Following ladders shall be supplied as per BPS for maintenance purpose of illumination system:

(i) A type Aluminum ladder of 3 Mtr vertical height.
(ii) Cartwheel mounted aluminum ladder Vertical Extendable from 5.1m to 11m.

7 TYPE TEST REQUIREMENT:

a) Lighting Panels, Receptacles, Junction Boxes etc. shall conform to following degree of protection:

- Installed outdoor: IP- 55
- Installed indoor in air conditioned area: IP-31
- Installed in covered area: IP-52
- Installed indoor in non-air conditioned area where possibility of entry of water is limited: IP-41.

b) Lighting fixtures LED type shall conform to type test requirements of LM-79, LM-80 and TTC.

8 LIGHTING SYSTEM INSTALLATION WORKS

Section -LIGHTING SYSTEM (Rev.07)

8.1 General

In accordance with the specified installation instructions as shown on manufacturer's drawings or as directed by Employer, Contractor shall unload, erect, install, test and put into commercial use all the electrical equipment included in the contract. Equipment shall be installed in a neat, workmanship manner so that it is level, Plumb Square and properly aligned and oriented. Tolerances shall be as established in manufacturers drawing or as stipulated by Purchaser.

All apparatus, connections and cabling shall be designed so as to minimize risk of fire or any damage which will be caused in the event of fire. All Lighting accessories mentioned in Clause 6.7 shall be supplied and erected as a part of Lighting System Installation works. Cost of Erection, Foundation & Civil Works of the above accessories and Lighting Poles are to be included in the Cost of the erection of Lighting system, no extra payment shall be made on account of the same.

Further, lighting control in GIS Hall has to be done in staggered way for the minimum basic illumination. Further separate switchboard shall be provided to have enhanced lighting for each bay.

8.2 Conduit System

(i) Contractor shall supply, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes (as specified in specification ordinary and inspection tees and elbow, check nuts, male and female bushings (brass or galvanized steel), caps, square headed make plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, glands, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. In case of false ceiling surface conduiting is permissible however all down run conduits will be concealed in wall below the false ceiling. The conduit fittings shall be of the same material as conduits. Separate Conduit should be laid for Communication purpose .The contractor shall also supply & install 20 mm PVC conduit and accessories for telephone wiring and LAN Cabling wherever feasible, telephone and LAN cabling can be laid in the same conduit.

(ii) In case of false Ceiling surface conduiting (GI Pipe) is permissible under the ceiling.

(iii) All unarmored cables/wires shall run within the conduits from lighting panels to lighting fixtures, receptacles. etc.

(iv) Size of conduit shall be suitably selected by the contactor.

(v) Conduit support shall be provided at an interval of 750 mm for horizontal runs and 1000 mm for vertical runs.

(vi) Conduit supports shall be clamped-on 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 raw plugs. Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.

(vii) 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.

(viii) For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

(ix) Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

(x) Conduits joints and connections shall be made through 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.

(xi) The entire GI conduit system (if used) shall be embedded, electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

(xii) Conduits and fittings shall be properly protected during construction period against mechanical injury. Conduit ends shall be plugged or capped to prevent entry of foreign material.

8.3 **Wiring**

i) The scope also includes wiring from nearest Lighting/Sub-Lighting Panel to the Controlling Switch/MCB/Lighting Fixtures.

ii) Wiring shall be generally carried out by PVC insulated wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawing of wires is permissible.

iii) Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

iv) Wiring shall be spliced only at junction boxes.

v) For lighting fixtures, connection shall be teed off through suitable

round conduit or junction box, so that the connection can be attended without taking down the fixture.

vi) Maximum two wires can be terminated to each way of terminal connections.

vii) AC and DC wiring should run through the separate conduits. Similarly Communication & LAN cables shall run in separate conduit than that of AC & DC Conduits.

8.4 **Lighting Panels**

i) The lighting panels shall be erected at the locations to be finalized during detailed engineering.

ii) Suitable foundations/supporting structures for all outdoor type lighting panels shall be provided by the Contractor.

iii) The Sub lighting Panel shall be provided where independent switch of fixtures are required.

8.5 **General Requirements for Cabling Work**

i) Each cable run shall be tagged with number that appears in the cable schedules. Cables shall be tagged at their entrance and/or exit from any piece of equipment, junction or pull box, floor opening etc.

ii) The tag shall be made up of aluminum with the number punched on it and securely attached to the cable by not less than two turns of G.I. wire. Cable tags shall be rectangular in shape for power cables and circular shape for control cables.

iii) Location of cables laid directly under ground shall be indicated clearly by cable marker made of galvanized iron plate embedded in concrete block.

iv) The location of underground cable joints if any shall be clearly indicated with cable marker with an additional inscription "cable joint".

v) The marker, which is a concrete block, shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change of direction. It shall also be located on both sides of the road or drain crossing.

vi) Road crossing of cables through suitable size of GI pipe/Hume pipe as required at site.

8.6 **Foundation & civil works**

i) Foundation for street lighting poles and panels shall be done by the

Contractor.

ii) All final adjustment of foundation levels, chipping and dressing of foundation surfaces, setting and grouting of anchor bolts, sills, inserts and fastening devices shall be carried out by the Contractor including minor modification of civil works as may be required for erection.

iii) Any Cutting of masonry/concrete work, which is necessary shall be done by the Contractor at his own cost and shall be made good to match the original work.

Section -LIGHTING SYSTEM (Rev.07)

ANNEXURE-I

BILL OF QUANTITY

Sr. No	Locations	Type & No of Lighting Fixture	With Anti Glare Film over the Fixture	Type of Fans
01.	**Control Room cum Administrative Building-Single Storey (As applicable)**			
(i)	Control Room	RSQ-I: 10 Nos.	Yes	--
(ii)	Station- In Charge Room	RSQ-I: 4 Nos. and RC-I : 4 Nos.	Yes	--
(iii)	Administrative Area	RSQ-I: 12 Nos. and RC-I : 9 Nos.	Yes	Pedestal Fans
(iv)	Conference Room	RSQ-I: 9 Nos. and RC-I : 4 Nos.	Yes	Wall Mounted Fans
(v)	Electrical Room/Telecommunication Room	RSQ-I: 4 Nos. and RC-I : 2 Nos.	Yes	Wall Mounted Fans
(vi)	ACDB/DCDB Room	SL-I: 16 Nos.	Yes	Ceiling Fan
(vii)	Battery & Battery Charger Room	RL-I: 6 Nos.	Yes	--
(viii)	Corridor & Reception	SC/RC-I: 8 Nos. and SL/RL-I: 2Nos.	Yes	Ceiling Fan
(ix)	Toilets	SC-I: 2 Nos.(in each Toilet)	No	Exhaust Fans
(x)	Pantry	SL-I: 2 Nos. and SC-I: 1 No.	Yes	Exhaust Fans
(xi)	Periphery of the Building	BL: 10Nos.	No	--
02.	**Control Room cum Administrative Building- Double Storey (As applicable)**			
(i)	Control Room	RSQ-I: 12 Nos.	Yes	--
(ii)	Station- In Charge Room	RSQ-I: 4 Nos. and RC-I : 2 Nos.	Yes	--
(iii)	Administrative Area	RSQ-I: 16 Nos. and RC-I : 12 Nos.	Yes	Pedestal Fans
(iv)	Conference Room	RSQ-I: 9 Nos. and RC-I : 5 Nos.	Yes	Wall Mounted Fans
(v)	Electronic Test Lab/Telecommunication Room	RSQ-I: 4 Nos.	Yes	Wall Mounted Fans
(vi)	ACDB Room	SL-I: 16 Nos.	Yes	Ceiling Fan
(vii)	DCDB Room	SL-I: 9 Nos.	Yes	Ceiling Fan
(viii)	Battery & Battery Charger Room	RL-I: 6 Nos.	Yes	--
(ix)	Store	SL-I: 6 Nos.	No	--
(x)	Lobby/ Waiting Area	SSQ-I: 5 Nos. and RC-I : 4 Nos.	Yes	Ceiling Fan
(xi)	Toilet	SC-I: 2 Nos. (in each Toilet)	No	Exhaust Fans
(xii)	Pantry	SL-I: 2 Nos. and SC-I: 1 No.	Yes	Exhaust Fans
(xiii)	Corridors	SC/RC-I: 36 Nos. and SL/RL-I: 6 Nos.	No	--
(xiv)	Periphery of the Building	BL: 15 Nos.	No	--
03.	**GIS Building**			
(i)	765kV, 400kV & 220kV GIS Hall	IHB: As per BPS	No	--
(ii)	AHU Room	SL-1: : As per BPS	Yes	--
(iii)	C&R Room	RSQ-I: : As per BPS	Yes	--
04.	**Fire Fighting Pump House**			
(i)	FFPH Building	SL-1: 9 Nos.	Yes	Wall Mounted Fan
(ii)	Periphery of the Building	BL: 4 Nos.	No	--
05.	**Switchyard Panel Room (SPR) (9 meter)**	SSQ-I: 10 Nos.	Yes	--
06.	**Switchyard Panel Room (SPR) (6 meter)**	SSQ-I: 8 Nos.	Yes	--
07.	**Switchyard and Outdoor Substation Area**	FL-1 & FL-2: As per BPS	No	--
08.	**Street lighting roads**	SL-LI & SL-DI:As per BPS	No	--

Section -LIGHTING SYSTEM (Rev.07)

TOWNSHIP & TRANSIT CAMP ILLUMINATION (As Applicable)

ANNEXURE-I

Sr. No	Locations	Type & No of Lighting Fixture	Anti-Glare Film Requirement	Type of Fans
01.	**Township Quarters**			
(i)	Bed Room	SL-I :1 Nos. and SC: 2 Nos.	Yes	Ceiling Fan
(ii)	Drawing Room	SSQ-I: 2Nos. and SC 2 Nos.	Yes	Ceiling Fan
(iii)	Dining Room	SSQ-I: 2 Nos.	Yes	Ceiling Fan
(iv)	Kitchen	SL-I: 1 Nos. and SC: 1 Nos.	Yes	Exhaust Fan
(v)	Lobby	SSQ-I and SC 2 Nos.	Yes	--
(vi)	Toilet	SC-I: 1 Nos.	No	Exhaust Fan
(vii)	Servant Room	SL-I: 1 Nos.	Yes	Ceiling Fan
(viii)	Car Parking	BL-I: 1 Nos.	No	--
(ix)	Stair	SC-I: 4 Nos.	No	--
(x)	Terrace/Balcony	BL-I : 1 Nos.	No	--
02.	**Transit Camp**			
(i)	VIP Lounge	SSQ-I:2 Nos. and SC: 2 Nos.	Yes	Ceiling Fan
(ii)	Dining Room	SSQ-I: 2 Nos. and SC: 2 Nos	Yes	Ceiling Fan
(iii)	Drawing Room	SSQ-I: 1 Nos. and 2 Nos.	Yes	Ceiling Fan
(iv)	Dormitory	SL-I : 4 Nos.	Yes	Ceiling Fan
(v)	Bed Room	SL-I :1 Nos. and SC: 2 Nos.	Yes	Ceiling Fan
(vi)	Store	SL-1: 2 Nos.	No	Exhaust Fan
(vii)	Corridors	SC-I: 2 Nos.	No	--
(viii)	Terrace/Balcony	BL-I : 1 Nos.	No	--
(ix)	Care Taker Room	SL-I: 1 Nos.	Yes	Ceiling Fan
(x)	Kitchen	SL-I: 1 Nos.	Yes	Exhaust Fan
(xi)	Stair	SC-I: 4 Nos.	No	--
(xii)	Toilet	SC-I: 1 Nos.	No	Exhaust Fan
(xiii)	Other Rooms	SC-I: 2 Nos.	No	--

Section -LIGHTING SYSTEM

ANNEXURE-II

Details of Lighting Fixture

(a) Indoor Application

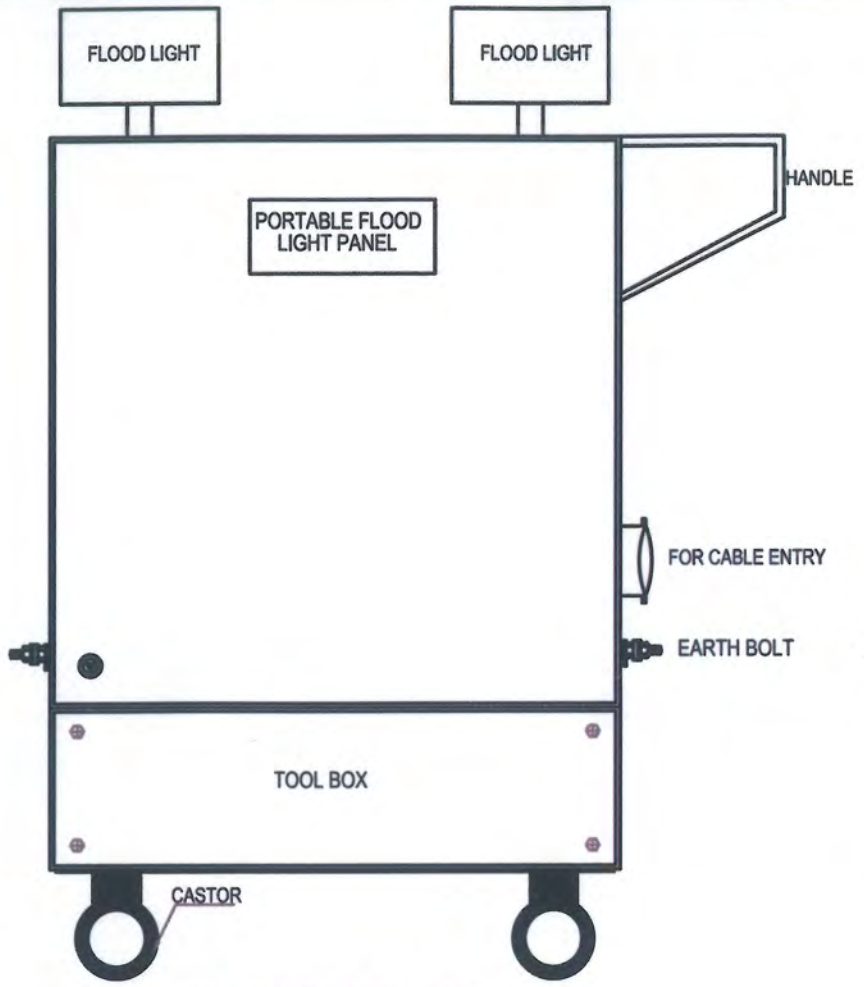
Sr. No	Technical Specification	SL-1 (Surface Mounted Linear LED Tube with Box)	RL-I (Recessed Mounted 4 x 1 Feet LED Panel)	SC-I (Surface Mounted Circular LED Downlight Luminaire)	Type RC-I (Recessed Mounted Circular LED Downlight Luminaire)	Type SSQ-1 (Surface Mounted 2X2 LED Luminaire)	Type RSQ-1 (Recessed Mounted 2x2 LED Luminaire)	Type IHB (LED Indoor High Bay)
1	System Wattage	≤ 2 X 20 W	≤ 40 W	≤ 15 W	≤ 15 W	≤ 40 W	≤40 W	≤150W
2	System Lumen Output	≥ 3600	≥ 3600	≥ 1200	≥ 1200	≥ 3400	≥ 3400	≥14000
3	System efficacy (Lumens/Watt)	≥ 100	≥ 100	≥ 80	≥ 80	≥ 85	≥ 85	≥ 100
4	Housing	CRCA Housing	CRCA Housing	Pressure Die Cast Housing	Pressure Die Cast Housing	CRCA Housing	CRCA Housing	Pressure Die Cast Aluminum Housing
5	Ingress Protection	IP20	IP-20	IP20	IP-20	IP-20	IP-20	IP-65
6	Surge Protector	2kV	2kV	2kV	2kV	2kV	2kV	4kV (Internal) & 10kV (External)
7	Mounting	Surface Mounted	False Ceiling	Surface Mounted	False Ceiling	Surface Mounted	False Ceiling	Hanging Type under Shed
8	THD	<10%	<10%	<10%	<10%	<10%	<10%	<10%
9	CRI	>80	>80	>80	>80	>80	>80	>70
10	CCT	5700k±300k	5700k±300k	5700k±300k	5700k±300k	5700k±300k	5700k±300k	5700k±300k
11	Power Factor	>0.95	>0.95	>0.95	>0.95	>0.95	>0.95	>0.95
12	Ik Protection	NA	NA	NA	NA	NA	NA	IK-05
13	Operating Humidity	90% RH	90% RH	90% RH	90% RH	90% RH	90% RH	90% RH
14	Burning Hours	50,000	50,000	50,000	50,000	50,000	50,000	50,000
15	Operating Temperature	-5℃ to 45℃						
16	Lumen Maintenance	70% at the End of Burning Hours						

Section -LIGHTING SYSTEM

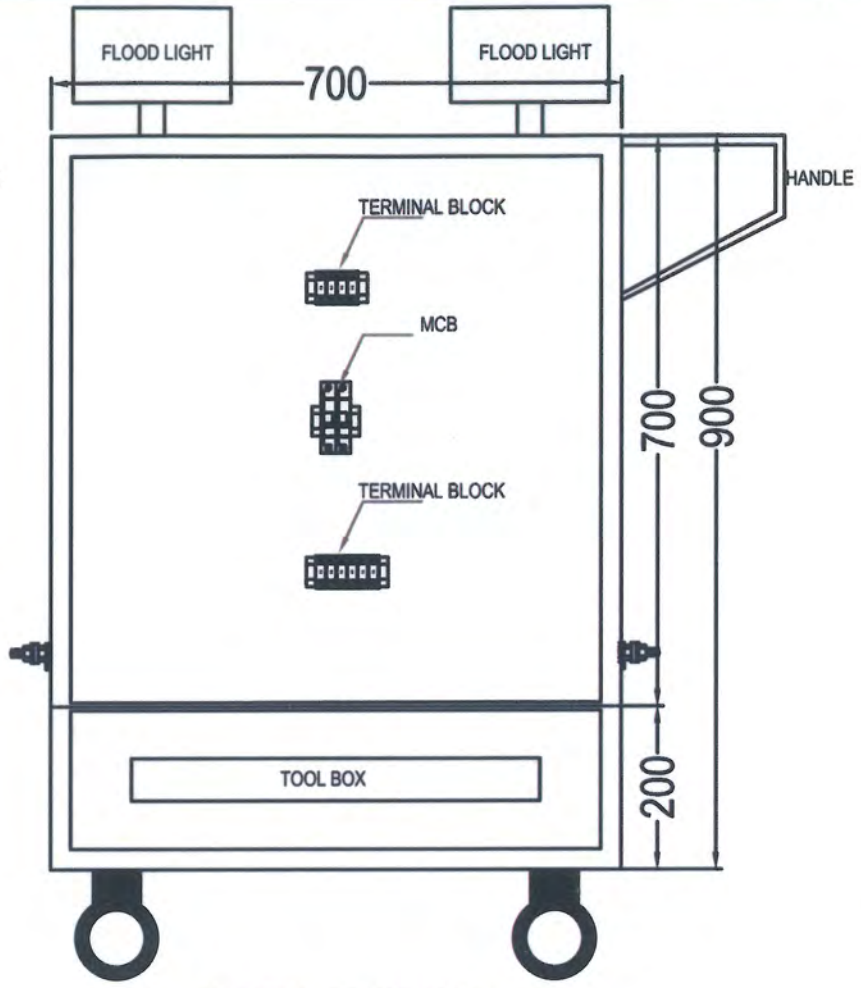
Details of Lighting Fixture

(b) Outdoor Application

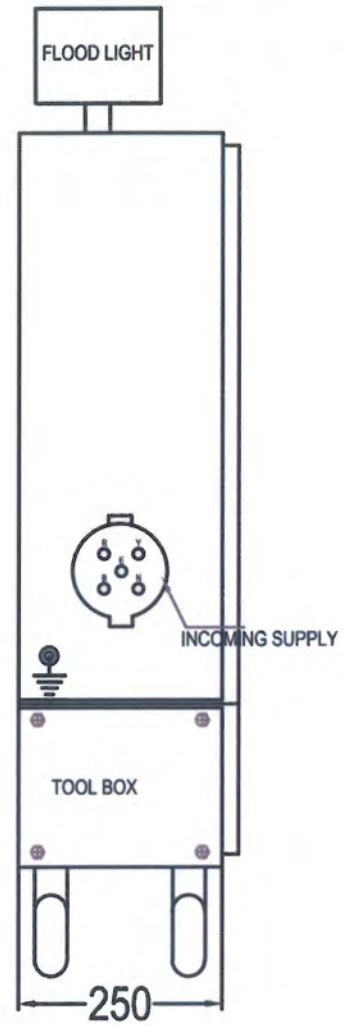
Sr.No	Technical Specification	BL (Surface Mounted Bulk Head)	Type SL-L1 (LED Street Light Luminaire)	Type SL-D1 (Pole Mounted LED Post Top Luminaire)	Type FL-1 (LED Flood Light Luminaries)	Type FL-2 (LED Flood Light Luminaries)
1	System Wattage	≤ 10W	≤45W	≤ 30W	≤150W	≤250W
2	System Lumen Output	≥ 800	≥4000	≥ 2600	≥ 14000	≥ 23000
3	System efficacy (Lumens/Watt)	≥ 80	≥ 100	≥ 90	≥ 100	≥ 100
4	Housing	Pressure Die Cast Housing and with Polycarbonate diffuser	Pressure Die Cast	Die Cast Aluminum	Pressure Die Cast Housing	Pressure Die Cast Housing
5	Ingress Protection	IP-65	IP-65	IP-65	IP-65	IP-65
6	Surge Protector(Internal)	3kV	3kV	3kV	3kV	3kV
7	Surge Protector(External)	10kV	10kV	10kV	10kV	10kV
8	Mounting	Wall Mounting	Pole Mounting for 40mm max O.D	Suitable for 60mm max O.D	On Lattice Structure	On Lattice Structure
9	THD	<20%	<10%	<10%	<10%	<10%
10	CRI	>70	>70	>70	>70	>70
11	CCT	5700k±300k	5700k±300k	5700k±300k	5700k±300k	5700k±300k
12	Power Factor	>0.90	>0.95	>0.95	>0.95	>0.95
13	Ik Protection	IK-09	IK-05	IK-05	IK-05	IK-05
14	Operating Humidity	90% RH	90% RH	90% RH	90% RH	90% RH
15	Burning Hours	50,000	50,000	50,000	50,000	50,000
16	Operating Temperature	-5℃ to 45℃				
17	Lumen Maintenance	70% at the End of Burning Hours				



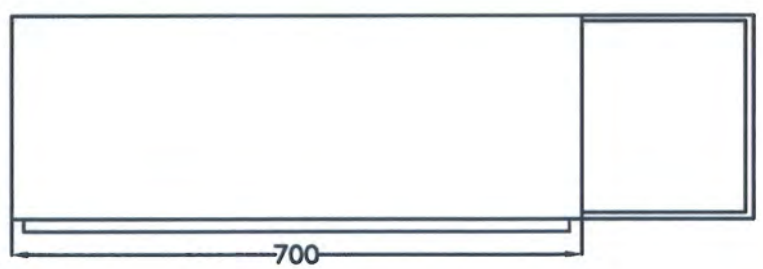
FRONT VIEW WITH DOOR



INTERNAL FRONT VIEW



SIDE VIEW



TOP VIEW

GENERAL NOTES

1	PANEL NAME	PORTABLE FLOOD LIGHT PANEL
2	TYPE OF PANEL	SINGLE FRONT FIXED TYPE
3	PANEL DIMENSION	SIZE: 700W X 900H X 250D MM
4	PANEL BODY	STAINLESS STEEL SS-304
5	IP CLASS OF PANEL	IP-55

PORTABLE CORD OF 25 METER WITH PLUG TO BE PROVIDED ALONGWITH THE PORTABLE FLOOD LIGHT PANEL

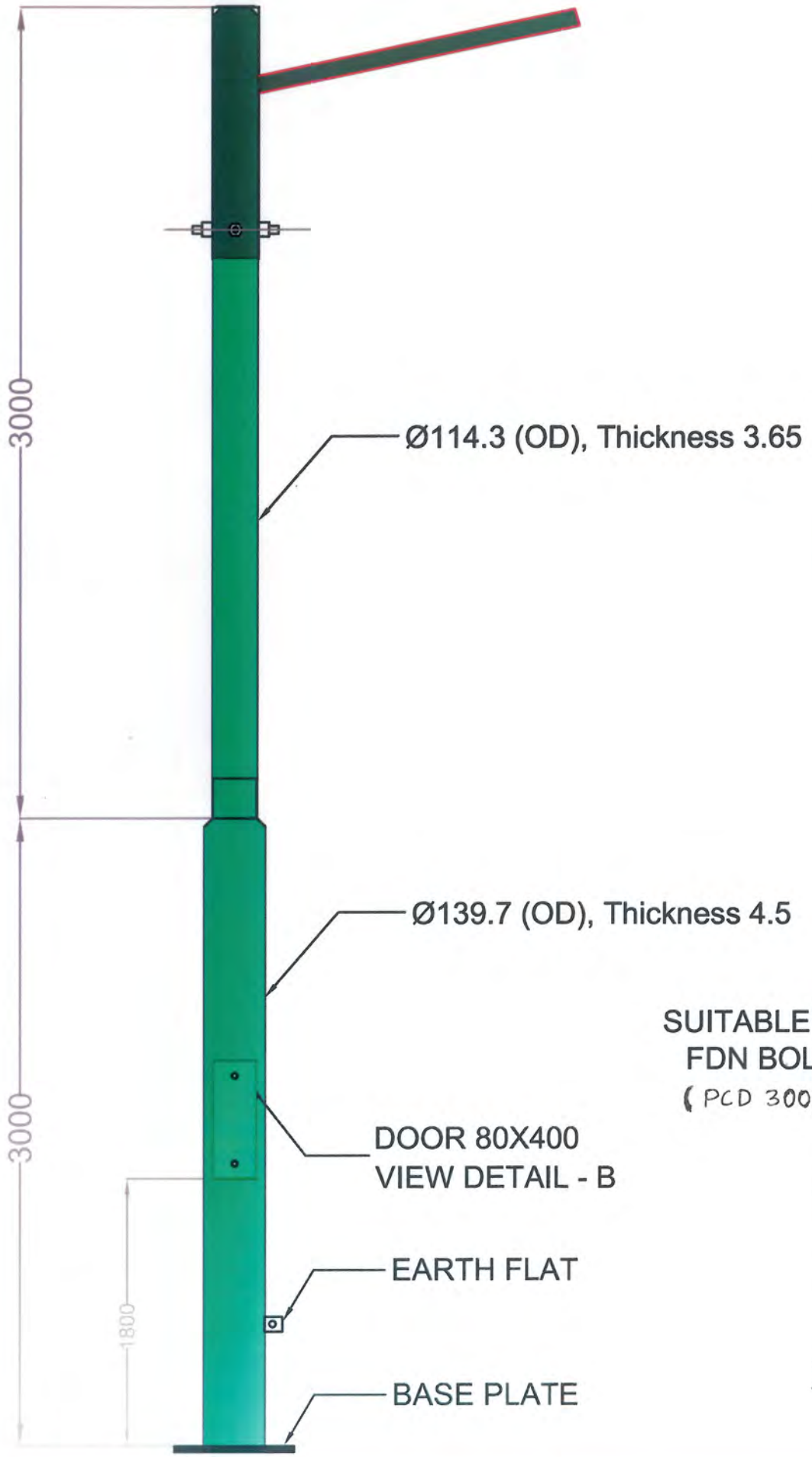
OWNER:-
POWERGRID CORPORATION OF INDIA LTD

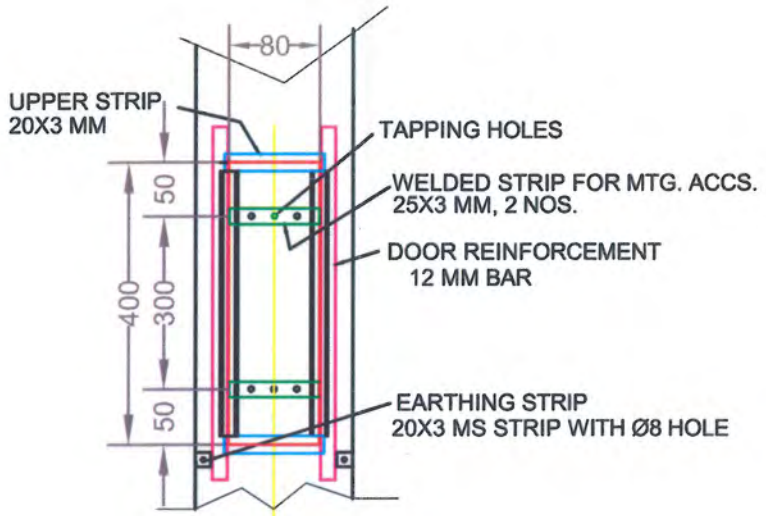
PROJECT:- STANDARD DRAWING

TITLE:- TYPICAL DRAWING FOR PORTABLE FLOOD LIGHT PANEL

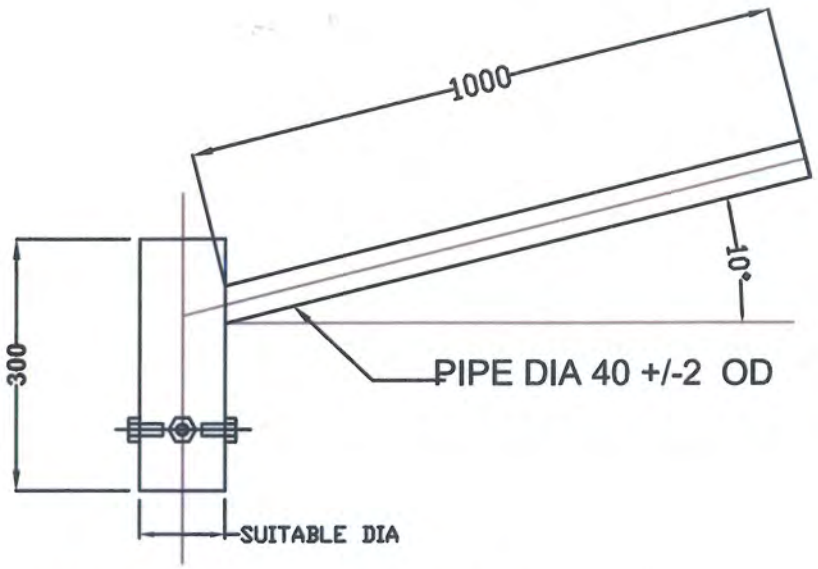
DRAWN BY :-	DRAWING NO: -C/ENGG/GA/PFL.	SHEET NO.	SCALE
CHECKED BY :-	APPROVEDBY :-	1 OF 1	N.T.S.

1401048/2023/TBG-TB_HVDC
309/811

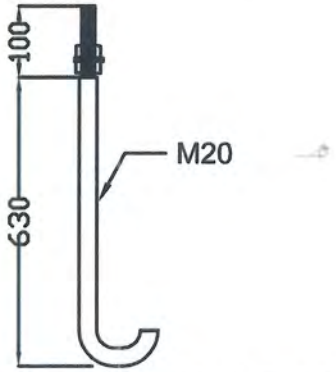




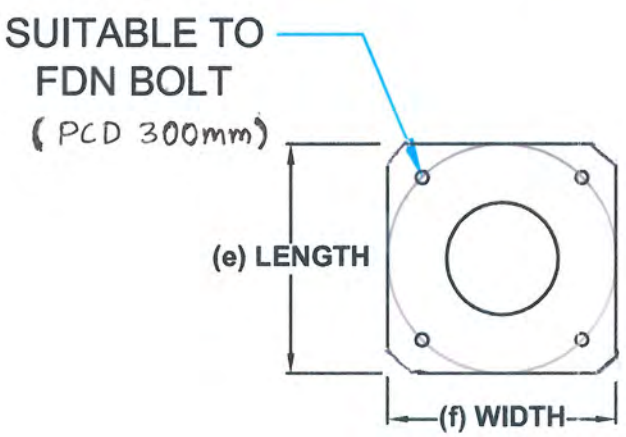
DETAIL - B
(AFTER REMOVE DOOR COVER)



SINGLE ARM BRACKET



FOUNDATION BOLTS J-TYPE
WITH HARDWARE

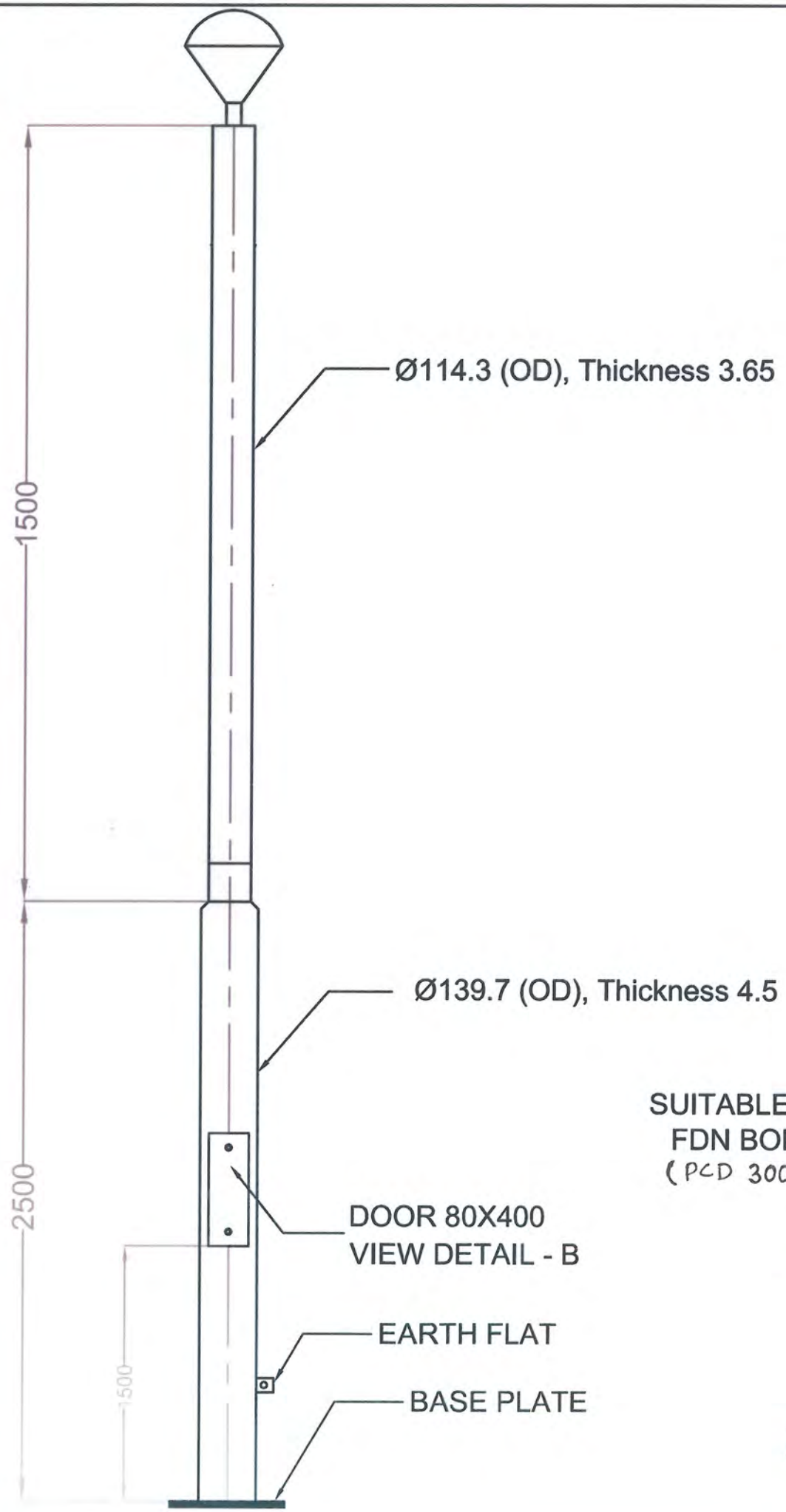


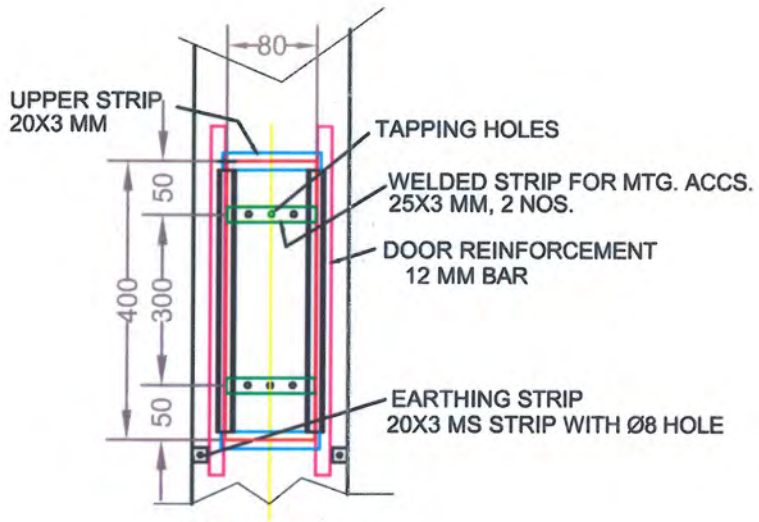
BASE PLATE 300 x 300 x 12mm
BOTTOM VIEW

NOTES:

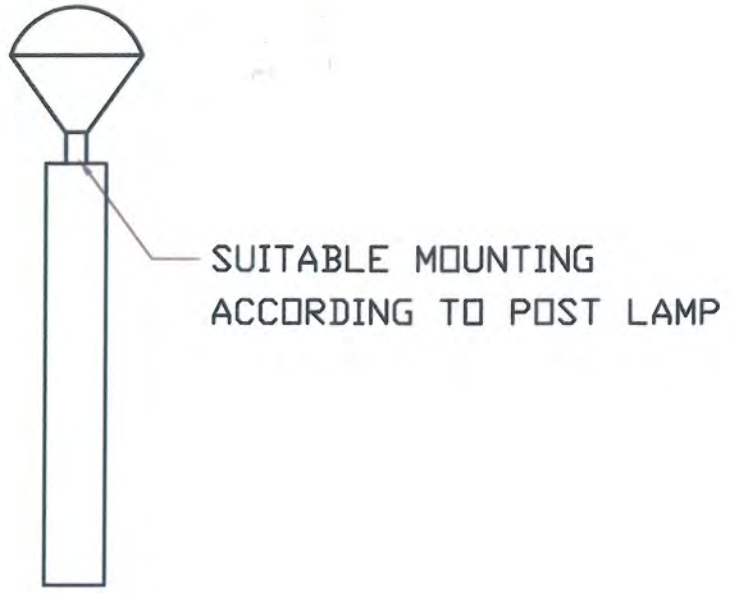
1. ALL DIMENSIONS ARE IN MM.
2. STEEL PIPES AS PER IS: 1161. & MS PLATES AS PER IS 2062.
3. TOLERANCES AS PER IS 1161 - 1979 & AS PER IS 2713.
4. POLE SHALL BE HOT DIP GALVANISED INSIDE & OUTSIDE & PU PAINTED IN APPROVED SHADE ON OUTSIDE OF POLE.

OWNER:- POWERGRID CORPORATION OF INDIA LIMITED			
PROJECT:- STANDARD DRAWINGS			
TITLE:- GA DRAWING FOR 6 METER STEEL TUBULAR POLE-SL-L1			
DRAWN BY:	DRG. NO:C/ENGG/GA/POLE/SL-L1		
CHECKED BY:-	APPROVED BY:-	1 OF 3	NTS

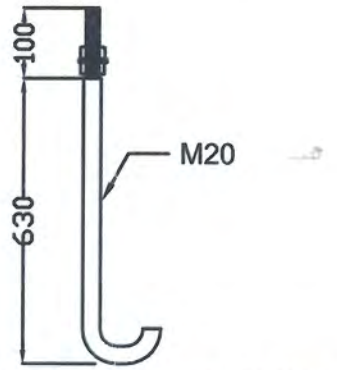




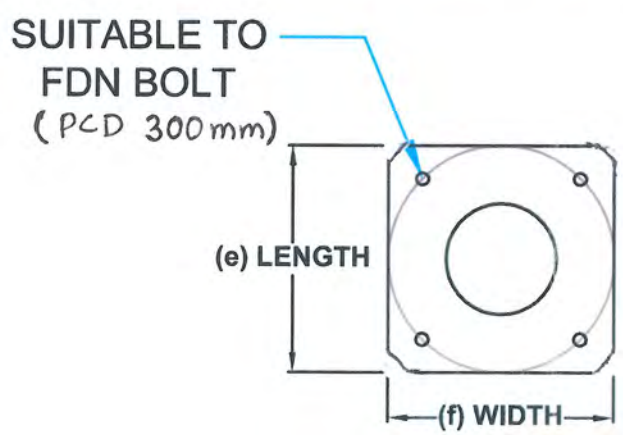
DETAIL - B
(AFTER REMOVE DOOR COVER)



DETAIL - A
POST TOP LAMP



FOUNDATION BOLTS J-TYPE
WITH HARDWARE

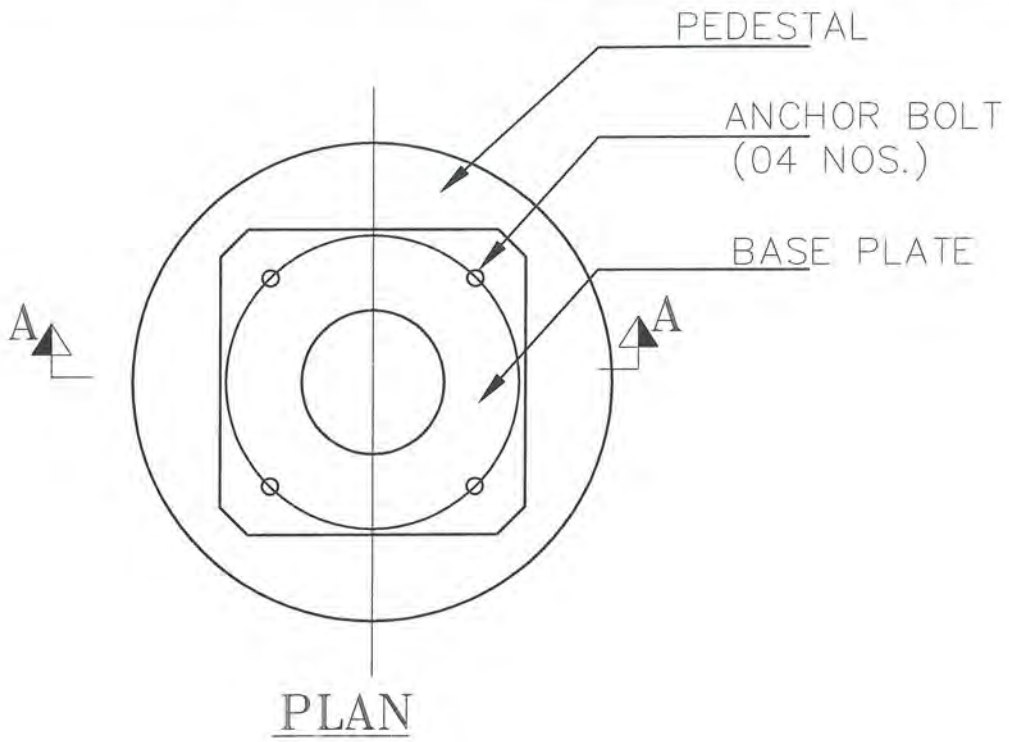


BASE PLATE 300 x 300 x 12mm
BOTTOM VIEW

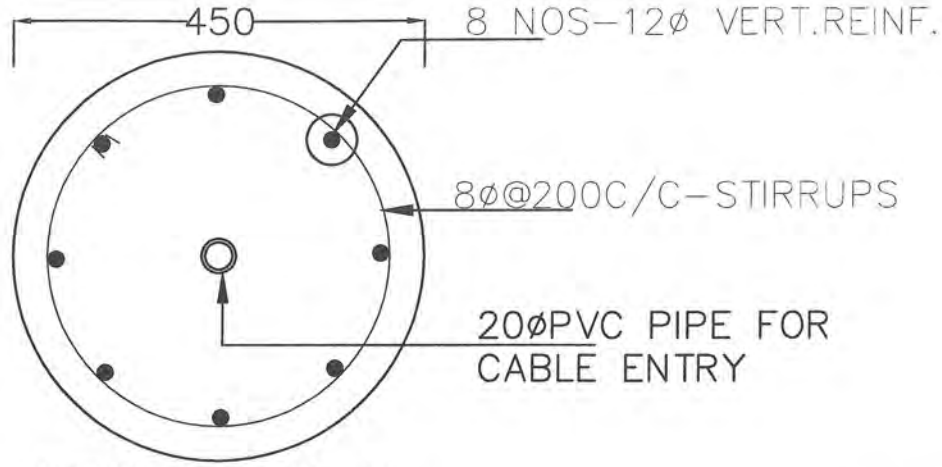
NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. STEEL PIPES AS PER IS: 1161. & MS PLATES AS PER IS 2062.
3. TOLERANCES AS PER IS 1161 - 1979 & AS PER IS 2713.
4. POLE SHALL BE HOT DIP GALVANISED INSIDE & OUTSIDE & PU PAINTED IN APPROVED SHADE ON OUTSIDE OF POLE.

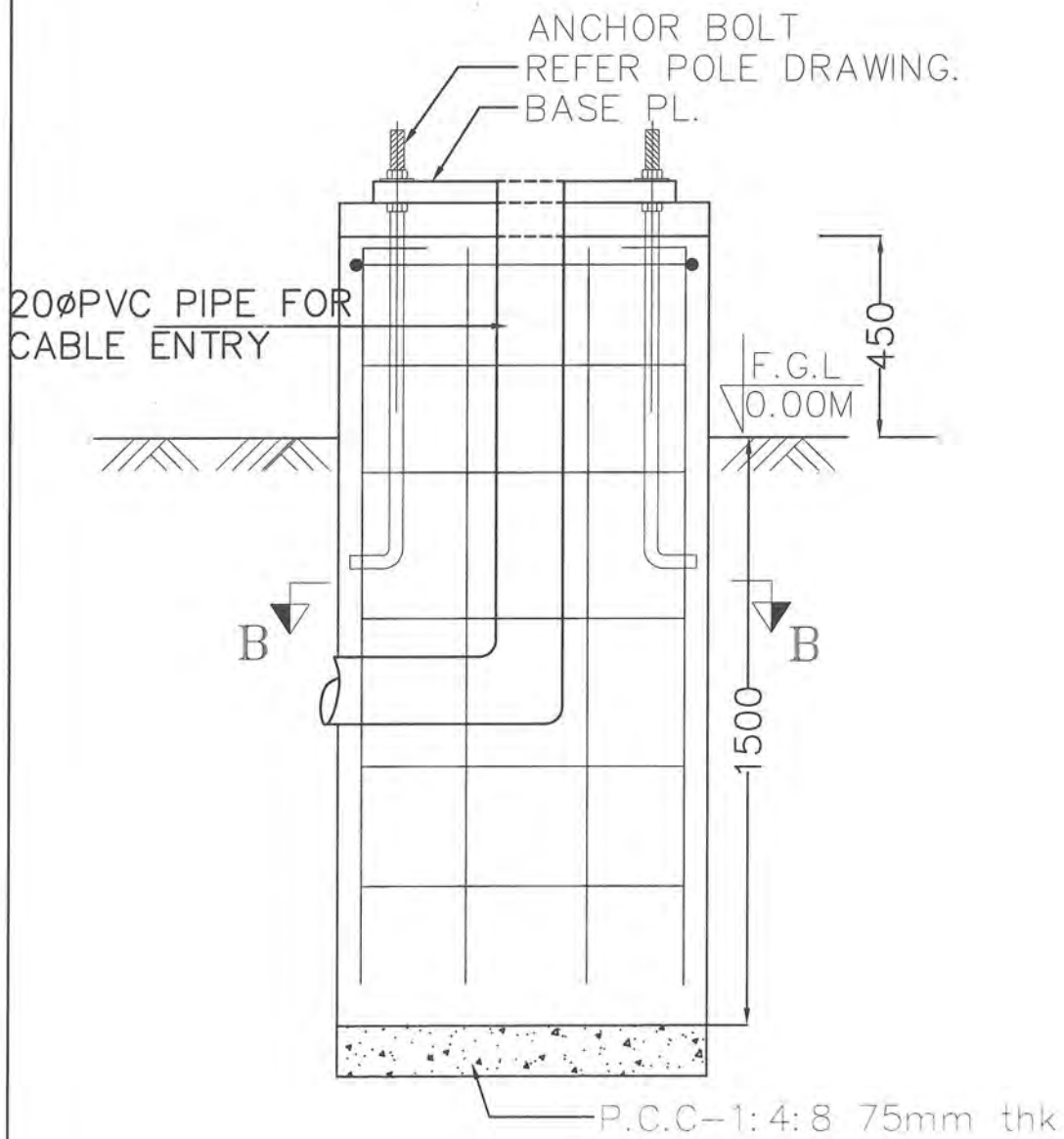
OWNER:- POWERGRID CORPORATION OF INDIA LIMITED			
PROJECT:- STANDARD DRAWINGS			
TITLE:- GA DRAWING FOR 4 METER POST LAMP -SL-D1			
DRAWN BY:	DRG. NO:C/ENGG/GA/POLE/SL-D1		
CHECKED BY:-	APPROVED BY:-	2 OF 3	NTS



PLAN



SECTION:B–B



SECTION:A–A

(A) GENERAL NOTES:

ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES
ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED. THE DRAWINGS SHALL NOT BE SCALED.
ALL STRUCTURAL DRAWINGS SHALL BE READ IN CONJUNCTION WITH ARCHITECTURAL
DISCREPANCY IN DRAWINGS IF ANY SHALL BE BROUGHT TO THE NOTICE OF THE DESIGN OFFICE PRIOR TO CONSTRUCTION.
EXCUTION OF R.C.C. WORKS/STRUCTURAL STEEL WORK AS PER OUR DRAWINGS SHALL BE THE RESPONSIBILITY OF SITE ENGINEER.

(B) SPECIFICATION NOTES FOR R.C.C WORK:

(GRADE OF CONCRETE)

CONCRETE FOR ALL WORKS AS PER BPS.

(REINFORCING STEEL)

ALL REINFORCING STEEL EXCEPT M.S LUGS FOR INSERT PLATES SHALL BE HIGH YIELD STRENGTH DEFORMED BARS CONFORMING TO GRADE Fe 415. OR Fe 500 AS

LUGS FOR INSERT PLATES SHALL BE PLAIN M.S BARS CONFORMING TO GRADE 1 OF IS:432 (PART–1) 1966.IF FLATS OR ANGLES ARE USED AS LUGS,THEY SHALL CONFORM TO

(CLEAR COVER TO MAIN REINFORCEMENT)

UNLESS SHOWN OTHERWISE MIN.CLEAR COVER TO MAIN REINFORCEMENT SHALL BE AS FOLLOWS

BOTTOM	40mm.
TOP,SIDES	40mm.

(LAP LENGTH OR DEVELOPMENT LENGTH FOR DEFORMED BARS SHALL BE AS FOLLOWS)

–45xDIA OF BAR.

NOT MORE THAN 50% BARS SHALL BE SPLICED AT A SECTION.
(LOCATION OF SPLICE SHALL BE DECIDED IN CONSULTATION WITH SITE ENGINEER & PRIOR APPROVAL OF DESIGN OFFICE).

IMP NOTE :THIS DRAWING IS NOT APPLICABLE FOR MARSHY LANDS

OWNER:- POWERGRID CORPORATION OF INDIA LIMITED			
PROJECT:- STANDARD DRAWINGS			
TITLE:- FOUNDATION DRAWING FOR POLE			
DRAWN BY:	DRG. NO:C/ENGG/FDN/POLE		
CHECKED BY:-	APPROVED BY:-	3 OF 3	NTS

1401648/2023/TBG-TB_HVDC

312/811

NOTE:-

1.INTERLOCK SHALL BE PROVIDED BETWEEN INCOMER-1 & 2. BUSCOUPLER TO AVOID PARALLELING OF SUPPLIES IN TOWNSHIP DB.

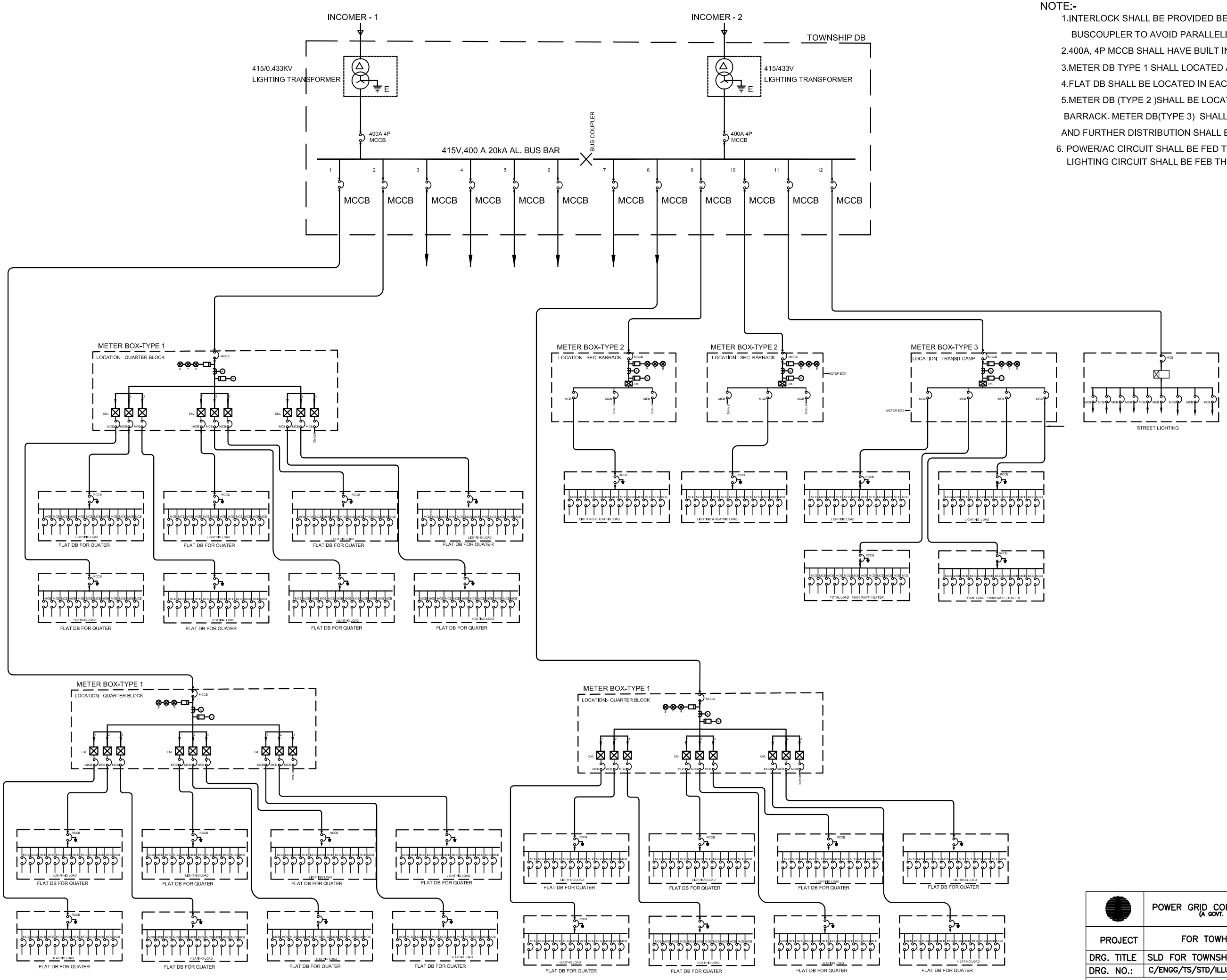
2.400A, 4P MCCB SHALL HAVE BUILT IN OL/SC PROTECTION.

3.METER DB TYPE 1 SHALL LOCATED AT G.F OF EACH TYPE OF BUILDING.

4.FLAT DB SHALL BE LOCATED IN EACH FLAT.

5.METER DB (TYPE 2)SHALL BE LOCATED AT EACH THE SECURITY BARRACK. METER DB(TYPE 3) SHALL BE LOCATED AT TRANSIT CAMP AND FURTHER DISTRIBUTION SHALL BE DONE THROUGH THE FLAT DBs.

6. POWER/AC CIRCUIT SHALL BE FED THROUGH DOUBLE POLE MCB WHILE LIGHTING CIRCUIT SHALL BE FEB THROUGH SINGLE POLE MCB.



SCHEDULE OF SYMBOL

SR. NO.	SYMBOL	DESCRIPTION
1.		MCCB
2.		RCCB
3.		MCB
4.		TIMER
5.	A	AMMETER
6.	V	VOLTMETER
7.		ENERGY METER
8.		FUSE
9.	E	TRANSFORMER

	POWER GRID CORPORATION OF INDIA LTD. (A GOVT. OF INDIA ENTERPRISE)
PROJECT	FOR TOWHSHIP ILLUMINATION
DRG. TITLE	SLD FOR TOWNSHIP (TYPICAL)
DRG. NO.:	C/ENGG/TS/STD/ILLU/TOWNSHIP/01
	SCALE: NTS | SHEET: 01 OF 01

TECHNICAL SPECIFICATION SECTION: SWITCHGEAR-CB REVISION-11

Summary of major changes made in this revision w.r.t earlier Technical Specification, Section: Switchgear, Chapter-CB, Rev.10A & Section: Switchgear, Chapter 765kV CB, Rev.02

1) Technical specification, Section: Switchgear, Chapter 765kV CB, Rev.02 and Section: Switchgear, Chapter CB, Rev.10A are merged to prepare this combined technical specification section up to 765kV CB.

2) All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD (refer clause 1.6)

3) Some duty requirements parameters added/modified (refer clause 2.0)

4) SF6 gas for main CBs shall be supplied in returnable cylinders (refer clause 5.0)

5) Insulators for Circuit breakers can be of Porcelain/polymer type (refer clause 6.0)

6) Included Indicative platform & ladder drawing for 400kV&765kV CB (refer clause 9.0)

7) Included Plug-in type arrangement for termination of inter pole cables (refer clause 11.0)

8) Included Technical parameters for 72.5kV CB (refer clause 16.0)

9) Some parameters like dielectric, creepage, seismic requirement etc w.r.t CBs are included (refer clause 16.0)

10) Included Actions required for defects observed during defect liability period (refer clause 18.0)

Note:
Changes made in this document are shown with bold letters, further major changes are listed above; however for complete details of changes, please refer the complete technical specification, Section: Switchgear-CB, REV.11

SECTION: SWITCHGEAR–CB (CIRCUIT BREAKER)

CONTENTS

Clause.No.	Description	Page No.
1.0	General	4
2.0	Duty requirements	4
2.6	Controlled Switching Device (CSD)	7
3.0	Total Break Time	9
4.0	Constructional Features	9
5.0	Sulphur Hexafluoride Gas (SF6 Gas)	11
6.0	Insulators	11
7.0	Spare Parts and Maintenance Equipment	11
8.0	Operating Mechanism and Control	12
9.0	Support Structure	15
10.0	Terminal Connector Pad	16
11.0	Inter-pole Cabling	16
12.0	Fittings and Accessories	17
13.0	Additional Data to be Furnished	18
14.0	Dead Tank Type Circuit Breaker	19
15.0	Tests	19
16.0	Technical Parameters for Circuit Breaker	21
17.0	Pre-commissioning tests	24
18.0	Actions required for defects observed during defect Liability period	26
9.b) drg:	Indicative drawing for Platform details of 400kV& 765kV CB	27

SECTION: SWITCHGEAR–CB (CIRCUIT BREAKER)

1.0 GENERAL

1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Section-GTR.

1.2 800/420/245/145/**72.5**kV circuit breakers offered would be of sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. The bidder may offer circuit breakers of either live tank type or dead tank type of proven design.

1.3 The circuit breaker shall be complete with operating mechanism, **common marshalling box**, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure, **platform with ladder** for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

1.4 Painting shall be done in line with Section – GTR. **Paint shade RAL-7032** or similar shades can be used for painting. The support structure, **platform & ladder** of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.

1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Section-**Project**.

1.6 **All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.**

2.0 DUTY REQUIREMENTS

2.1 The circuit breakers shall be capable of performing their duties without opening resistors.

2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location **and** also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.2.1 PRE-INSERTION RESISTER

800kV & 420kV circuit breakers shall be provided with single step pre-insertion closing resistors **(wherever the requirement of PIR is explicitly specified in bid price schedules)** to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time **is** given in clause **16.0** of this section. The resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT

Close .... 1 Min .... Open Close Open…..2 min ..... Close ..... 1 Min ..... Open Close Open.

ii) RECLOSING AGAINST TRAPPED CHARGES

Duty shall be the same as under (i) above. The first, third and fourth closures are to be on de - energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) OUT OF PHASE CLOSING

One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and insertion time.

2.3 The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current corresponding to Power transformers as follows:

Voltage rating of CB	**Type of Transformer**	**Rating (in MVA)**
800kV	**765/400kV**	**250 to 1500**
420kV	**765/400kV**	**250 to 1500**
	400/220kV	**250 to 630**
	400/132kV	**160 to 315**
245kV	**400/220kV**	**200 to 630**
	220/132kV	**50 to 200**

	220/66kV	**50 to 200**
145kV	**220/132kV**	**50 to 200**
	132/33kV	**10 to 50**

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. **The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/√3 and 1.4**

iii) Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

i**v) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).**

v) Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage rating of CB	**Reactor Rating (in MVAR)**	**Max. rise of over voltage (in p.u.)**
800kV	**150 to 330**	**1.9**
420kV	**50 to 150**	**2.3**
245kV	**25 to 50**	**2.3**

a. Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate the actual inductive load switching.

b. Current chopping capability (chopping number) of circuit breaker as per IEC-62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.

c. To validate the results of above said simulation study/analysis report, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.

d. Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:

i. Different short circuit current capability

ii. Different model/type

vi) The breakers shall also withstand the voltages specified under clause **16.0** of this section.

2.6 CONTROLLED SWITCHING DEVICE (CSD) :

Circuit Breakers shall be equipped with controlled switching **device** with consequent optimization of switching behavior, when used in:

- Switching of transformer **(from 765kV and 400kV side circuit breakers only)**
- Switching of shunt Reactor

The CSD shall be provided in Circuit breaker of switchable line reactor **bay** and in Main & Tie **bay** circuit breakers of Transformers, line with non-switchable line reactors and Bus reactors. **The CSD shall be supplied as per bid price schedules.**

2.6.1 Technical Requirement for controlled switching device:

a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section - GTR.

b) The CSD shall meet the requirements **of IEC-61000-4-16 class IV** for HF disturbance test **(for short and long durations both)** and fast transient test shall be as per **IEC-61000-4-4 level IV** and insulation test as per IEC 60255–5.

c) The CSD shall have functions for switching ON & OFF the circuit breakers.

d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.

e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than **± 0.5 ms.**

f) The CSD should have display facility at the front for the display of settings and measured values.

g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.

h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSD shall **withstand** transient and dynamic state values of the current from the secondary of the CTs and CVTs.

i) The CSD shall have time setting resolution of 0.1 ms or better.

j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.

k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.

l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both **so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit**

Breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils **through subsequent command.**

m) The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.

3.0 TOTAL BREAK TIME

3.1 The total break time as specified under this section shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC: 62271-100)

ii) Short line fault L75, L90 (with TRV as per IEC: 62271-100)

3.2 The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles **shall be brought out to establish** guaranteed total break time.

3.3 The values guaranteed shall be supported with the type test reports.

4.0 CONSTRUCTIONAL FEATURES

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

4.1 Contacts

4.1.1 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

4.2 If multi-break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/

test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty specified.

4.3 The SF6 Circuit Breaker shall meet the following additional requirements:

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed **during the warrantee period**. In case the leakage under the specified conditions is found to be greater than 0.5% **per** year **after** commissioning of circuit breaker **during the warrantee period**, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during **the warrantee period**.

c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 800, 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. **Separate density monitor and dial type temperature compensated pressure guage is also acceptable.** The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

f) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

g) Sufficient SF6 gas **(including that will be required for gas analysis during filling)** shall be provided to fill all the circuit breakers **being supplied.** Spare gas shall be supplied in separate unused cylinders as per requirement specified in **BPS.**

4.4 Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, pre insertion timings of closing resisters if used, synchronisation of contacts in one pole.

4.5 **The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.**

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

a) The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. **SF6 gas shall be supplied (in returnable cylinders) for all circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non-returnable cylinders.**

c) Test: SF6 gas shall be tested for purity, dew point, air, **hydro-soluble** fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gas bottles should be checked for leakage during receipt at site.

6.0 INSULATORS

a) The porcelain**/polymer** of the insulators shall conform to the requirements stipulated under Section-GTR.

b) The mechanical characteristics of insulators shall match with the requirements specified under this section.

c) All **porcelain & polymer** hollow **column** insulators shall conform to IEC-62155 & **IEC-61462 respectively.**

d) Hollow Porcelain**/polymer** for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT

The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

8.0 OPERATING MECHANISM AND CONTROL

8.1 General Requirements

8.1.1 **Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.**

8.1.2 The operating mechanism **box** shall be strong, rigid, **rebound free and shall be readily accessible for maintenance**.

8.1.3 The mechanism shall be anti-pumping and trip free under every method of closing.

8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause **unwanted** trip or closing operation of the Circuit Breaker

8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the **common marshalling box**.

8.1.6 Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

8.1.7 The **contractor** shall furnish detailed operation and maintenance manual of the mechanism alongwith the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

8.1.8 Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-inflammable wire troughs with covers.

8.1.9 Space shall be available in 765kV CB common marshalling box to mount monitoring device, of about 300x300x150mm size and of approximately 7kg weight, by the owner in future.

8.1.10 Operating mechanism and Marshalling box should be provided with space heater with thermostat, CFL/LED lamp and AC point /Socket.

8.2 **Control:**

8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.

8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker **common marshalling box**.

8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.

8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.

8.2.6 The 765kV kV, 3-Phase circuit breakers suitable for single phase switching shall be suitable for taking a spare pole into service in case of any operational requirement and their marshalling box shall be suitable for accommodating the additional relays etc. required for changeover arrangement of all contacts, alarms, signals, indications, interlocks and lockouts.

8.2.7 In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.

8.2.8 Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.

8.2.9 Density Monitor contacts and pressure switch contacts shall be **preferably** suitable for direct use as permissive in closing and tripping circuits. **The devices shall provide continuous & automatic monitoring of the state of the gas as follows:**

a) 'Gas Refill' level

This contact will be used for remote indication/ to annunciate the need for gas refilling.

b) 'SF6 gas density Low' Alarm level - 1
This contact will be used for remote indication/ to annunciate the need for the urgent gas refilling.

c) 'SF6 gas density Low' Alarm level - 2
This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

d) 'Breaker Block' level
This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

8.2.10 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 **Spring operated mechanism:**

a) Spring operated mechanism shall be complete with motor **as per manufacturer practice**. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

i) **The spring charging failure alarm shall be provided with a time delay relay having setting range from 0-1minute.**

j) **Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.**

k) **An overload relay shall be provided for protection of the spring charging motor.**

9.0 SUPPORT STRUCTURE

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

b) **Ladder and Maintenance platform for 400kV and 765kV Circuit breaker:**

A suitable ladder with the safety cage and a free standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and it's support structure. The platform shall be suitable for maintenance personnel to stand and carryout the activities along with the tools and plant.
The ladder cum maintenance platform shall be designed as a free standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0m shall have at least 15 degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall be as per IS: 2062 and to be galvanized. An indicative drawing of ladder and platform (Drg.Ref.: C-ENGG-IND.DWG-PLATFORM-CB, Rev.0) is added at page 27 of 27 with this specification for guidance which may be modified to suit the requirement of CB by CB manufacturer. However, the minimum size of the structural members shall be maintained as mentioned in the drawing.

c) **For 220kV, 132kV & 66kV circuit breakers a suitable platform cum ladder shall be provided as per manufacturer design.**

10.0 TERMINAL CONNECTOR PAD

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium and shall be conforming to Australian Standard AS-2935 **or equivalent standard** for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTER-POLE CABLING

11.1 All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, **temperature Transducer/CB Status Signals for CSD** and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.

11.2 Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 1.5 sq.mm. Copper.

11.3 The cables shall be with oxygen index Minimum 29 and temperature index as $250^{o}C$ as per relevant standards.

11.4 **Separate cables shall be used for AC, DC-I, DC-II and selected DC.**

11.5 **All inter-pole cabling of Circuit breakers and up to common marshalling box shall be done by plug-in type arrangement. Suitable removable type**

encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in type cable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.

11.6 **Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.**

11.7 **Wiring** shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

12.0 FITTINGS AND ACCESSORIES

12.1 Following is **list of** some of the major fittings and accessories to be furnished by Contractor in the **common marshalling box**. Number and exact location of these parts shall be indicated **in the drawing**.

i) Cable glands (Double compression type), Lugs, Ferrules etc.

ii) Local/remote changeover switch.

iii) Operation counter

iv) Control switches to cut off control power supply.

v) Fuses/**MCBs** as required.

vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.

vii) Anti-pumping relay.

viii) Pole discrepancy relay (for electrically ganged CBs).

ix) D.C. Supervision relays.

x) Rating plate description in accordance with IEC incorporating year of manufacture.

xi) Controlled switching **accessories** like sensors, timers, relays etc.(as applicable)

xii) **Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.**

13.0 ADDITIONAL DATA TO BE FURNISHED

a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.

c) Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.

d) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

e) **Maximum** non-simultaneity between contacts, between poles and **effect of the same on the** guaranteed total break time.

f) Sectional view of non-return couplings used for SF6 pipes.

g) Details & type of filters used in interrupter assembly and also the operating experience with such filters.

h) Details of SF6 gas:

   i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.

   ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.

j) Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.

k) Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnished alongwith the calculations in respect of thermal rating of resistors for the duties specified under clause **2.2.1** of this section in case of 420 kV **& 800kV** circuit breakers.

l) All duty requirements as applicable to 800 kV, 420 kV, 245 kV, 145 kV & 72.5kV CBs specified under Clause **2.0** of this section shall be provided with the support of adequate test reports.

14.0 DEAD TANK TYPE CIRCUIT BREAKER

14.1 In case dead tank type circuit breaker is offered, the Bidder shall offer bushing type CTs (whose secondary parameters are given in under **Section: Switchgear-Instrument Transformer** and in case of 765kV and 400kV these secondaries shall be provided in sets of 3 cores, i.e., 2 cores of PX class and one core of metering, on both sides of dead tank circuit breaker instead of conventional outdoor CTs.

14.2 The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanized). The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel codes {i.e., latest edition of the ASME code for pressure vessel - Section VIII of BS-5179, IS4379, IS-7311 (as applicable) and also shall meet Indian Boiler Regulations}.

The maximum temperature of enclosure with CB breaker carrying full load current shall not exceed the ambient by more than 20 deg C.

14.3 The enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. A bursting pressure test shall be carried out at 5 times the design pressure as type test on the enclosure.

15.0 TESTS

15.1 In accordance with the requirements stipulated under Section-GTR the circuit breaker alongwith its operating mechanism shall conform to **the type tests as per** IEC: 62271-100.

15.2 The type test reports **as per IEC** and the following additional type test reports shall also be submitted for purchaser's/**employer's** review:

i) Corona extinction voltage test (**procedure** as per Annexure-A of Section-GTR).

ii) Out of phase closing test as per IEC: 62271-100.

iii) Line charging interrupting current for proving parameters as per clause no. **16.0** of this section.

iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).

v) Seismic withstand test **(procedure** as per Annexure-B of Section-GTR) in unpressurised condition.

vi) Verification of the degree of protection.

vii) Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg.C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.

viii) Static Terminal Load test.

ix) Critical Currents test (if applicable).

x) Switching of Shunt Reactors. **Test reports shall be submitted as per IEC. Calculations shall be submitted for meeting the requirements of clause 2.3(v) of this section.**

xi) Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.

15.3 **Routine Tests**

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

i) Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **control voltage conditions**. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be **arranged by the contractor at his own cost**.

ii) **During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A**

current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.

iii) **Routine tests on Circuit breakers with Controlled switching device as per IEC/TR 62271-302.**

iv) **Tan delta and Capacitance measurement for grading capacitors at rated voltage and also at 10kV (for reference).**

16.0 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in section-GTR)

Sl. no.	Parameter	765kV system	400kV system	220kV system	132 kV system	66 kV system
1.	Rated voltage (Umax) kV (rms)	800	420	245	145	72.5
2.	Rated frequency (Hz)	50	50	50	50	50
3.	No. of poles	3	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50^0C	3150/4000	2000/3150/ 4000 (as applicable)	1600/2500 (as applicable)	1250	1250
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	50kA (As applicable)	40/50/63kA (As applicable)	40/50 kA (As applicable)	31.5kA	25kA
7.	Symmetrical interrupting capability kA (rms)	50	40/50/63 (As applicable)	40/50 (As applicable)	31.5	25
8.	Rated short circuit making current kAp	125	100/125/ 157.5 (As applicable)	100/125 (As applicable)	80	63
9.	Short time current carrying capability kA (rms)	50 for one second	40/50/63 As applicable for one second	40/50 As applicable for one second	31.5 for one second	25 for three second
10.	Out of phase breaking current carrying capability kA (rms)	12.5	10/12.5/15.75 (As applicable)	**As per IEC**	**As per IEC**	**As per IEC**
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before	900	600	As per IEC	As per IEC	As per IEC

	opening equal to the product of U/√3 and 1.4 as per IEC-62271-100					
12.	First pole to clear factor	1.3	1.3	1.3	1.3	1.5
13.	Temperature rise over an ambient temperature of 50^0C	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100
14.	Rated break time as IEC (ms)	40	40	60	60	Less than 75
15.	Total break time (ms)	45	45	65	65	Less than 80
16.	Total closing time (ms)	Not more than 150	Not more than 150	Not more than **150**	Not more than **150**	Not more than **150**
17.	Operating mechanism or a combination of these	Spring	Spring	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in section-project)	Three phase auto reclosing.
20.	Pre-insertion resistor requirement	As per BPS	As per BPS	NA	NA	NA
i)	Rating (ohms)	450(max.) with tolerance as applicable	400(max.) with tolerance as applicable	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time +pre-arcing time) pre-insertion time (ms)	9	8	NA	NA	NA
iii)	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the	NA	NA	NA

		PIR contacts remain closed	PIR contacts remain closed			
21.	Max. difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching media pressures	2.5(within a pole) 3.3(opening) 5.0(closing)	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening) 3.3(closing)	As per IEC
22.	Maximum allowable switching over voltage under any switching condition	1.9 p.u.	2.3 p.u.	As per IEC	As per IEC	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC	220V DC	220V DC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	As per IEC	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC
26.	Breaking capacity of Aux. Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	**Rated insulation levels**					
i)	Full wave impulse withstand (1.2 /50 µs) between line terminals and ground	±2100kVp	±1425 kVp	±1050 kVp	±650 kVp	±325 kVp
ii)	Full wave impulse withstand (1.2 /50 µs) between terminals with circuit breaker open	2100kVp impulse on one terminal & 455 kVp power frequency voltage of opposite polarity on the other terminal	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	±1050 kVp	+ 650kVp	±325 kVp
iii)	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet between line terminals and ground	+ 1550kVp	+1050 kVp .	NA	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open	1175kVp impulse on one terminal & 650 kVp power frequency	900 kVp impulse on one terminal & 345 kVp power frequency	NA	NA	NA

		voltage of opposite polarity on the other terminal	voltage of opposite polarity on the other terminal			
v)	One minute power frequency dry withstand voltage between line terminals and ground	830kV rms	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	1150kV rms	610 kV rms.	460 kV rms.	275 kV rms	160 kV rms
28.	Minimum corona extinction voltage with CB in all positions	508 kV rms	320kV rms	156 kV rms	92 kV rms	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	2500 µV (at 508kV rms)	1000 µV (at 266kV rms)	1000 µV (at 156kV rms)	500µV (at 92kV rms)	NA
30.	Minimum Creepage distance*					
i)	Phase to ground (25mm/kV)	20000mm	10500mm	6125mm	3625mm	1813mm
ii)	Between CB terminals	18000mm	10500mm	6125mm	3625mm	1813mm
31.	System neutral earthing	Effectively earthed				
32.	Rated terminal load	As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher.				
33.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box.				
34.	No. of terminals in common marshalling box	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use				
35.	Seismic level	0.5g horizontal for the site location under the Zone-V as per IS-1893 0.3g horizontal for the site location under other than the Zone-V as per IS-1893				

*** The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV specified, the Minimum Creepage distance values shall be concidered proportionately.**

17.0 PRE-COMMISSIONING TESTS

17.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. For Pre-commissioning tests, procedures and formats for circuit breakers, POWERGRID document no. CF/CB/03/R-4 dated 01/04/2013 of document no. D-2-01-03-01-04 dated 01-04-2013 will be the reference document. This document will be available at respective sites and shall be referred by the contractor. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier 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 of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Dynamic Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Operation check of pressure switches and gas density monitor during gas filling.

(n) Checking of mechanical ‘CLOSE’ interlock, wherever applicable.

(o) Testing of grading capacitor.

(p) Resistance measurement of main circuit.

(q) Checking of operating mechanisms

(r) Check for annunciations in control room.

(s) Point of wave switching test (wherever applicable)

17.2 The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer’s representative.

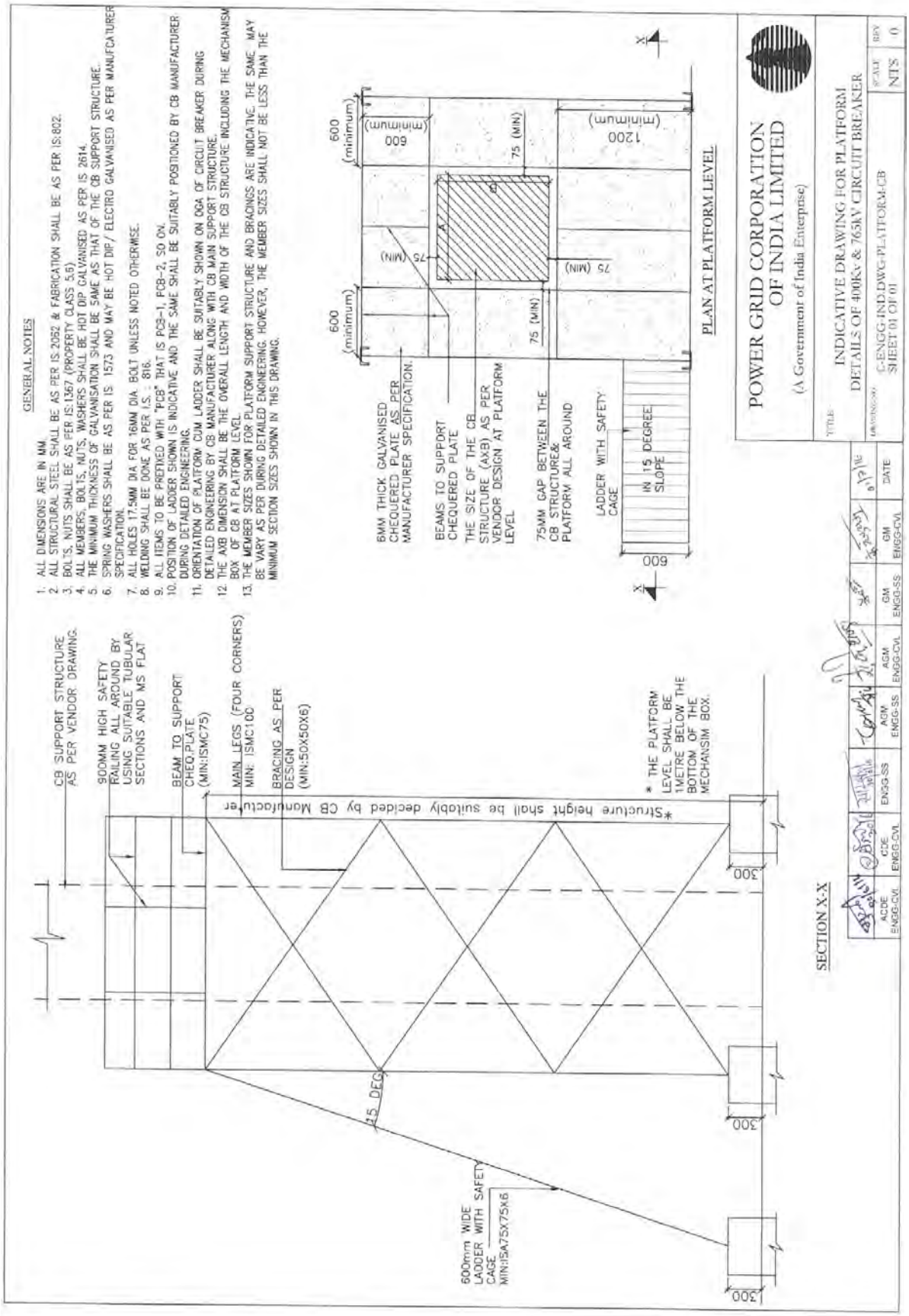
18.0 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/ refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause 22 in SCC.

Sl.no.	Nature of problem	Corrective measures to be taken by contractor
1.	Blasting of interrupter, PIR, pole column,	Replacement of compete CB pole Including SF6 gas
	a. Abnormal DCRM and Travel Measurement b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR	Repair/replacement of affected assembly/ component based on repair procedure approved by QA
2.	Crack in insulator, cementing joint of interrupter , PIR , pole column	Replacement of affected part
3.	SF6 gas leakage from sealing and bolted joints. SF6 gas leakage detectable by any Leakage Detection Method	Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc If unable to arrest the leakage in 02 attempts, replacement of interrupter/ column
4.	SF6 gas low dew point: > (-)35 deg C at atmospheric pressure.	Re-conditioning of gas. If does not improve, complete evacuation of CB, replacement filter material and gas
5.	Oil leakage of grading capacitor Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test.	Replacement or Refurbishment of grading capacitor
6.	Pole/ break discrepancy (during O&M) Limits: Break to Break (Opening/Closing) : max. 2.5 ms Phase to Phase (Opening) : max. 3.33 ms Phase to Phase (Closing) : max 5 ms	Rectification/replacement of affected parts
7.	Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower	Rectification/Replacement of pole
8.	Drive mechanism assembly failure	Rectification/ Replacement of affected part
9.	Trip/ close coil, density monitor, relays and contactors and components of common MB	Replacement of affected part

Note: 1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.

2) The measurement at site shall be carried out as per POWERGRID standard Pre-commissioning procedures as indicated in Technical Specification.


GENERAL NOTES
1. ALL DIMENSIONS ARE IN MM.
2. ALL STRUCTURAL STEEL SHALL BE AS PER IS:2062 & FABRICATION SHALL BE AS PER IS:802.
3. BOLTS, NUTS SHALL BE AS PER IS:1367 (PROPERTY CLASS 5.6)
4. ALL MEMBERS, BOLTS, NUTS, WASHERS SHALL BE HOT DIP GALVANISED AS PER IS 2614.
5. THE MINIMUM THICKNESS OF GALVANISATION SHALL BE SAME AS THAT OF THE CB SUPPORT STRUCTURE.
6. SPRING WASHERS SHALL BE AS PER IS 1573 AND MAY BE HOT DIP / ELECTRO GALVANISED AS PER MANUFACTURER SPECIFICATION.
7. ALL HOLES 17.5MM DIA FOR 16MM DIA BOLT UNLESS NOTED OTHERWISE.
8. WELDING SHALL BE DONE AS PER I.S. : 816.
9. ALL ITEMS TO BE PREFIXED WITH "PCB" THAT IS PCB-1, PCB-2, SO ON.
10. POSITION OF LADDER SHOWN IS INDICATIVE AND THE SAME SHALL BE SUITABLY POSITIONED BY CB MANUFACTURER DURING DETAILED ENGINEERING.
11. ORIENTATION OF PLATFORM CUM LADDER SHALL BE SUITABLY SHOWN ON OGA OF CIRCUIT BREAKER DURING DETAILED ENGINEERING BY CB MANUFACTURER ALONG WITH CB MAIN SUPPORT STRUCTURE.
12. THE AXB DIMENSION SHALL BE THE OVERALL LENGTH AND WIDTH OF THE CB STRUCTURE INCLUDING THE MECHANISM BOX OF CB AT PLATFORM LEVEL.
13. THE MEMBER SIZES SHOWN FOR PLATFORM SUPPORT STRUCTURE AND BRACINGS ARE INDICATIVE. THE SAME MAY BE VARY AS PER DURING DETAILED ENGINEERING. HOWEVER, THE MEMBER SIZES SHALL NOT BE LESS THAN THE MINIMUM SECTION SIZES SHOWN IN THIS DRAWING.
PLAN AT PLATFORM LEVEL
SECTION X-X
CB SUPPORT STRUCTURE AS PER VENDOR DRAWING.
900MM HIGH SAFETY RAILING ALL AROUND BY USING SUITABLE TUBULAR SECTIONS AND MS FLAT
BEAM TO SUPPORT CHEQ.PLATE (MIN:ISMC75)
MAIN LEGS (FOUR CORNERS) MIN: ISMC100
BRACING AS PER DESIGN (MIN:50X50X6)
*Structure height shall be suitably decided by CB Manufacturer
* THE PLATFORM LEVEL SHALL BE 1METRE BELOW THE BOTTOM OF THE MECHANSIM BOX.
600mm WIDE LADDER WITH SAFETY CAGE MIN:ISA75X75X6
15 DEG
300
8MM THICK GALVANISED CHEQUERED PLATE AS PER MANUFACTURER SPECIFICATION.
BEAMS TO SUPPORT CHEQUERED PLATE
THE SIZE OF THE CB STRUCTURE (AXB) AS PER VENDOR DESIGN AT PLATFORM LEVEL
75MM GAP BETWEEN THE CB STRUCTURE& PLATFORM ALL AROUND
LADDER WITH SAFETY CAGE
IN 15 DEGREE SLOPE
600 (minimum)
1200 (minimum)
75 (MIN)
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
INDICATIVE DRAWING FOR PLATFORM DETAILS OF 400Kv & 765kV CIRCUIT BREAKER
C-ENGG-IND.DWG-PLATFORM-CB
SHEET 01 OF 01
NTS
0
ACDE ENGG-CVL
CDE ENGG-CVL
AGM ENGG-SS
AGM ENGG-CVL
GM ENGG-SS
GM ENGG-CVL
DATE

MODEL TECHNICAL SPECIFICATION

SECTION-SWITCHGEAR - ISOLATOR

(REV. NO. 11B)

Following are the major changes made in the Technical specification, Section-Switchgear - ISOLATOR, Rev. 11B:

Clause No.	Major Modification
1.2.1	Interpole cables deleted from scope of manufacturer
3.1(e)	Current Density value deleted
5(m)	Common Marshalling Box deleted
5(n)	Plug-in type terminals for interconnecting cables deleted

Notes: The above is the list of major changes with respect to previous revision (Rev. 11/11A). However, the bidders are advised to read the entire section for other changes and quote accordingly.

SWITCHGEAR – ISOLATOR

CONTENTS

Clause.No. No.	Description	Page
1.0	General	4
2.0	Duty requirements	4
3.0	Constructional Features	5
4.0	Earthing Switches	8
5.0	Operating Mechanism	9
6.0	Operation	10
7.0	Terminal Connector stud/pad	11
8.0	Support Structure	12
9.0	Tests	12
10.0	Mandatory Spares	12
11.0	Technical Parameters	12
12.0	Pre-Commissioning Tests	13

Annexure-I

SWITCHGEAR - ISOLATOR

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to IEC: 62271-102/103 except to the extent explicitly modified in specification and shall be in accordance with requirement of Section-GTR.

1.2 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

1.2.1 Isolator with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlock etc.

1.2.2 All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

1.2.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section-Project.

2.0 DUTY REQUIREMENTS:

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from station DC supply and within a variation range as stipulated in Section-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

3.0 CONSTRUCTIONAL FEATURES:

Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 800kV isolator design shall be double break or vertical break or knee-type. 420kV & below rated isolators shall be double break type, unless specified otherwise. Isolator design shall be such as to permit addition of earth switches at a future date. The features and constructional details of isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 Contacts:

a) The contacts shall be self aligning and self cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

d) The moving contact of double break isolator shall have preferably turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

e) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

3.2 Base :

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure. Common base frame shall be provided for 400/220/132kV isolators suitable for mounting on pipe structures.

3.3 **Blades :**

a) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

d) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e. after every 1000 operations or after 5 years whichever is earlier.

3.4 **Insulator :**

a) The insulator shall conform to IS: 2544, IEC-60168 and IEC-60815. The porcelain of the insulator shall conform to the requirements stipulated under Section-GTR.

b) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

c) Insulator shall be type and routine tested as per IEC-60168. Besides following additional routine/acceptance tests shall also be conducted:

   (i) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as a routine test.

   (ii) Bending load test in four directions at 100% of minimum bending load as a sample test on each lot.

(iii) Torsional test on sample insulators of a lot.

(iv) Ultrasonic test as a routine test.

d) Requirement of Insulators of Isolators shall be as follows:

i) **For 800 kV Insulator**:

Cantilever strength (min.)	=	1000kg
Top PCD	=	225 mm
No. of holes	=	4 x M16
Bottom PCD	=	356 mm
No. of holes	=	8 x 18mm dia.

ii) **For 420 kV Insulator**:

Cantilever strength (min.)	=	1000kg
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	325 mm
No. of holes	=	8 x 18mm dia

iii) **For 245 kV Insulator**:

Cantilever strength (min.)	=	1000kg
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	275 mm
No. of holes	=	8 x 18mm dia

iv) **For 145 kV Insulator**:

Cantilever strength (min.)	=	600kg
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	254 mm
No. of holes	=	8 x 18mm dia

3.5 **Name Plate :**

The name plate shall conform to the requirements of IEC incorporating year of manufacture.

4.0 EARTHING SWITCHES :

a) Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

c) Earthing switches shall be only locally operated.

d) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

e) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

f) The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

g) The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

h) 800kV, 420 kV & 245 kV earth switches shall also comply with the requirements of IEC-62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E-0 for earthing switches.

i) Earth switch blade in open condition shall not project (from the centre line of Insulator) by more than 4200mm for 400kV and 2810mm for 220kV respectively.

5.0 OPERATING MECHANISM :

a) The bidder shall offer motor operated Isolators and earth switches. Isolators of 36 kV and below and earth switches of 72.5 kV and below rating shall be manual operated.

b) Control cabinet/operating mechanism box shall conform to the requirement stipulated in Section-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm) or stainless steel (grade-304) of minimum thickness 2mm.

c) A “Local/Remote” selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

d) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

e) Motor shall be an AC motor and conform to the requirements of Section-GTR.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electro-mechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

g) Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

h) Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also all gear and connected material should be so chosen/surface treated to avoid rusting.

i) Blocked rotor test of motor shall be conducted as a routine test. During the blocked rotor test, overload protection relay should operate to prevent failure of motor.

j) Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).

k) The operating mechanism shall be located such that it can be directly mounted on any one of the support structure.

l) Snap type limit/auxiliary switches shall be used with Factory set values. No adjustment shall be required at site during commissioning.

6.0 OPERATION :

a) The main Isolator and earth switches shall be individual pole operated for 800/420 kV and gang operated in case of 245 kV & 145 kV. However, 245 kV Tandem Isolators shall be individual-pole operated. The operating mechanism of all the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection and strain less than 1%. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock-nut after an adjustment has been made. The isolator and earth switches shall be provided with "over dead center" device in the operating mechanism at open and close position to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of isolator support structure.

d) The isolator contacts shall be positively driven by the operating mechanism continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing / opening operation. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported, the operating rods shall be provided with bearings on each support and at the ~~either~~ ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

e) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rust-proof.

f) Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current,

peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is atleast 80% of the isolating distance.

g) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

h) The contractor shall furnish the following details alongwith quality norms, during detailed engineering stage:

(i) Current transfer arrangement from main blades of isolator alongwith milli volt drop immediately across transfer point.

(ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator alongwith stoppers to prevent over travel.

7.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminum and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections. Only terminal pads shall be used for current ratings above 1250A. Terminal pads shall be mounted below the current transfer contacts so that the cantilever pull from the terminal connector is not transferred through the current transfer point to the support insulator. The terminal pad shall be suitable for horizontal plane connection with terminal connector. The terminal pads for all isolators with 3150A & above rating shall have six holes for terminal pad.

8.0 SUPPORT STRUCTURE:

800 kV/420 kV/245 kV/145 kV Isolators along with Earth switches shall be suitable for mounting on standard support structures.

9.0 TESTS:

9.1 In continuation to the requirements stipulated under Section-GTR the isolator alongwith its earthing switch and operating mechanism should have been type tested as per IEC/IS and shall be subjected to routine tests in accordance with IEC-62271-102. Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) isolator out

of every lot of Isolators, assembled completely with all accessories including insulators, as acceptance test for the lot. The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than (+/-) 10% after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked.

9.2 The test reports of the type tests as per IEC 62271-102 and the following additional type tests (additional type tests are required for isolators rated above 72.5 kV only) shall also be submitted for the Employer's review.

(i) Radio interference voltage test as per Annexure-A of Section-GTR.

(ii) Corona Extinction Voltage test as per Annexure-A of Section-GTR

(iii) Seismic withstand test on isolator mounted on Support structure as per Annexure-B of Section-GTR. The test shall be performed in the following position :

Isolator open	E/S Closed
Isolator open	E/S Open
Isolator Closed	E/S Open

10.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

11.0 TECHNICAL PARAMETERS: As per table given at **Annexure-I**:

12.0 PRE-COMMISSIONING TESTS

12.1 Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates at his own cost.

An indicative list of tests on isolator and earthswitch is given below. For pre-commissioning procedures and formats for Isolators and Grounding switch, Doc.No.: CF/ISO/07/R-4, dtd-01.04.2013 under POWERGRID Document no. D-2-01-03-01-04 will be the reference document. This document will be available at respective sites and shall be referred by the contractor.

(a) Insulation resistance of each pole

(b) Manual and electrical operation and interlocks

(c) Insulation resistance of control circuits and motors

(d) Ground connections

(e) Contact resistance

(f) Proper alignment so as to minimize vibration during operation

(g) Measurement of operating Torque for isolator and Earth switch

(h) Resistance of operating and interlocks coils

(i) Functional check of the control schematic and electrical & mechanical interlocks

(j) 50 operations test on isolator and earth switch

12. 2 The Contractor shall ensure that erection, testing and commissioning of Isolators above 72.5 kV class shall be carried out under the supervision of the Isolator manufacturer's representative and the cost of the same shall be included in the erection price of the respective equipment.

Annexure-I

1. Technical Parameters for 765kV, 400kV, 220kV and 132kV Isolators

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
1	Rated voltage	kVrms	800	420	245	145
2	Rated frequency	Hz	50	50	50	50
3	No. of poles	Nos.	3	3	3	3
4	Design ambient temperature	℃	50	50	50	50
5	Type		Outdoor	Outdoor	Outdoor	Outdoor
6	Rated current at 50°C ambient temperature	A	3150	3150	1600A / 2500 A (as applicable)	1250
7	Rated short time withstand current of isolator and earth switch	kA	40 / 50 for 1 sec (as applicable)	40 /50 /63 for 1 sec (as applicable)	40 / 50 for 1 sec (as applicable)	31.5 for 1 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	102kAp	100 kAp / 125 kAp / 157.5 kAp (as applicable)	100 kAp / 125 kAp (as applicable)	80kAp
9	Temperature rise over design ambient temperature	As per Table-3 of IEC-62271-1				
10	Rated mechanical terminal load	N	As per table III of IEC-62271-102 or as per value calculated in Section-GTR whichever is higher			
11	Mechanical Endurance Class	Isolator-M2 E/S-M0				
12	Operating mechanism of isolator/erathswitch	A.C. Motor operated				
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.				
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.				

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
14	Max. Operating time	secs	20 sec. for Isolator and 25 seconds for earth switch	20 secs	12 secs	12 secs
15	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.				
16	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	between line terminals and ground	kVpeak	±2100	±1425	±1050	±650
ii)	between terminals with isolator open	kVpeak	±2100 kVp impulse on one terminal and 455 kVp power frequency voltage of opposite polarity on other terminal	±1425 kVp impulse on one terminal and 240 kVp power frequency voltage of opposite polarity on other terminal	±1200	±750
b)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet					
i)	between line terminals and ground	kV peak	± 1550	± 1050	-NA-	-NA-
ii)	between terminals with Isolator open	kV peak	1175 kVp impulse on one terminal and 650 kVp power frequency voltage of opposite polarity on other terminal	900 kVp impulse on one terminal and 345 kVp power frequency voltage of opposite polarity on other terminal	-NA-	-NA-
c)	One minute power frequency dry withstand voltage					
i)	between line terminals and ground	kV rms	830	520	460	275
ii)	between terminals with isolator open	kV rms	1150	610	530	315
17	Minimum Corona extinction voltage	KV rms	508	320	156	92

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
	with Isolator in all positions					
18	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz. in all positions	micro volts	2500 at 508 kVrms	1000 at 266 kVrms	1000 at 156 kVrms	500 at 92 kVrms
19	Minimum Creepage distance					
i)	Phase to ground	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	As per Section-GTR
20	Seismic acceleration		As per IS:1893	As per IS:1893	As per IS:1893	As per IS:1893
21	Thermal Rating of Auxiliary Contacts	A	10 A at 220 V DC	10 A at 220 V DC	10 A at 220 V DC	10 A at 220 V DC
22	Breaking Capacity of auxiliary contacts		2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms
	Distance between support structures foundations (within same phase)	m	6.0	4.0	2.5	-
23	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

2. Technical Parameters for 72.5 kV, 36 kV and 11 kV Isolator

Sl. No.	Description	Unit	72.5kV ISO	36kV ISO	12kV ISO
1	Rated voltage	kVrms	72.5	36	11
2	Rated frequency	Hz	50	50	50
3	No. of poles	Nos.	3	3	3
4	Design ambient temperature	℃	50	50	50
5	Type		Outdoor, Mechanically gang operated	Outdoor, Mechanically gang operated	Outdoor, Mechanically gang operated
6	Rated current at 50^{O}C ambient temperature	A	As per requirement	As per requirement	As per requirement
7	Rated short time withstand current of isolator and earth switch	kA	25 kA for 3 sec	25 kA for 3 sec	25 kA for 3 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	62.5kAp	62.5kAp	62.5kAp
9	Temperature rise over design ambient temperature	As per Table-3 of IEC-62271-1			
10	Rated mechanical terminal load	N	As per IEC or as per value calculated in Section-GTR whichever is higher		
11	Mechanical Endurance Class		Isolator-M1 E/S-M0		
12	Operating mechanism of isolator/erathswitch		Isolator - A.C. Motor operated E/S – Manual operated	Isolator - Manual operated E/S – Manual operated	Isolator - Manual operated E/S – Manual operated
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.			
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.			
14	Max. Operating time	sec	12 sec.	NA for manual operation	NA for manual operation

Sl. No.	Description	Unit	72.5kV ISO	36kV ISO	12kV ISO
15	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.			
16	Rated Insulation levels				
a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
i)	between line terminals and ground	kVpeak	±325	±170	-
ii)	between terminals with isolator open	kVpeak	±375 kVp	±180 kVp	-
b)	One minute power frequency dry withstand voltage				
i)	between line terminals and ground	kV rms	140	70	-
ii)	between terminals with isolator open	kV rms	160	80	-
17	Minimum Creepage distance				
i)	Phase to ground	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR
20	Seismic acceleration		As per IS:1893	As per IS:1893	As per IS:1893
21	Thermal Rating of Auxiliary Contacts	A	10 A at 220V/110V DC	10 A at 220V/110V DC	10 A at 220V/110V DC
22	Breaking Capacity of auxiliary contacts		2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms
	Distance between support structures foundations (within same phase)	m	As per layout		
23	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

MODEL TECHNICAL SPECIFICATION

SECTION-SWITCHGEAR-INST

(INSTRUMENT TRANSFORMERS)

(REV. NO. 11)

Following are the major changes made in the Technical specification, Section-Switchgear-INST, Rev. 11:

Clause No.	Major Modification
1.	**New IEC-61869 referred. IEC-60044 is superseded by IEC-61869**
2.	**245kV and above rating CT are acceptable with Polymer Insulator**
3.	**Cantilever strength for 72.5kV Instrument Transformer specified**
4.	**Live Tank CT shall be preferably of Bar primary design with SS Bellow**
5.	**Type test & Special test requirements mentioned in line with IEC-61869**
6.	**DGA sampling after commissioning elaborated**
7.	**Requirement of Oil sampling device added**
8.	**Defect liability clause added for actions required in case of defects observed during warrantee period**
9.	**Protection class of CT mentioned as "PX class" in line with IEC-61869**

Note: The above is the list of major changes with respect to previous revision (Rev. 10). However, the bidders are advised to read the entire section/chapter for other changes and quote accordingly.

SECTION-SWITCHGEAR–INST

INSTRUMENT TRANSFORMERS

CONTENTS

Clause.No.	Description	Page No.
1.0	General	4
2.0	Constructional Features	4
3.0	Current Transformers	6
4.0	Voltage Transformers	8
5.0	Terminal Connectors	9
6.0	Tests	10
7.0	Mandatory Spares	12
8.0	Technical Parameters	13
9.0	Pre-Commissioning tests	13
10.0	**Defect Liability**	**14**
Table-IA	Requirements of 800 kV CVT	15
Table-IB	Requirements of 420 kV VT	16
Table-IC	Requirements of 245 kV VT	17
Table-ID	Requirements of 145 kV VT	18
Table-IE	Requirements of 72.5 kV VT	19
Table-IIA	Requirements of 800 kV CT	20
Table-IIB	Requirements of 420 kV CT	21
Table-IIC	Requirements of 245 kV CT	22
Table-IID	Requirements of 145 kV CT-800A	23
Table-IIE	Requirements of 145 kV CT-600A	24
Table-IIF	Requirements for 72.5 kV CT	25
Annexure-I	Technical Parameters of CT	26
Annexure-II	Technical Parameters of CVT/IVT	28
Annexure-III	Wiring diagram for CT	30
Annexure-IV	Wiring diagram for CVT	32
Annexure-V	Actions required in case of defects observed during the warrantee period	34

SECTION-SWITCHGEAR-INST

INSTRUMENT TRANSFORMERS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in this specification and shall be in accordance with the requirements in Section-GTR.

Current Transformers (CT): IEC: ***61869-1 & 61869-2*** or IS: 2705 ***Part-1 to 4***

Capacitive Voltage Transformers (CVT): IEC: ***61869-1, 61869-5*** & IEC-60358 ***or IS-3156 Part-1 to 4***

Inductive Voltage Transformers (IVT): IEC: ***61869-1 & 61869-3 or IS-3156 Part-1 to 3***

1.2 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Section-GTR **and Section-Project.**

2.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

a) Instrument transformers of **800kV/420kV/245kV/145kV/72.5** kV class, shall be oil filled/SF_6 gas filled, suitable for outdoor service and upright mounting on steel structures. **245kV, 420kV and** 800kV CT shall be with polymer insulator.

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT & IVT. Oil sight glass shall be provided for electromagnetic unit of CVT. ***The Instrument transformer shall have cantilever strength of not less than 500 kg, 500 kg, 350 kg, 350 kg and 250 kg respectively for 800kV, 420kV, 245kV, 145kV and 72.5kV Instrument Transformers.*** For CVT/IVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required for SF_6 gas filled CT/IVT.

d) Instruments transformers shall be hermetically sealed units. The details of the arrangements made for the sealing of instrument transformers shall be furnish during detailed engineering.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) SF_6 gas filled CT/IVT shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 gas leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

g) The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

h) The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per Section-GTR. External surface of aluminum can have natural finish.

i) The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

2.2 **Terminal box/Marshalling Box:**

Terminal box/**Marshalling Box** shall conform to the requirements of Section-GTR.

2.3 **Insulating Oil/Gas:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS-335/IEC-60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 **shall** be used in the capacitor units of CVT.

b) The SF_6 gas shall comply with IEC-60376, 60376A, 60376B **& IEC-60480** and shall be suitable in all respects for use in the switchgear under operating conditions.

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current **&** extended current rating in case of current transformers and rated voltage, voltage factor **& intermediate voltage** in case of voltage transformers shall be clearly indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type or hair pin type and suitably designed for bringing out the secondary terminals

in a weather proof (IP-55) terminal box at the bottom. PF **(Tan delta)** terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box.

In case of inverted type **(Live Tank)** current transformers, the manufacturer shall meet following additional requirements:

(i) The primary conductor shall preferably be of bar type meeting the desired characteristics.

(ii) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly **i.e. insulation at neck** shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) **Bellows made of stainless steel shall be used at the top for hermetic sealing of CT.**

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. μ metal or nano-crystalline core can also be used for metering cores.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current Transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) The rated extended currents for 800kV and 420kV class Current transformers shall be as given below:

Tap Ratio	800kV, 3000A	400kV, 3000A
	Rated extended currents in % of rated current	
500/1	200	200
1000/1	---	---
2000/1	180	180
3000/1	120 (200 for 15 min)	120

h) The secondary winding shall be rated for 2A continuously.

Further, the intermediate tapping at 3000-2000 of metering core of 3000 A rated 400kV and 800kV CTs shall be suitable for using as 1000/1 ratio **also**. The Auxiliary reactor, **if used,** as referred at wiring diagram No.0000-000-T-E-L-028 shall be suitable for connecting to the selected taps. The requirements of 3000A CTs are given at TABLE II-A.

For 245/145/**72.5**kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs.

h) For 800/420/245/145/**72.5**kV Current Transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing **and transportation** design to the Employer for review.

j) For 800kV CTs, the instrument security factor at all ratios shall be less than ten (10) for metering core. For 420/245/145/**72.5**kV CTs, the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical

wiring diagram no. 0000-000-T-E-L-028 (Sh.1 & 2) is enclosed herewith at Annexure-III **of this specification**.

l) The Current Transformers should be suitable for mounting on lattice structure (for 800 kV) or pipe structure (for 420 kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/**Section-Structures.**

m) The CT shall be designed so as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 800/420/245/145kV Current Transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 800/420/245/145kV Voltage Transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition, fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCBs.

c) CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. H.F. terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferroresonance oscillations.

f) The accuracy of 0.2 on secondary III for all CVTs/IVTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) **The Voltage Transformers shall be suitable for mounting on lattice structure (for 800kV) or Pipe structure (for 420kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/Section-Structures.**

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided, if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. **Alternate arrangement shall also be acceptable**.

j) The wiring diagram for the interconnection of the three single phase CVTs/IVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. Wiring diagram no.: 0000-000-T-E-L-029 enclosed herewith at Annexure-IV **of this specification shall be** followed.

5.0 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Section-GTR **and technical parameters for the respective equipment as per Annexure-I and Annexure-II of this specification.**

6.0 TESTS:

6.1 In accordance with the requirements in Section-GTR, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with **relevant IEC**.

6.2 The test reports of type tests**, as applicable, as per IEC-61869-2 for CT, IEC-61869-5/IEC-60358 for CVT, and IEC-61869-3 for IVT** and following additional tests shall be submitted for the Employer's review. **The type tests for which the procedure is under consideration as per abovesaid IEC is not required to be considered.**

a) Current Transformers (CT):

i) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating.**

ii) RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iii) Seismic withstand test as per Annexure-B of Section-GTR **or IEC-62271-2 (with Seismic acceleration requirement as per Annexure-I of this specification/Section-Project) for 145kV and above voltage rating.**

iv) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

v) Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between $80^{O}C$ & $90^{O}C$) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

vi) Multiple chopped impulse test (not applicable for SF_6 filled CT) with the application of 600 chopped impulses **for 145kV and above voltage rating**.

. **vii) Transmitted over voltage test for 145kV and above voltage rating**

viii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 145kV and above voltage rating

ix) Internal Arc fault test for 145kV and above voltage rating (not applicable for CT with Polymer Insulator)

x) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

xi) Gas dew point test for SF_6 filled CT

xii) Corrosion test for 145kV and above voltage rating

b) Capacitive Voltage Transformers (CVT):

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358)

ii) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage class.**

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358)

iv) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating**.

v) RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

vi) Transmitted over voltage test for 145kV and above voltage rating

vii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating

viii) Determination of Temperature coefficient for 145kV and above voltage rating

ix) Tightness design test of capacitor units for 145kV and above voltage rating

x) Corrosion test for 145kV and above voltage rating

c) Inductive Voltage Transformers (IVT):

i) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage rating.**

ii) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating**.

ii) RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iii) Multiple chopped impulse test with application of 600 chopped impulses for 145kV and above voltage rating (not applicable for SF_6 filled CT).

iv) Transmitted over voltage test for 145kV and above voltage rating

v) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating

vi) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

vii) Gas dew point test for SF_6 filled CT

viii) Corrosion test for 145kV and above voltage rating

ix) Measurement of Capacitance and Dielectric dissipation factor for 145kV and above voltage rating

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per ***relevant*** IEC~~.~~

a) CURRENT TRANSFORMERS:

ROUTINE TESTS:

For Oil filled CT:

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/√3.

For SF_6 filled CT:

i) Dew point measurement

ii) SF_6 alarm/ lockout check.

iii) SF_6 gas leakage test: Gas leakage rate shall be maintained within 0.2% per annum.

b) VOLTAGE TRANSFORMERS:

Routine tests on CVT/IVT shall be done in line with IEC-61869-3/61869-5.

7.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

8.0 MAJOR TECHNICAL PARAMETERS:

Major technical parameters for 800kV/420kV/245kV/145kV/72.5kV Instrument Transformers are enclosed at Annexure-I and Annexure-II to this specification.

9.0 PRE-COMMISSIONING TESTS

9.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Employer without any extra cost to the Employer. **The Contractor shall arrange all instruments**

required for conducting these tests alongwith calibration certificates at his own cost.

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current

(d) Dielectric test of oil (wherever applicable)

(e) Magnetizing characteristics test

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible)

(i) Test for SF_6 (for SF_6 filled CTs) – Dew point measurement, SF_6 alarm/ lockout check

(j) DGA test of oil

Dissolved Gas Analysis (DGA) shall be carried out twice within the first year of service, first within the first month of commissioning/charging and second between six months to one year from the date of commissioning/charging.

CTs/IVTs must have adequate provision for taking oil samples from the bottom of the CT/IVT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. ~~Bidder/~~Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

Bidder shall supply 2 nos. oil sampling device for every 20 nos. oil filled CT supplied with a minimum of 2 nos. oil sampling device for each substation.

9.3 **Inductive Voltage Transformers/Capacitive Voltage Transformers**

(a) Insulation Resistance test for primary (if applicable) and secondary winding
(b) Polarity test
(c) Ratio test
(d) Dielectric test of oil (wherever applicable)

(e) Tan delta and capacitance measurement of individual capacitor stacks
(f) Secondary winding resistance measurement

For pre-commissioning procedures and formats for Current Transformers, Doc.No.: CF/CT/04/R-4 dtd-01.04.2013 and for Voltage Transformers, CF/CVT/05/R-4 dtd-01.04.2011 under POWERGRID document no. D-2-01-03-01-04 will be the reference document. **This document will be available at respective sites and shall be referred by the contractor.**

10.0 Defect Liability

The actions required to be taken by contractor in case of defects observed in CT/CVT of ratings 145kV & above during the warranty period (defect liability period) shall be as per enclosed Annexure-V of this specification. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have Two (2) years warranty without prejudice to contractual warranty period (defect liability period).

TABLE - IA

REQUIREMENTS OF 800 KV CAPACITIVE VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	800		
2.	Type	Single phase Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	**± 10 minutes** (For metering core)		
6.	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IB

REQUIREMENTS OF 420 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	420		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IC

REQUIREMENTS OF 245 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous		
		1.5 - 30 seconds		
5.	Phase angle error	± 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - ID

REQUIREMENTS OF 145 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	8800 (+ 10% / -5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$132/\frac{0.11}{\sqrt{3}}$	$132/\frac{0.11}{\sqrt{3}}$	$132/\frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

TABLE - IE

REQUIREMENTS OF 72.5 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR		
1.	Rated primary voltage (kV rms)	72.5	
2.	Type	Single phase Electro-magnetic or Capacitive VT	
3.	No. of secondaries	2 cores	
4.	Rated Voltage Factor	1.2 continuous 1.5 – 30 seconds	
5.	Phase angle error	+ 20 minutes (For metering core)	
6.	Core details	**Core-1**	**Core-2**
	a) Voltage ratio	**For 66 kV feeder application** 66/√3 /0.11/√3	66/√3 /0.11/√3
		For tertiary loading (of ICT) application 33/√3 /0.11/√3	33/√3 /0.11/√3
	b) Application	Protection	Metering
	c) Accuracy	3P	0.5
	d) Output Burden (VA) (minimum)	10	10

TABLE-IIA

REQUIREMENTS FOR 800 KV CURRENT TRANSFORMER

No. of Cores.	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANSF DIFF./ LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6	LINE PROTN/LBB PROTN.	3000- 2000- 500/1	-	**PX**	3000/ 2000 500	15/10/2.5	20 on 3000/1 Tap,30 on 2000/1 Tap,120 on 500/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIB

REQUIREMENTS FOR 420 KV CURRENT TRANSFORMER

No. of cores	Core No.	Application	Ratio	Output Burden	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANS. BACK UP/LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6.	TRANS. DIFF. /LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IIC

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	**PX**	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	**PX**	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	**PX**	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	**PX**	1600/ 800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IID

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	2	BUS DIFF MAIN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	3	METERING	800-400/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	5	TRANS. DIFF/LINE PROTN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIE

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	2	BUS DIFF MAIN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; on 300/1 Tap
	3	METERING	300-150/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	5	TRANS. DIFF/LINE PROTN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIF

REQUIREMENTS FOR 72.5 kV CURRENT TRANSFORMER (FOR TERTIARY LOADING OF ICT)

No. of Cores	Core No.	Application	Current Ratio	Output burden (VA)	Accuracy class & ALF
2	1	O/C & E/F	50/1	10	5P10
	2	Metering	50/1	10	0.5

Annexure-I

MAJOR TECHNICAL PARAMETERS FOR CT

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
1	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
2	Rated frequency (Hz)	50	50	50	50	50
3	No. of Poles	1	1	1	1	1
4	Design ambient temperature (°C)	50	50	50	50	50
5	Rated Primary Current (A)	3000	3000	1600	800/600	50
6	Rated extended primary current	120%	120%	120%/150%	120%/150 %	120%
7	Rated short time thermal withstand current	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
8	Rated dynamic current	100kAp/125kAp (as applicable)	100kAp/125kAp/ 157.5kAp (as applicable)	100kAp/125kAp (as applicable)	80kAp	63kAp
9	Temperature rise over design ambient temperature	As per IEC				
10	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground(kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth (kVrms)	5kV				

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813
17	System neutral earthing	Effectively Earthed				

*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CTs.

Annexure-II

MAJOR TECHNICAL PARAMETERS FOR CVT/IVT

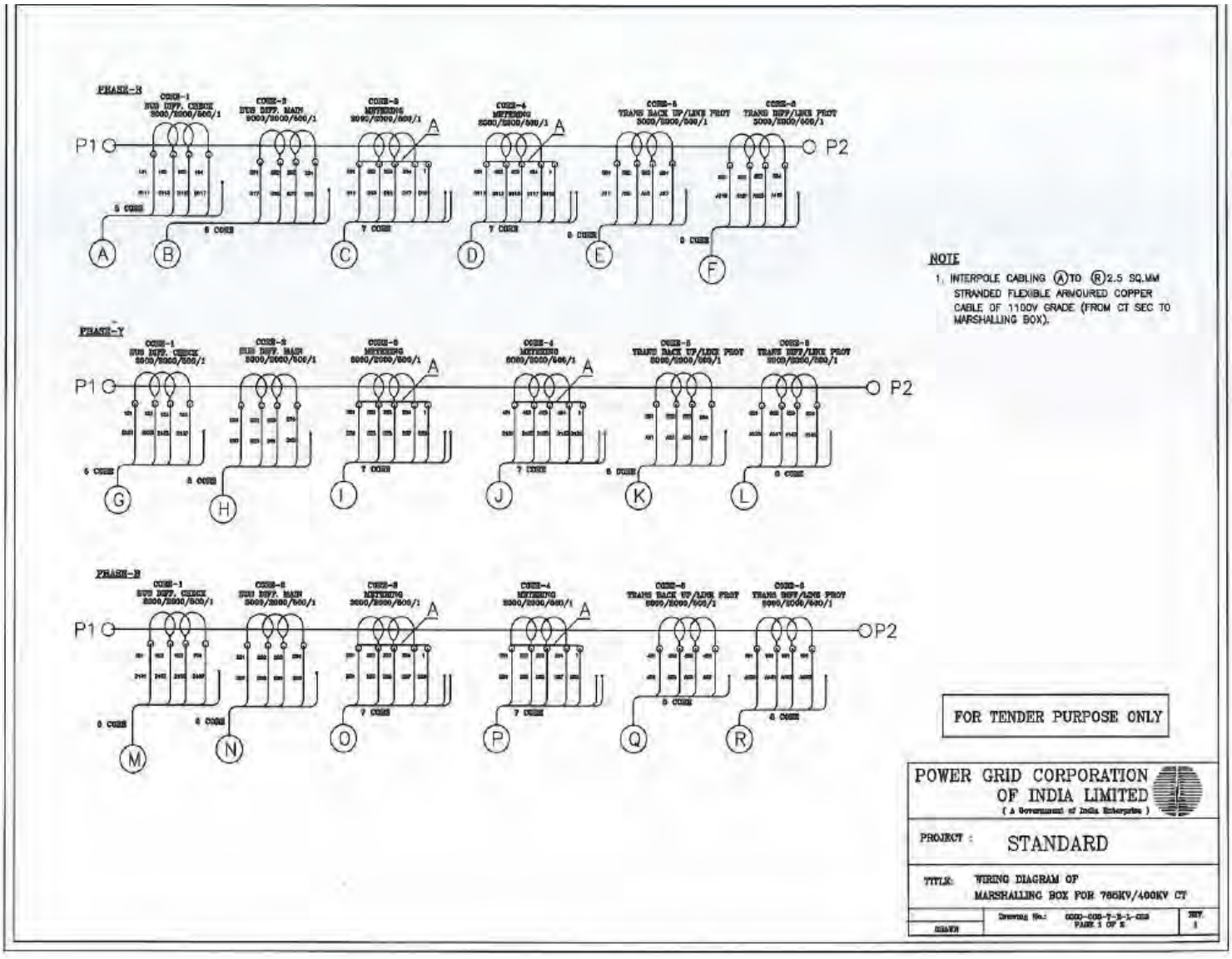
S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
1	Type (CVT/IVT)	**CVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**
2	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
3	Rated frequency (Hz)	50	50	50	50	50
4	No. of Poles	1	1	1	1	1
5	Design ambient temperature (°C)	50	50	50	50	50
6	System fault level (kA)	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
6	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement				
7	High frequency capacitance for entire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance				-
8	Equivalent series resistance over entire carrier frequency range (for CVT)	Less than 40 Ohms				-
9	Stray capacitance and stray conductance of HF terminal over entire carrier frequency range (for CVT)	As per IEC-60358				-
10	Temperature rise over design ambient temperature	As per IEC				
11	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground (kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth					
i)	between LV (HF) terminal and earth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box				
ii)	For secondary winding	3kVrms				
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Rated Total Thermal Burden (VA)	300 VA (100VA/winding)				20VA
17	System neutral earthing	Effectively Earthed				
	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813

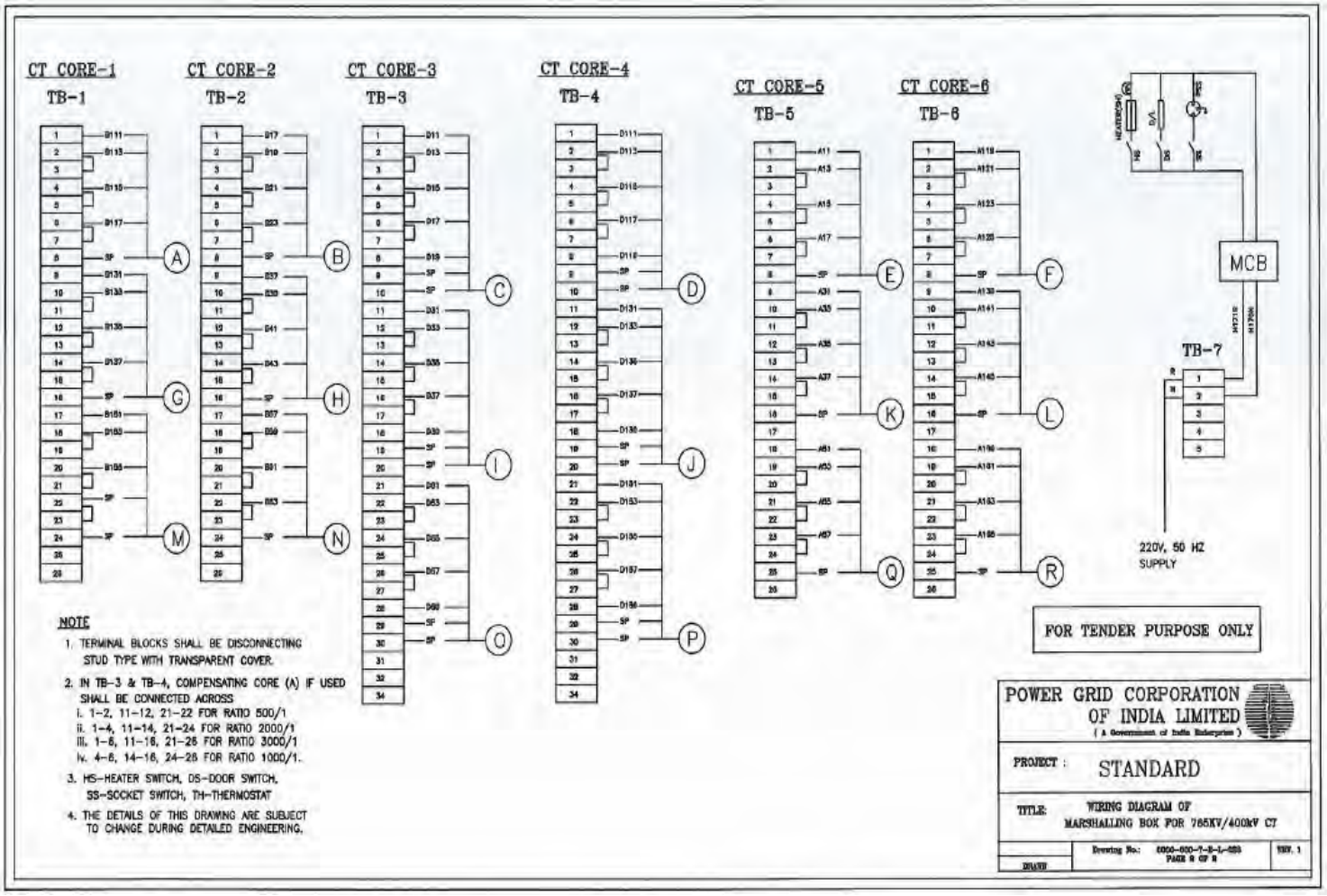
*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CVTs/IVTs.

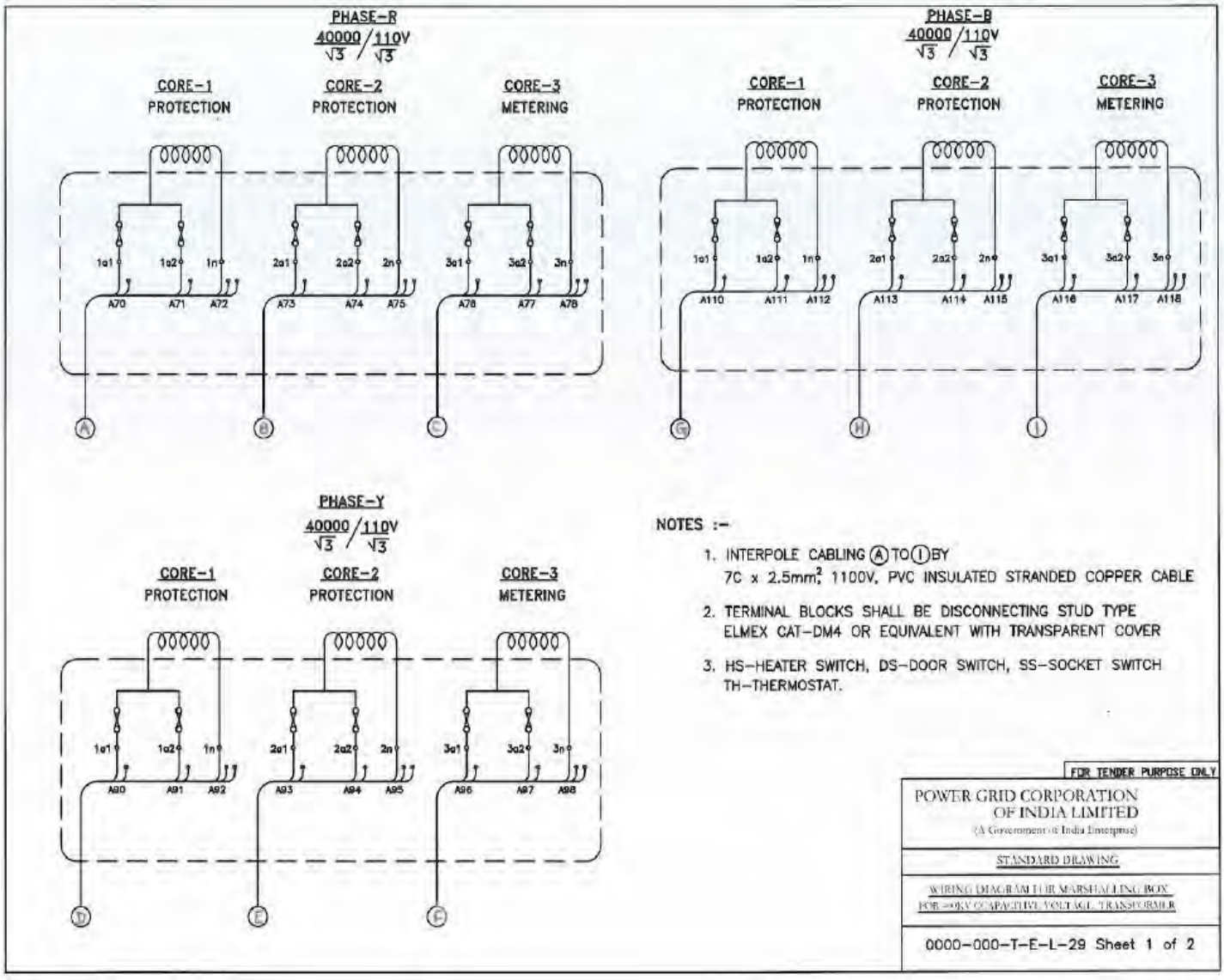
Annexure-III: Wiring Diagram of CT



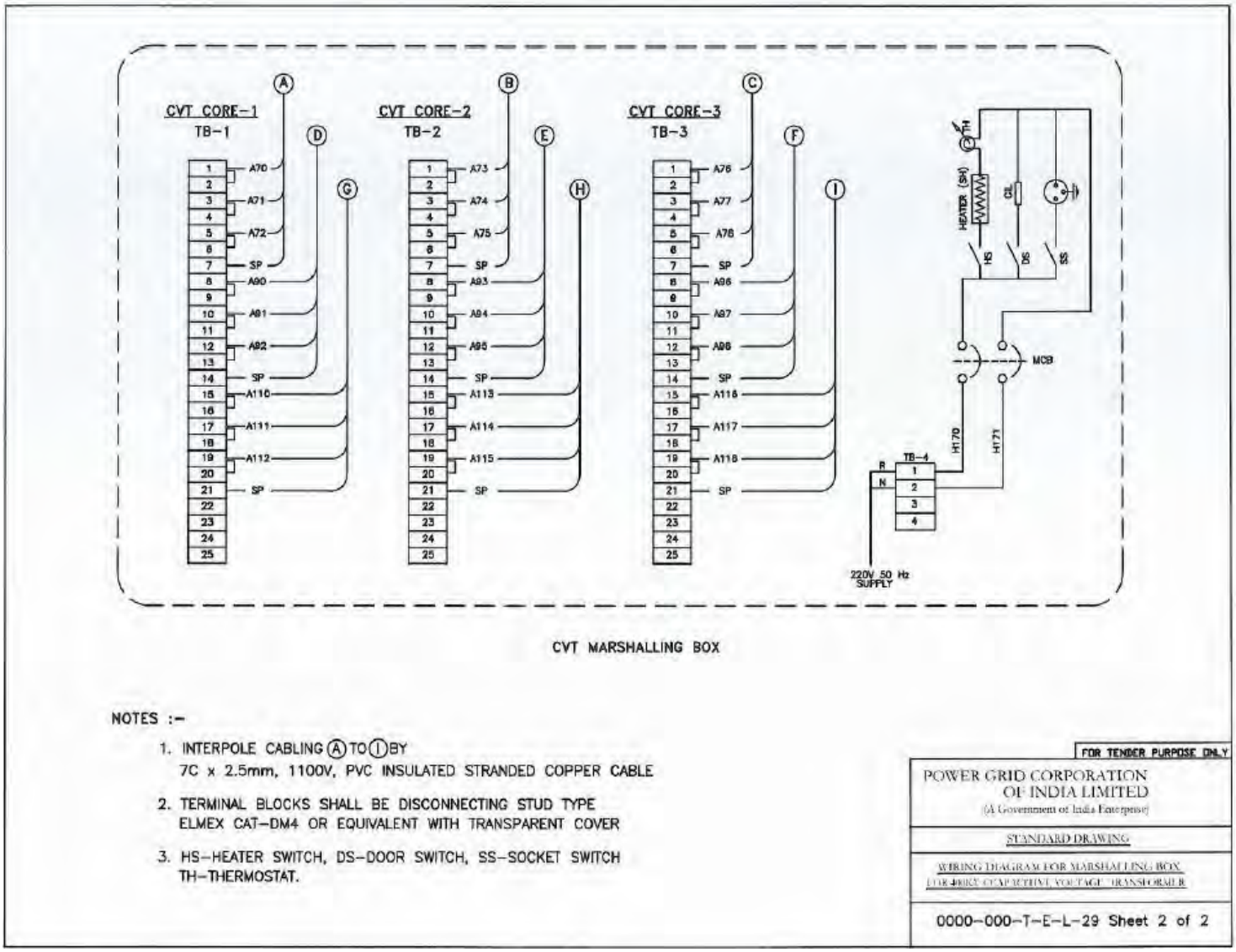
Annexure-III: Wiring Diagram of CT



Annexure-IV: Wiring Diagram of VT



Annexure-IV: Wiring Diagram of VT



NOTES :-

1. INTERPOLE CABLING Ⓐ TO Ⓘ BY 7C x 2.5mm, 1100V, PVC INSULATED STRANDED COPPER CABLE
2. TERMINAL BLOCKS SHALL BE DISCONNECTING STUD TYPE ELMEX CAT-DM4 OR EQUIVALENT WITH TRANSPARENT COVER
3. HS-HEATER SWITCH, DS-DOOR SWITCH, SS-SOCKET SWITCH TH-THERMOSTAT.

FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

STANDARD DRAWING

WIRING DIAGRAM FOR MARSHALLING BOX FOR 400KV CVT/CAPACITIVE VOLTAGE TRANSFORMER

0000-000-T-E-L-29 Sheet 2 of 2

Annexure-V: Actions required in case of defects observed during warrantee period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT (Oil filled)	**DGA Violation** H2 > 300 ppm C2H2> 2 ppm	CT to be **refurbished** or replaced
CT (SF_6 filled)	a) SF6 gas leakage b) High Dew point of SF6 gas (> -36 deg C at atm press)	a)Repair/ replacement b)Re-processing of gas and replacement of Gas in case of no improvement
CT (Oil filled)	**Violation of Tan delta** Tan Delta: >0.5%(during pre-commisioning) >0.7% (in operation) or change w.r.t. to previous **year** value > 0.1%	Replacement of CT
CT & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 **or beyond**	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

MODEL TECHNICAL SPECIFICATION
SECTION: SWITCHGEAR - SURGE ARRESTER
(REV. NO. 12)

Following are the major changes made in the Technical specification, Section-Switchgear - SA, Rev. 12:

Clause No.	Major Modification
1.1, 2.1, 2.4, 2.5 and Annexure-I	As per latest IS 15086 part 4/ IEC 60099-4:2014, new classification of Surge Arresters added. A new concept of arrester classification and energy withstand testing is introduced in line with IEC : line discharge classification is replaced by a classification based on repetitive charge transfer rating (Qrs) as well as on thermal energy rating (Wth) and thermal charge transfer rating (Qth), respectively.
Clause 3	1) Construction features of SA classified into Design A and Design B as per IEC. Design A for 336kV and above SA and Design A/Design B for <336kV SA. 2) Outer insulator of SA shall be either Polymer/Porcelain.
Clause 4.3	Option of PVC insulated flexible copper cable included for Surge monitor connection.
Clause 5.2	Special type tests not specified in IEC 60099-4 /IS are specified and other type tests to be carried out as per latest IEC/IS.
Annexure-I	1) LDC replaced with new arrester classification as per IEC, Minimum discharge capacity replaced with Thermal energy rating, Wth and repetitive charge transfer, Qrs added as new parameter. 2) Insulation withstand data shall be as per IEC 60099-4: 2014 latest edition. 3) Allowable deflection values changed as per cantilever strength. 4) Steep front residual voltage value for 624kV LA updated.

Notes: The above is the list of major changes with respect to previous revision (Rev. 11). However, bidders are advised to read the entire section for other changes and quote accordingly.

Table of Contents

1. GENERAL 3
2. DUTY REQUIREMENTS 3
3. CONSTRUCTIONAL FEATURES 4
4. FITTINGS AND ACCESSORIES 5
5. TESTS 6
6. MANDATORY SPARES 7
7. TECHNICAL PARAMETERS 7
8. PRE-COMMISSIONING TESTS 7
ANNEXURE-I 9

1. GENERAL

1.1. The Surge arresters shall conform to **IS 15086 part 4/IEC: 60099-4 (latest edition)** except to the extent modified in the specification and shall also be in accordance with requirements under Section -GTR.

1.2. The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section- Project.

2. DUTY REQUIREMENTS

2.1. The surge arresters shall be of **Station High Duty (SH) / Station Medium Duty (SM) / Station Low Duty (SL) as per requirement** and gapless type without any series or shunt gaps.

2.2. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

2.3. 420 kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 400kV, 450km long line with Surge impedance of 300 ohms and capacitance of 11.986nF/km and over voltage factor of 2.3 p.u. Similarly, 800kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 765kV, 450km line with Surge impedance of 270 ohms and capacitance of 13 nF/km.

2.4. 420kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 12 kJ/kV for a 420kV system** followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks

575 kVp for 0.1 second

550 kVp for 1 second

475 kVp for 10 seconds

800kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 13 kJ/kV for an 800kV system** followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

1000 kVp for 3 peaks

910 kVp for 0.1 second

885 kVp for 1 second

866 kVp for 10 seconds

2.5. 245/145 kV class arrester shall be capable for discharging energy equivalent **to Station Medium Duty (SM) class of IEC with thermal energy (Wth) of minimum 7 kJ/kV for 245/145 kV system** followed by procedure as per IEC.

2.6. The surge arresters shall be suitable for withstanding forces as defined in Section-GTR.

2.7. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

2.8. The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below: -

Equipment to be protected	Lightning Impulse (kVp) for 800 kV system	Switching surge(kV) for 800 kV system	Lightning impulse(kVp) for 420 kV system	Switching surge(kV) for 420 kV system	Lightning impulse (kVp) for 245 kV system	Lightning Surge (kVp) for 145 kV system
Power transformer	± 1950	± 1550	±1300	±1050	±950	± 550
Reactor	± 1950	± 1550	± 1300	±1050	± 950	± 550
Instrument Transformer	± 2100	±1550	±1425	±1050	± 1050	±650
CB/Isolator Phase to ground	± 2100	± 1550	±1425	±1050	± 1050	± 650
CB/Isolator Across open contacts	± 2100 (-/+457)	± 1140 (-/+653)	±1425 (-/+240)	± 900 (-/+345)	±1050 (for CB) ± 1200 (for Isolator)	± 750 (for Isolator)

2.9. The duty cycle of CB installed in 800/420/245/145 kV System of the Employer shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3. CONSTRUCTIONAL FEATURES

The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

3.1. The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

3.2. **The surge arrester offered shall be of Design A (for 336kV and above SA) and Design A/Design B for <336kV SA.**

a. **Design A type arresters must be** fitted with pressure relief devices suitable for preventing violent failure of insulator housing and providing path for flow of rated fault currents in the event of arrester failure.

b. **Design B arrester should be embedded, all the components free of bubbles and gaps thus preventing partial discharge and moisture ingress. This type of design must have ability to control the cracking or tearing open of housing due to arc action and thereby avoiding violent shattering.**

3.3. **Outer insulator of surge arrester shall be porcelain/polymer conforming to requirements stipulated in Section-GTR.** Terminal connectors shall conform to requirements stipulated under Section-GTR. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester. **Arresters shall not fail due to arrester insulator contamination.**

3.4. Seals **(for design A arresters)** shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

3.5. The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

3.6. The name plate shall conform to the requirements of IEC incorporating the year of manufacture.

3.7. The following details shall be furnished for quality checks:

a. The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.

b. Metalizing coating thickness for reduced resistance between adjacent discs.

3.8. The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

3.9. The sealing arrangement **(for design A arresters)** of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.

3.10. Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on tubular support structures. However, 765 kV Surge Arrester shall be suitable for mounting on lattice type support structures.

3.11. For 624kV Surge arresters, number of stacks shall be three (3). The FRP tube outer diameter shall be 300mm (min) and FRP tube thickness shall be 25mm (min).

4. FITTINGS AND ACCESSORIES

4.1. Arresters shall be complete with insulating base having provision for bolting to flat surface of structure.

4.2. Self contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters should also be provided. The reading of milliammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 Volt (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

4.3. Surge monitor consisting of discharge counters and milliammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard insulating mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall be supplied by the Contractor. The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m (minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area or **PVC insulated flexible copper cable of at least 70 Sqmm.** The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

4.4. Grading/corona rings shall be provided on each complete arrester unit, as required. Suitable terminal connectors shall be supplied by the Contractor.

5. TESTS

5.1. In accordance with the requirements stipulated under Section-GTR, the surge arresters should have been type tested as per **latest IEC/IS** and shall be subjected to routine and acceptance tests in accordance with **latest IEC/IS**.

5.2. Test reports for all type tests **as per latest IS 15086 part4/IEC-60099-4** including following additional type tests shall also be submitted for the Employer's review:

a. Seismic withstand test as per Annexure-B of Section-GTR.

b. Corona Extinction Voltage test as per Annexure-A of Section-GTR.

c. Cantilever test on complete arrester as per requirement of Annexure-I.

5.3. (a) **Acceptance Tests:**

a. Measurement of power frequency reference voltage of the arrester units.

b. Lightning Impulse Residual voltage on arrester units as per IEC.

c. Internal Ionisation or partial Discharge test.

(b) **Special Acceptance Test:**

a. Thermal stability test on three sections as per IEC Clause 9.2.2.

b. Aging test for Zinc oxide blocks is to be carried out on 3 samples for 72 hours at maximum continuous over voltage (MCOV) and at a temperature of 115°C. Acceptance norm being Ir (resistive current)/watt loss shall remain or decrease at the end of 72 hrs from the value taken after 1 hour of start of test.

c. Watt loss test.

(c) **Routine Tests:**

a. Sealing test: Water dip test at 1.5m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).

b. Measurement of reference voltage.

c. Residual voltage test of arrester unit.

d. Internal Ionisation test or partial discharge test.

e. Verticality check on completely assembled Surge arresters as a sample test on each lot.

(d) **Routine Tests on Surge Monitors:**

a. The Surge monitors shall be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/ functional tests with one 100A and 10kA current impulse (8/20 micro sec.) shall also be performed on the Surge monitor.

b. Surge monitors shall be routinely tested for water dip test at 1.5m depth for 30 minutes. No water vapours shall be visible on the monitor glass.

(e) **Routine Tests on insulators**

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

6. MANDATORY SPARES

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

7. TECHNICAL PARAMETERS

The technical parameters shall be as per enclosed Annexure-I.

8. PRE-COMMISSIONING TESTS

8.1. An indicative list of tests is given below:

a. Operation check of LA counters.

b. Insulation resistance measurement

c. Capacitance and Tan delta measurement of individual stacks.

d. Third harmonic resistive current measurement (to be conducted after energisation.)

8.2. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates at his own cost.

8.3. For pre-commissioning procedures and formats for Surge Arresters, Doc.No.: CF/SA/08/R-4 dtd-01/04/2013 under POWERGRID Document no. D-2-01-03-01-04 will be reference document. This document will be available at respective sites and shall be referred by the contractor.

ANNEXURE-I

Technical Parameters for 765kV, 400kV, 220kV and 132kV Surge Arresters (with Polymer/Porcelain Housing)

Sl. No.	Description	Unit	800kV SA	420kV SA	245kV SA	145kV SA
1	Nominal System Operating voltage	kV, rms	765	400	220	132
2	Rated frequency	Hz	50	50	50	50
3	No. of Poles	No.	1	1	1	1
4	Design ambient temperature	℃	50	50	50	50
5	Rated arrester voltage	kV	624	336	216	120
6	Continuous operating voltage at 50 deg.C	kV	490	267	168	102
7	Nominal discharge current		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
8	Discharge current at which insulation co-ordination will be done		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
9	**Rated thermal energy rating Wth**	kJ/kV **of rated arrester voltage**	13kJ/kV	12kJ/kV	**7kJ/kV**	**7kJ/kV**
10	**Repetitive charge transfer rating Qrs in coulombs**	**C**	**3.6C**	**2.4C**	**1.6C**	**1.6C**
11	Max. switching surge residual voltage	kVp	1180 (at 1kA) 1220 (at 2kA)	670(at 2kA) 650 (at 500A)	500 (at 1kA)	280 (at 1kA)
12	Max. residual voltage at					
i)	5kA	kVp	-	-	560	310
ii)	10 kA nominal discharge current	kVp	-	800	600	330
iii)	20 kA nominal discharge current	kVp	1480	850	-	-
iv)	Steep fronted wave residual voltage at 20 kA	kVp	**1650**	925	-	-
13	**Arrester classification**		**Station High duty(SH)**	**Station High duty(SH)**	**Station Medium duty (SM)**	**Station Medium duty(SM)**
14	High current short duration test value(4/10 micro second wave)	kAp	100	100	100	100
15	Current for pressure relief test	kA rms	63	40 / 50 / 63 (as applicable)	40 / 50 (as applicable)	40

Sl. No.	Description	Unit	800kV SA	420kV SA	245kV SA	145kV SA
16	Low current long duration test value		As per IEC			
17	Insulation Level					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	Arrester Housing	kVpeak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
b)	Switching impulse withstand voltage (250/2500 micro-second) dry/wet					
i)	Arrester Housing	kV peak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	-NA-	-NA-
c)	One minute power frequency dry/wet withstand voltage					
i)	Arrester Housing	kV rms	**-N/A-**	**-NA-**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
18	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz. in all positions	micro volts	2500 at 508 kVrms	500 at 266 kVrms	500 at 156 kVrms	500 at 92 kVrms
19	Minimum Creepage distance	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	As per Section-GTR
20	Cantilever Strength (for 1 minute withstand test)	kg	500	350	150	150
21	Maximum deflection at above cantilever load	mm	200	200	**125**	**50**
22	Seismic acceleration		As per IS:1893	As per IS:1893	**---**	**---**
23	Partial Discharge at 1.05 COV		≤ 10pC	≤ 10pC	≤ 10pC	≤ 10pC
24	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

Technical parameters for 72.5kV, 36 kV and 11 kV Surge Arresters (with Porcelain /Polymer Housing)

Sl. No.	Description	Unit	72.5kV SA	36kV SA	12kV SA
1	Nominal System Operating voltage	kV, rms	66kV	33kV	11kV
2	Rated frequency	Hz	50	50	50
3	No. of Poles	No.	1	1	1
4	Design ambient temperature	℃	50	50	50
5	Rated arrester voltage	kV	60	30	9
6	Continuous operating voltage at 50 deg.C	kVrms	51	25	7.2
7	Nominal discharge current	kA	10 kA of 8/20 microsecond wave		
8	Discharge current at which insulation co- ordination will be done	kA	10 kA of 8/20 microsecond wave		
9	**Rated thermal energy rating Wth**	kJ/kV **of rated arrester voltage**	**7**	4	4
10	**Repetitive charge transfer rating Qrs in coulombs**	**C**	**1.6**	**1**	**1**
11	Max. switching surge residual voltage	kVp	136 (at 1kA)	72 (at 1kA)	22.4 (at 1kA)
12	Max. residual voltage at				
i)	5kA	kVp	160	85	26
ii)	10 kA nominal discharge current	kVp	170	90	28
iii)	20 kA nominal discharge current	kVp	190	- -	--
iv)	Steep fronted wave residual voltage at 10 kA	kVp	190	- -	--
13	**Arrester designation**		**Station Medium duty (SM)**	**Station Low duty (SL)**	**Station Low duty (SL)**
14	High current short duration test value(4/10 micro second wave)	kArms	100	100	100
15	Current for pressure relief test	kAp	40	25	25
16	Low current long duration test value		As per IEC		
17	Insulation Level				
a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
i)	Arrester Housing	kVpeak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**

Sl. No.	Description	Unit	72.5kV SA	36kV SA	12kV SA
b)	One minute power frequency dry/wet withstand voltage				
i)	Arrester Housing	kV rms	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
18	Minimum Creepage distance	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR
19	Cantilever Strength (for 1 minute withstand test)	kg	150	150	150
20	Maximum deflection at above cantilever load	mm	**20**	**20**	**20**

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

SECTION: POWER AND CONTROL CABLE

Table of contents

SN	DESCRIPTION	PAGE NO.
1	POWER & CONTROL CABLES [FOR WORKING VOLTAGES UP TO AND INCLUDING 1100V]	2
2	HV POWER CABLES [FOR WORKING VOLTAGES FROM 3.3KV AND INCLUDING 33KV]	7
3	EHV XLPE POWER CABLES [FOR WORKING VOLTAGES FROM 66KV UP TO AND INCLUDING 500KV]	8
4	CABLE DRUMS	9
5	TYPE TESTS	10
	STANDARD TECHNICAL DATASHEETS [UP TO AND INCLUDING 1100V	
	XPLE INSULATED POWER CABLE	Sheet 1 of 3
	PVC INSULATED POWER CABLE	Sheet 2 of 3
	PVC INSULATED CONTROL CABLE	Sheet 3 of 3

SECTION: POWER & CONTROL CABLES

1. POWER & CONTROL CABLES[FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards, ***supply to oil filtration units, DG supply to AC distribution board*** and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 For all control/protection purposes, PVC insulated armoured control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.1.4 POWERGRID has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit ***& looping to other oil filtration units.***	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE

5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	1-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm^2	PVC
9.	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 35 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC
15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current ***(including future bays/load requirement)***, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval. ***The entire power and control cables & special cables (if any) required shall be executed by contractor for completion of present scope of work.***

1.1.6 Cables shall be laid conforming to IS : 1255.

1.1.7 While preparing cable schedules for control/protection purpose, following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 At least one (1) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.10 For control cabling, including CT/VT circuits, 2.5 sq.mm. size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration, additional cores shall be used. Further for potential circuits of energy meters, separate connections by 2 cores of 2.5 sq.mm. size shall be provided.

1.1.11 Standard technical data sheets for cable sizes up to and including 1100V are enclosed at Annexure. Cable sizes shall be offered/manufactured in accordance with parameters specified in standard technical data sheets. Technical data sheet for any other cores/sizes required during detailed engineering shall be separately offered for owner's approval by the contractor/supplier. ***Submission of standard technical data sheets for these cable sizes are not required for approval. Contractor/supplier shall intimate name of proposed approved cable manufacturer along with cable sizes, its quantity required during detailed engineering for purchaser's information and acceptance.***

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

1.2.1.4. The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

1.2.1.5. The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS : 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.2.1.9. All the cables shall pass fire resistance test as per IS:1554 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IS:3961.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. **XLPE Power Cables**

1.2.2.1. The XLPE (90°C) insulated cables shall be of FR type, C1 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.

1.2.3. **PVC Power Cables**

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 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.

1.2.4. **PVC Control Cables**

1.2.4.1. The PVC (70°C) insulated control cables shall be of FR type C1 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.

1.2.4.2. Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of

cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS 1554 (Part-1).

2. HV POWER CABLES[FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

2.1. *HV* POWER CABLE FOR AUXILIARY POWER SUPPLY

(a) The HV cable of 1Cx185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor) of voltage class as specified for 630 kVA ***and 800 kVA*** LT transformer for interconnecting 630kVA ***and 800 kVA*** LT transformer to the SEB feeder shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 61442-1997/IEC60502-4 1998.

(b) The HV cable of 3Cx95 mm^2 (Aluminium Conductor) or 3Cx70mm^2 (Copper Conductor) of voltage class as specified for 250kVA LT transformer for interconnecting 250kVA LT transformer to the SEB feeder shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 61442-1997/IEC60502-4 1998.

2.2. Only overhead connection has been foreseen for interconnecting ***630 kVA and*** 800 kVA, LT transformer to the tertiary of the ICT. However, HV cable connections in place of overhead connection, if necessary shall also be in the scope of contractor. In this case contractor shall provide 1C x 185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor), 38/66kV HV cable along with necessary terminating accessories. The construction of XLPE insulated, armoured HV cable shall be generally conforming to IS 7098 (Part-III). Terminating accessories shall conform to IEC60840 1999.

2.3. Bidder may offer sizes other than the sizes specified in clause 2.1 and 2.2. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

2.4. Constructional Requirements

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound , XLPE insulated, insulation screened with extruded semi conducting compound, ***distinct extruded PVC inner sheath (Type ST-2) with FR properties***, armoured

with non-magnetic material ***for single core cables and galvanized steel wire/strip for multicore cables*** , followed by extruded PVC outer sheath(Type ST-2), with FR properties . ***The armour shall be capable of withstanding rated short time current of conductor***.

2.5 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.6 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

2.7 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3. EHV XLPE POWER CABLE [FOR WORKING VOLTAGES FROM 66 kV UP TO AND INCLUDING 500 kV]

3.1 TECHNICAL REQUIREMENTS

The XLPE insulated, EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/ IEC62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840 / IEC62067 (as applicable).

3.2 The cable shall be of specified EHV grade, single core, unarmoured, stranded compacted Copper conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy ‘E’), metallic screening by concentric layer of plain copper wire followed by an open helix of copper & overall ***HDPE*** sheathed & graphite coated and conforming to the technical particulars of specification.

3.3 The construction of cable shall generally conform to the description mentioned in above mentioned clause of the specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable. The bidder shall enclose with the bid, drawing showing cross section of the cable. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

3.4 The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

3.5 They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

3.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

3.7 The cables shall have outer sheath of ~~a~~ ***HDPE*** material.

3.8 Repaired cables shall not be accepted.

3.9 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

4 CABLE DRUMS

4.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. ***Drums offered shall conform to relevant standards. Drum drawings are not required to be submitted for approval.***

4.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number non standard length of cable size(s) may be supplied in drums for completion of project.

4.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

4.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

4.5 Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

4.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

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

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.

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).

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.

5.4 ***XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)-***

5.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for XLPE insulated HV power cables (as per IS 7098 Part-II including its amendment or as per IEC).

5.5 ***XLPE INSULATED EHV POWER CABLES (For working voltages from 66kV up to and including 500 kV)-***

5.5.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for XLPE insulated EHV cables (as per IEC60840 for cables up to 150 kV & IEC 62067 for cables above 150 kV).

5.6 TERMINATING & JOINTING ACCESSORIES-

5.6.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Terminating/jointing accessories as per IS 17573:1992/ IEC 60840:1999/ IEC62067.

1401648/2023/TBG-TB_HVDC

STANDARD TECHNICAL DATA SHEET
(1.1 kV GRADE XLPE POWER CABLES)

SN	CUSTOMER :	POWERGRID CORPORATION OF INDIA LIMITED	
	Name of manufacturer :	As per approved list	
	Cable Sizes	1 C x 630	3½ C x 300
1	Manufacturer's type designation	: A2XWaY	A2XWY
2	Applicable standard	: ----------IS: 7098/PT-I/1988 & its referred specifications----------	
3	Rated Voltage(volts)	: ----------1100 V grade----------	
4	Type & Category	: FR & C1	FR & C1
5	Suitable for earthed or unearthed system	: ----------for both----------	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	: 732	410
7	Rating factors applicable to the current ratings for various conditions of installation:	: ----------As per IS-3961-Pt-II-67----------	
8	Short circuit Capacity		
	a) Guranteed Short Circuit Amp. (rms)KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA.	: 45 KA	45 KA
	b) Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above.	: ----------250 °C----------	
9	Conductor		
	a) Material	Stranded Aluminium as per Class 2 of IS : 8130	
	b) Grade	: ---------- H 2 (Electrolytic grade) ----------	
	c) Cross Section area (Sq.mm.)	: 630	300/150
	d) Number of wires(No.)minimum	: 53	30/15
	e) Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
	f) Direction of lay of stranded layers	: -------- Outermost layer shall be R.H lay & opposite in successive layers --------	
10	Conductor resistance (DC) at 20°C per km-maximum	0.0469	0.1 / 0.206
11	Insulation		
	a) Composition of insulation	: ----------Extruded XLPE as per IS-7098 Part(1)----------	
	b) Nominal thickness of insulation(mm)	: 2.8	1.8/1.4
	c) Minimum thickness of insulation	: 2.42	1.52/1.16
12	Inner Sheath		
	a) Material	: ----------Extruded PVC type ST-2 as per IS-5831-84----------	
	b) Calculated diameter over the laid up cores,(mm)	: NA	52
	c) Thickness of Sheath (minimum)mm	: N.A	0.6
	d) Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
	a) Type and material of armour	: Al. Wire[H4 grade]	Gal. Steel wire
	b) Direction of armouring	: ----------left hand----------	
	c) Calculated diameter of cable over inner sheath (under armour), mm	: 33.9	53.2
	d)Nominal diameter of round armour wire (minimum)	: 2	2.5
	e)Guranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45 KA	45 KA
	f) DC resistance at 20°C (Ω/Km)	$	0.577
14	Outer Sheath		
	a) Material (PVC Type)	: ST-2& FR	ST-2& FR
	b) Calculated diameter under the sheath	: 38.3	59.50
	c) Min.thickness of sheath(mm)	: 1.72	2.36
	d) Guaranteed value of minimum oxygen index of outer sheath at 27 °C	Min 29.0	Min 29.0
	e) Guranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250
	f) colour of sheath	: Black	Black
15	a) Nominal Overall diameter of cable	$	$
	b) Tolerance on overall diameter (mm)	: ----------+2/-2 mm----------	
16	Cable Drums	: ---------- shall conform to IS 10418 and technical specification	
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500
	b) Non standard drum lengths	: Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).	
17	Whether progressive sequential marking on outer sheath provided at 1 meter interval	: ---------- YES ----------	
18	Identification of cores		
	a) colour of cores	As per IS 7098 Part(1)	
	b) Numbering	: ---------- N.A ----------	
19	Whether Cables offered are ISI marked	: ---------- YES ----------	
20	Whether Cables offered are suitable for laying as per IS 1255	: ---------- YES ----------	

$'- As per manufacturer design data

1401648/2023/TBG-TB_HVDC

STANDARD TECHNICAL DATA SHEET
(1.1 kV GRADE PVC POWER CABLES)

SN							
	CUSTOMER :	**POWERGRID CORPORATION OF INDIA LIMITED**					
	Name of manufacturer :	**As per approved list**					
	Cable Sizes	**1 c x 150**	**3.5 cx 70**	**3.5 cx 35**	**4 c x 16**	**4c x 6**	**2 c x 6**
1	Manufacturer's type designation	: AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	: ---------- ----------IS: 1554/PT-I/1988 & its referred standards----------					
3	Rated Voltage(volts)	: ----------1100 V grade----------					
4	Type & Category	: FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	: ----------for both----------					
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	: 202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	: x----------As per IS-3961-Pt-II-67----------					
8	Short circuit Capacity						
	a) Short Circuit Amp. (rms)KA for 1 sec duration	: 11.2	5.22	2.61	1.19	0.448	0.448
	b) Conductor temp. allowed for the short circuit duty (deg C.)	: ----------160 °C----------					
9	Conductor						
	a) Material	: ----------STRANDED ALUMINIUM ----------					
	b) Grade	: ---------- H 2 (Electrolytic grade) ----------					
	c) Cross Section area (Sq.mm.)	: 150	M-70 N-35	M-35 N-16	16	6	6
	d) Number of wires(No.)	: ---------- as per Table 2 of IS 8130 ----------					
	e) Form of Conductor	Non-compacted Standed circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Standed circular	Non-compacted Standed circular
	f) Direction of lay of stranded layers	: -------- Outermost layer shall be R.H lay & opposite in successive layers --------					
10	Conductor resistance (DC) at 20 °C per km-maximum	0.206	0.443/ 0.868	0.868/ 1.91	1.91	4.61	4.61
11	Insulation						
	a) Composition of insulation	: ----------Extruded PVC type A as per IS-5831-84----------					
	b) Nominal thickness of insulation(mm)	: 2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
	c) Minimum thickness of insulation	: 1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
	a) Material	: ----------Extruded PVC type ST-I as per IS-5831-84----------					
	b) Calculated diameter over the laid up cores,(mm)	: N.A	27.6	20.4	15.7	11.6	9.6
	c) Thickness of Sheath (minimum)mm	: N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	: ---------- as per IS 3975/88 ----------					
	a) Type and material of armour	: Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal. Steel wire	Gal. Steel wire
	b) Direction of armouring	: ----------left hand----------					
	c) Calculated diameter of cable over inner sheath (under armour), mm	: 18	28.4	21	16.3	12.2	10.2
	d) Nominal diameter of round armour wire/strip	: 1.6	4 x 0.8	4 x 0.8	4 x 0.8	1.4	1.4
	e) Number of armour wires/strips	: ----------Armouring shall be as close as practicable----------					
	f) Short circuit capacity of the armour along for 1 sec-for info only	: --K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
	g) DC resistance at 20 °C (Ω/Km)	: 0.44	2.57	3.38	3.99	3.76	4.4
14	Outer Sheath						
	a) Material (PVC Type)	: ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
	b) Calculated diameter under the sheath	: 21.2	30.1	22.6	17.9	15	13
	c) Min.thickness of sheath(mm)	: 1.4	1.56	1.4	1.4	1.4	1.24
	d) Guaranteed value of minimum oxygen index of outer sheath at 27°C	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
	e) Guranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
	f) colour of sheath	: Black	Black	Black	Black	Black	Black
15	a) Overall diameter of cable	;----------$----------					
	b) Tolerance on overall diameter (mm)	: ----------+2/-2 mm----------					
16	Cable Drums	: ---------- shall conform to IS 10418 and technical specification					
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
	b) Non standard drum lengths	: Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).					
17	Whether progressive sequential marking on outer sheath provided	: ---------- YES ----------					
18	Identification of cores						
	a) colour of cores	Red	R,Y,Bl &Bk	R,Y,Bl &Bk	R,Y,Bl &Bk	R,Y,Bl &Bk	Red & Bk
	b) Numbering	: ---------- N.A ----------					
19	Whether Cables offered are ISI marked	: ---------- YES ----------					
20	Whether Cables offered are suitable for laying as per IS 1255	: ---------- YES ----------					

$'- As per manufacturer design data

1401648/2023/TBG-TB_HVDC

TECHNICAL DATA SHEET
(1.1 kV GRADE PVC CONTROL CABLES)

	CUSTOMER :	**POWERGRID CORPORATION OF INDIA LIMITED**							
SN	**Name of manufacturer :**	**As per approved list**							
	Cable Sizes	**2c x 2.5**	**3c x 2.5**	**5c x 2.5**	**7c x 2.5**	**10c x 2.5**	**14c x 2.5**	**19c x 2.5**	**27c x 2.5**
1	**Manufacturer's type designation**	**YWY**	**YWY**	**YWY**	**YWY**	**YWY**	**YWY**	**YWY**	**YWY**
2	**Applicable standard**	**----------IS: 1554/PT-I/1988 & its referred standards----------**							
3	**Rated Voltage(volts)**	**----------1100----------**							
4	**Type & Category**	**----------FR & C1----------**							
5	**Suitable for earthed or unearthed system**	**----------for both----------**							
6	**Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70°C of PVC Cables[For information only]**	**22**	**19**	**19**	**14**	**12**	**10.5**	**9.7**	**8**
7	**Rating factors applicable to the current ratings for various conditions of installation:**	**----------As per IS-3961-Pt-II-67----------**							
8	**Short circuit Capacity**								
	a) Short Circuit Amp. (rms)KA for 1 sec-for information only	**0.285**	**0.285**	**0.285**	**0.285**	**0.285**	**0.285**	**0.285**	**0.285**
	b) Conductor temp. allowed for the short circuit duty (deg C.)	**----------160 °C----------**							
9	**Conductor**								
	a) Material	**---------- Plain annealed High Conductivity stranded Copper (as per IS 8130/84) -----**							
	b) Grade	**---------- Electrolytic----------**							
	c) Cross Section area (Sq.mm.)	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**
	d) Number of wires(No.)	**---------- as per Table 2 of IS 8130 ----------**							
	e) Form of Conductor	**----------Non-Compacted stranded circular conductor---------**							
	f) Direction of lay of stranded layers	**---------- Outermost layer shall be R.H lay ----------**							
10	**Conductor resistance (DC) at 20 °C per km(maxm)**	**7.41**	**7.41**	**7.41**	**7.41**	**7.41**	**7.41**	**7.41**	**7.41**
11	**Insulation**								
	a) Composition of insulation	**----------Extruded PVC type A as per IS-5831-84----------**							
	b) Nominal thickness of insulation(mm)	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**
	c) Minimum thickness of insulation	**0.71**	**0.71**	**0.71**	**0.71**	**0.71**	**0.71**	**0.71**	**0.71**
12	**Inner Sheath**								
	a) Material	**----------Extruded PVC type ST-I as per IS-5831-84----------**							
	b) Calculated diameter over the laid up cores,(mm)	**7.2**	**7.8**	**9.7**	**10.8**	**14.4**	**15.9**	**18**	**22.1**
	c) Thickness of Sheath (minimum)mm	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**
13	**Armour**	**---------- as per IS 3975/99 ----------**							
	a) Type and material of armour	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**	**Gal. Steel wire**
	b) Direction of armouring	**----------left land----------**							
	c) Calculated diameter of cable over inner sheath (under armour), mm	**7.8**	**8.4**	**10.3**	**11.4**	**15**	**16.5**	**18.6**	**22.7**
	d) Nominal diameter of round armour wire / dimensions of armour strip	**1.4**	**1.4**	**1.4**	**1.4**	**1.6**	**1.6**	**1.6**	**1.6**
	e) Number of armour wires	**----------Armouring shall be as close as practicable----------**							
	f) Short circuit capacity of the armour and duration-for info only	**--0.05 x A$\sqrt{t}$ (K Amp)(where A = total area of armour in mm^2& t = time in seconds)----**							
	g) DC resistance at 20 °C (Ω/Km) & Resistivity of armour	**----------As per IS 1554 Part(1), whereever applicable & IS 3975-1999----------**							
14	**Outer Sheath**								
	a) Material (PVC Type)	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**	**ST-1& FR**
	b) Calculated diameter under the sheath	**10.6**	**11.2**	**13.1**	**14.2**	**18.2**	**19.7**	**21.8**	**25.9**
	c) Min.thickness of sheath(mm)	**1.24**	**1.24**	**1.24**	**1.24**	**1.4**	**1.4**	**1.4**	**1.56**
	d) Guaranteed value of minimum oxygen index of outer sheath	**Min 29.0**	**Min 29.0**	**Min 29.0**	**Min 29.0**	**Min 29.0**	**Min 29.0**	**Min 29.0**	**Min 29.0**
	e) Guranteed value of minimum temperature index at 21 oxygen index	**Min 250**	**Min 250**	**Min 250**	**Min 250**	**Min 250**	**Min 250**	**Min 250**	**Min 250**
	f) colour of sheath	**Grey**	**Grey**	**Grey**	**Grey**	**Grey**	**Grey**	**Grey**	**Grey**
15	**a) Overall diameter of cable**	**$**							
	b) Tolerance on overall diameter (mm)	**----------+2/-2 mm----------**							
16	**Cable Drums**	**---------- shall conform to IS 10418 and technical specification**							
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	**1000/500**	**1000/500**	**1000/500**	**1000/500**	**1000/500**	**1000/500**	**1000/500**	**1000/500**
	b) Non standard drum lengths	**Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).**							
17	**Whether progressive sequential marking on outer sheath provided**	**---------- YES ----------**							
18	**Identification of cores**								
	a) colour of cores	**R & Bk**	**R,Y &Bl**	**:,Y,Bl,Bk&(**	**Grey**	**Grey**	**Grey**	**Grey**	**Grey**
	b) Numbering	**N.A.**	**N.A.**	**N.A.**	**Numerals in black ink**	**Numerals in black ink**	**Numerals in black ink**	**Numerals in black ink**	**Numerals in black ink**
19	**Whether Cables offered are ISI marked**	**---------- YES ----------**							
20	**Whether Cables offered are suitable for laying as per IS 1255**	**---------- YES ----------**							

$'- As per manufacturer design data

Technical Specification

SECTION- SHUNT REACTOR UPTO 400kV, NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

REV 11

JUNE'2021

1401648/2023/TBG-TB_HVDC

Major changes in the latest Technical Specification Section – Shunt Reactor 400kV, Neutral Grounding Reactor and Surge Arrester REV 11

Sr. No.	Clause	Brief Description of Major Changes
1.	1.2,1.3, 1.4	*New clause added*
2.	3.3, 3.5, 3.6	*Clause modified*
3.	4.7	*New clause added*
4.	6.1, 6.2, 6.4, 7.1.6, 7.1.7, 7.1.8, 7.1.9,	*Clause modified*
5.	7.1.10	*New clause added*
6.	7.2.3, 7.3, 7.4, 7.5.1, 7.6.3, 7.8, 7.9, 7.10, 7.11, 7.12, 7.14.4, 7.17, 7.18.2, 7.19.1, 7.19.2, 7.19.3, 7.19.9, 7.19.13,	*Clause modified*
7.	7.19.14	*New clause added*
8.	9, 9.1, 11.2, 11.4,11.14, 11.15, 13.3, 13.4, 14.6, 14.7.1, 14.9, 15, 16.3, 17, 18.1, 22, 23.1	*Clause revised.*
9.	Annexure-A	*Reactor Technical parameters revised*
10.	Annexure-I	*Cable specification revised.*
11.	Annexure-L	*On-line insulating oil drying system included with each Reactor*
12.	-	*Optical Temperature Sensors & Measuring Unit deleted*

Disclaimer:

Major changes are listed above. However, for details of all major and minor modifications, please refer the complete technical specification Section - Shunt Reactor 400kV, Neutral Grounding Reactor and Surge Arrester REV 11.

SECTION- SHUNT REACTOR (UPTO 400kV), NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

Clause No.	Description
1.	General
2.	Type of Reactor
3.	Transportation
4.	Performance
5.	Measurable Defects
6.	Design review
7.	Construction Details
8.	Paint system and procedures
9.	Unused inhibited Insulating Oil
10.	Spare Reactor Units Storage & Connection Arrangement
11.	Bushings
12.	Neutral Formation and Earthing Arrangement
13.	Cooling Equipment
14.	Valves
15.	Cabling
16.	Individual Marshalling Box and Common Marshalling Box
17.	SCADA Integration
18.	Current Transformer
19.	Surge Arrester
20.	Hand Tools
21.	Test Kit
22.	Fittings
23.	Inspection & Testing
Annexure –A	Technical Particulars / Parameters of Reactors & NGR
Annexure –B	Test Plan
Annexure –C	Reference Drawings
Annexure –D	Design Review Document
Annexure –E	Painting Procedure
Annexure –F	Unused inhibited Insulating Oil Parameters
Annexure –G	Technical Parameters of Current Transformers
Annexure –H	Gapless Surge Arrester – Technical parameters
Annexure –I	Cable specification
Annexure –J	Oil BDV Test Set & Portable Dissolved Gas Analysis of Oil
Annexure –K	Online Dissolved Gas (Multi-gas) and Moisture Analyser
Annexure –L	Online Hydrogen And Moisture Measurement Equipment
Annexure –M	On-Line Insulating Oil Drying System (Cartridge Type)
Annexure –N	Nitrogen Injection Type Fire Prevention & Extinguishing System
Annexure –O	Oil sampling bottles & Oil Syringe
Annexure –P	Oil Storage Tank
Annexure –Q	Spare Reactor Units Storage & Connection Arrangement
Annexure– R	Standard dimensions for lower portion of condenser bushings
Annexure- S	Standard Test Procedure of Transformer & Reactor

TECHNICAL SPECIFICATION FOR SHUNT REACTOR (UPTO 400kV), NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

1. General

1.1. This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The Reactor 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. If the IS standard is not available, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted.

1.3. Any material and equipment not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

1.4. Components having identical rating shall be interchangeable.

2. Type of Reactor

The shunt reactor shall be of either gapped core type or magnetically shielded air core type (shell type) construction. The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

i) Adopting single phase construction in separate tanks.
ii) Adopting 5 limb core construction, for 3-Phase

In case of coreless construction following requirements are stipulated.

i) A magnetic shield shall be provided around the coreless coils.
ii) Non-magnetic material sheet shall form the central core to minimize the vibrations.

The neutral grounding reactors are required for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value.

3. Transportation

3.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Reactor for all the stages from the manufacturer’s work to site.

3.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of reactor and based on route survey, any

modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

3.3. The inland transportation of the reactor unit shall be on trailer equipped with GPS system for tracking the location of Reactor at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Reactor. The requisite details for tracking the Reactor during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

3.4. All metal blanking plates and covers, which are specifically required to transport the reactor, shall be considered part of the reactor and handed over to the Employer after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

3.5. The Contractor shall despatch the Reactor filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

In case, turrets are having insulation assembly and is transported separately then the same shall also be filled with dry air.

3.6. The Reactor shall also be fitted with atleast 2 numbers of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed“3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

4. Performance

4.1. Shunt Reactors will be connected to the transmission system for reactive compensation and shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.

4.2. The reactors shall be designed for switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u. voltage.

4.3. Shunt Reactors of 420kV Class shall be capable of operating continuously at a voltage 5% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.4. Shunt Reactors of 245kV Class and below shall be capable of operating continuously at a voltage 10% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.5. The reactor shall be designed to withstand the following over-voltages repeatedly without risk of failure (w.r.t. Hotspot temperature & core saturation):

1.05 Ur for continuous (for 420kV Class Reactor)
1.10 Ur for continuous (for below 420kV Class Reactor)
1.25 Ur for 1 minute
1.50 Ur for 5 seconds

4.6. The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

4.7. Also, the most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

4.8. Tank hotspot temperature under over voltage condition specified above shall not exceed 110 Deg C considering maximum ambient temperature as 50 Deg C.

4.9. The magnetic circuit will be designed such that the reactor is linear upto voltage specified at **Annexure – A**.

4.10. **Radio Interference and Noise Level**

4.10.1. The reactor shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

4.10.2. The noise level of reactor, when energised at rated voltage and frequency shall not exceed the values specified at **Annexure-A** measured under standard conditions.

5. Measurable Defects

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Reactor either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are given below:

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding Tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta

a) The moisture content goes above 12 ppm at any temperature during operation.

6. Design review

6.1. The reactor shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin w.r.t. thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. The scope of such design review shall include but not limited to the requirement as mentioned at Annexure – D.

6.2. Design reviews shall be conducted by Employer or by an appointed consultant during the procurement process for Reactors; however the entire responsibility of design shall be with the manufacturer. Employer may also visit the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with the successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor under the scope of this specification. It shall be conducted generally following the ““CIGRE TB 529: Guidelines for conducting design reviews for power transformers”.

6.3. The manufacturer shall provide all necessary information and calculations to demonstrate that the reactor meets the requirements for mechanical strength and durability due to inrush current. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

6.4. **Type test requirement & it’s validity**

The offered Reactor or the Reactor, the design of which is similar to the offered Reactor, should have been successfully type tested. Manufacturer may use same or different approved make of Bushings and other accessories used in type tested or short circuit tested unit in their Reactor. Further, type test report of Reactor shall only be acceptable provided the offered Reactor has been manufactured from the same plant. The Reactor Type test validity period shall be as per Technical Specification Section-General Technical Requirement (GTR).

Central Electricity Authority’s “Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission system” shall be followed regarding the validity of type tests of Bushings and other accessories.

7. Construction Details

The construction details and features of each Shunt Reactor shall be in accordance with the requirement stated hereunder.

7.1. **Tank**

7.1.1. Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with IS 2062.

7.1.2. All seams and those joints not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of IS 10801.

7.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

7.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld spatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

7.1.5. The tank shall be designed in such a way that it can be mounted on the plinth directly.

7.1.6. The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails and the base plate shall have following minimum thickness:

Length of tank (m)	Minimum plate thickness (mm)
Flat bases	
over 2.5m but less than 5m	20
over 5m but less than 7.5m	26
exceed 7.5m	32

7.1.7. The hotspot temperature in any location of the tank shall not exceed 110 degree Celsius at max. continuous operating voltage. This shall be measured during temperature rise test at manufacturer’s works.

7.1.8. Tank shall be capable of withstanding, without damage, severe strains that may be induced under normal operating conditions or forces encountered during lifting, jacking and pulling during shipping and handling at site or factory. Tank, tank cover and associated structure should be adequately designed to withstand, without damage or permanent deflection / deformation, the forces arising out of normal oil pressure, test pressures, vacuum, seismic conditions and short circuit forces specified.

7.1.9. Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

7.1.10. All pipes connected to Reactor shall follow IS 1239.

7.1.11. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete Reactor when filled with oil without structural damage to any part of the Reactor. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the Reactor complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the Reactor filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. Suitable provision (valves, etc.) as required for installation of Nitrogen Injection Fire Protection System in Reactor shall be provided.

e. 04 nos. of Gate valves for UHF sensors for PD Measurements (applicable for 420kV Reactor only) at various locations. Location of valves shall be finalized during design review.

7.1.12. The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails.

7.2. **Tank Cover**

7.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

7.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

7.2.3. The tank cover shall be provided with pockets for OTI, WTI and RTDs including 2 spare pockets. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

7.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

7.2.5. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression

7.2.6. **Currents flowing in tank cover and bushing turrets** - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the Reactor in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

7.2.7. The Reactor shall be provided with a 100 mm nominal diameter butterfly valve and bolted blanking plate, gasket and shall be fitted at the highest point of the Reactor for maintaining vacuum in the tank.

7.2.8. **Gas venting** - The reactor cover, and generally the internal spaces of the reactor and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the reactor to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the Reactor is being mounted.

7.3. **Gasket for tank & cover**

All gasketed joints in contact with oil shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

All tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) Material selected shall suit temperature conditions expected to be encountered. Neoprene / cork sheets gaskets are not acceptable. The Gaskets and O-rings shall be replaced every time whenever the joints are opened.

7.4. **Foundation, Roller Assembly & Anti Earthquake Clamping Device**

The Reactor shall be placed directly on concrete plinth foundation. To facilitate the movement of reactor to its foundation over rail track, bi-directional flanged rollers shall be provided. It shall be suitable for fixing to the under carriage of Reactor. The rail track gauge shall be 1676 mm. Two rails shall be provided as per the drawing mentioned at **Annexure-C.**

Scope shall include supply of complete two sets of rollers assembly for movement of Reactors over rail track for each substation in case scope covers more than one Reactor per sub-station under the package. Otherwise, atleast one set shall be supplied.

Foundation bolts and other locking devices shall be in the scope of contractor.

Regarding cooler pipe supports, Buchholz pipe (if required) and fire-fighting pipe supports shall be fixed on concrete block through Anchor Fastener with chemical grouting and no pockets for bolting shall be provided.

All control cubicles shall be mounted at least one meter above FGL (Finished Ground Level) to take care of water logging (if any) during flooding. Suitable arrangement (ladder and platform) shall be provided for safe access to control cubicles.

All fittings (Foundation bolts, supports, embedded plates if any) including anchor fastener with chemical grouting are in the scope of contractor.

7.5. **Conservator**

7.5.1. Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay

7.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the reactor and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the reactor shall be able to carry the specified overload without overflowing of oil.

7.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

7.5.4. Conservator shall be positioned so as not to obstruct any electrical connection to Reactor.

7.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the Reactor is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The Reactor rating and diagram plate shall bear a warning statement that the **"Conservator is fitted with an air cell".**

7.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to $110^{O}C$ during operation. As such air cell used shall be suitable for operating continuously at this temperature.

7.5.7. The reactor manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

7.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

7.5.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough that the oil will not become saturated with oxygen before 10 years. Air cells with well proven long life characteristics shall be preferred.

7.6. **Piping works for conservator**

7.6.1. Pipe work connections shall be of adequate size for their duty and possibly short and direct. Only radiused elbows shall be used.

7.6.2. The feed pipe to the Reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80 mm for reactor. Gas-venting pipes shall be connected to the final rising pipe between the reactor and Buchholz relay as near as possible in axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

7.6.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm.

7.6.4. A double flange valve of preferably 50 mm size shall be provided to fully drain the oil from the main tank conservator.

7.6.5. Pipe work shall neither obstruct the removal of the opening of inspection or manhole covers.

7.7. **Dehydrating Silicagel Filter Breather**

Conservator shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers having a mass less than 10 kg may be supported by the connecting pipe, whereas units of 10 kg and above shall be supported independent of the connecting pipe. Connecting pipes shall be securely cleated to the reactor, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. In the case where a breather of less than 10 kg is supported by the pipe, there shall be a cleat directly above the breather flange. It shall be so designed that:

a) Passage of air is through silicagel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.
f) Two breathers (each of 2.5 litres minimum volume) shall be connected in series for NGR tank conservator

7.8. **Pressure Relief Device**

One PRD of 150 mm Diameter is required for every 30000 Litres of oil. However, at least two numbers PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to bushing turret or cover. PRD operating pressure selected shall be verified during design review. PRD shall be provided with special shroud to direct the hot oil in case of fault condition. It shall be provided with an outlet pipe which shall be taken right up to the soak pit of the reactor. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating

position to avoid injury to personnel in the event of PRD operation. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

7.9. **Sudden Pressure Relay**

One number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement**) shall be provided on tank of Reactor. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.

7.10. **Buchholz Relay**

One number Double float, reed type Buchholz relay complying to IS 3637 shall be provided in the connecting pipe between the oil conservator and the Reactor tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Reactor shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Reactor in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable is not acceptable at site.

It should be possible to inspect Buchholz relay or Oil surge relay, standing on tank cover and suitable arrangement shall be made to access Buchholz relay safely.

The Buchholz relay shall not operate during starting/stopping of the Reactor oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the Reactor during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

7.11. **Oil Temperature Indicator (OTI)**

All Reactors shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication with angular sweep of 270°. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI instrument by means of flexible capillary tubing with stainless-steel armoured. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. The setting of alarm and tripping contacts shall be adjustable at site. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947/IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with Pt100 sensor

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IS/IEC 61850 compliant communications.

7.12. Winding Temperature Indicator (WTI)

All Reactor shall be provided with a device for measuring the hot spot temperature of winding with dial type thermometer of 150 mm diameter for winding temperature indication with angular sweep of 270°and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. The setting of alarm and tripping contacts shall be adjustable at site. A temperature sensing bulb located in a thermometer pocket on tank cover should be provided to sense top oil. This shall be connected to the WTI instrument by means of flexible capillary tubing with stainless-steel armoured. WTI shall have image coil and auxiliary CTs, if required to match the image coil, shall be mounted in the Marshalling Box / cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2^0C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947 /IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of winding temperature:

Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IS / IEC 61850 compliant communications.

7.13. The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

7.14. **Earthing Terminals**

7.14.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

7.14.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/etc double earthing shall be provided through the tank for which provision shall be made on the tank and connected through two flexible insulated copper link.

7.14.3. To allow for the effect of possible induced and capacitive surge current, good electrical connection is maintained between the tank and turrets. Equi-potential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc connected to tank shall also be provided with equipotential flexible copper link.

7.14.4. Each Reactor unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, line Terminals shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above. 1.1kV Grade PVC FR type cable of 16 sq.mm (minimum) shall be used for above connection. Neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

7.15. **Core**

7.15.1. The core shall be constructed from non-ageing, cold rolled grain oriented silicon steel laminations of conventional grade (as per BIS) / regular grade (as per IEC) or better. Indian reactor manufacturers shall use core material as per above specification with BIS certification.

7.15.2. The leg magnetic packets (cheeses) shall be made from state of the art low loss electrical steel CRGO (conventional/regular grade or better). The "Cheeses" shall be designed to minimize losses and equalize the distribution of flux in the legs.

7.15.3. The "cheeses" shall be bonded using high temperature epoxy resins to assure that they will remain bonded in service at the maximum temperatures that will occur in the magnetic circuit and for the full expected life. Vacuum impregnation is preferred. The contractor shall present data on the characteristics of the packets at the time of design review.

7.15.4. Material with high temperature withstand capability such as ceramic/ slate spacers shall be used to separate the packets. High temperature, mechanically stable material shall be used between the end packets and the top and bottom yokes. Special care shall be taken not to impede the cooling in these areas.

7.15.5. Means shall be provided to distribute the flux from the "cheeses" and the windings to the top and bottom yokes to prevent concentrations of flux with resulting high temperatures in the yokes.

7.15.6. The yokes shall be designed such that high temperatures resulting from unequal distribution of the flux in the yokes will not occur.

7.15.7. The spaces between "cheeses" will be designed so that high temperatures will not result due to fringing of flux at the oil gaps between them. The designer shall calculate the temperatures resulting from fringing.

7.15.8. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

7.16. **Internal Structure Design**

7.16.1. The structural design shall be made so that pressure will be maintained to prevent loosening resulting from thermal expansion and contraction during all loading cycles.

7.16.2. The design shall be made in such a way that excessive vibration does not occur in the windings, structural supports of the windings and magnetic circuit and this will be subjected to design review.

7.16.3. The structure shall be designed to withstand the clamping and magnetic forces. The calculated magnetic forces will be furnished at the time of design review.

7.16.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

7.17. **Calculation of hot spots**

7.17.1. The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature.

7.18. The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

7.18.1. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

7.18.2. The hot spot in the windings and magnetic circuit shall be calculated for the over voltage conditions specified.

7.18.3. The most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

7.19. **Earthing of core and clamping structure**

7.19.1. If grounding of the core cheeses are required a separate strap shall be brought to a terminal located in a waterproof enclosure on the tank. Separate ground leads will be routed from the top and bottom yokes to separate terminals in the enclosure.

7.19.2. Single point core earthing should be ensured to avoid circulating current. Core earth should be brought separately on the top of the tank to facilitate testing after installation on all Reactors. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the ‘Core’ and ‘Core clamp’.

Cross section of Core earthing connection shall be of minimum size 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

7.19.3. Where the core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the laminations, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

7.19.4. A drawing showing the details of the earthing design and connection shall be furnished during detailed engineering.

7.20. **Windings**

7.20.1. The manufacturer shall ensure that windings of all reactors are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity controlled environment with positive atmospheric pressure.

7.20.2. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.

7.20.3. Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.

7.20.4. The insulation of Reactor windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in Reactor oil during service.

7.20.5. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

7.20.6. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

7.20.7. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

7.20.8. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and the fact that the system will not always be in the new factory condition.

7.20.9. The barrier insulation including spacers shall be made from high density pre-compressed pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.

7.20.10. All spacers shall have rounded edges. Radially stepped spacers between winding disks will not be accepted.

7.20.11. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

7.20.12. An electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit unless otherwise approved.

7.20.13. Either brazing/crimping type of connections are permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including line to line and line to ground faults /Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.

7.20.14. Winding paper moisture shall be less than 0.5%.

7.20.15. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

Full details of the winding clamping arrangements, and their adjustment in or out of the tank together with relevant drawings and values, shall be submitted during design review.

7.21. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

7.22. **Winding terminations into bushings**

7.22.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the Reactor in service.

7.22.2. The winding–end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

7.22.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated.

7.22.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

7.22.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

8. Painting system and procedures

The typical painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – E**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

9. Unused inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IS 335 / IEC-60296 & all parameters specified at **Annexure – F**, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – F**, prior to despatch of oil from refinery to site. The Unused Inhibited Insulating Oil parameters including parameters of oil used at manufacturer’s works, processed oil, oil after filtration and settling are attached at **Annexure – F**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil which shall be supplied at site and shall meet parameters as per specification.

9.1. **Particles in the oil**

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration the oil is to be flushed and particle count to be measured.

Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 μm; 130 particle/100 ml with size ≥ 15 μm.

9.2. **Oil filling**

9.2.1. Procedures for site drying, oil purification, oil filling etc shall be done as per Field Quality Plan (FQP).

9.2.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the Reactor tank and should be less than 1mbar.

9.2.3. Oil filling under vacuum at site shall be done with reactor oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Reactor is oil filled up to the Buchholz relay.

9.2.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Reactor shall be oil filled under vacuum, shall be indicated in the manual.

9.2.5. **Oil treatment plant**

The Ultra High Vacuum type oil treatment plant (on returnable basis) of suitable capacity (**minimum 6000** litres per hour) shall be arranged by the contractor at his own cost for treatment of oil in EHV class Reactor in order to achieve properties of treated oil. The plant shall be capable of treatment of oil at rated capacity on single pass basis as follows:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.

vi) Processing temperature shall be automatically controlled and have an adjustable range from 40°C to 80°C.

9.2.6. **Transportation of Oil**

The insulating oil for the Reactor shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in reactor due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / stainless steel tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

10. Spare Reactor Units Storage & Connection Arrangement

Detail procedure for storage of spare reactor unit with and without **isolator switching arrangement** is enclosed at **Annexure-Q.**

11. Bushings

11.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Reactor with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

11.2. Bushing for voltage of 145 kV and above shall be RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing). 52kV Bushing shall of porcelain or composite polymer housing and hermetically sealed Oil filled condenser type or RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing). 36 kV and below rating bushing shall be solid porcelain or oil communicating type.

11.3. RIP/RIS type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

11.4. Oil filled condenser type bushing shall be provided with at least following fittings:

a) Oil level gauge
b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable
c) Oil filling plug & drain valve (if not hermetically sealed)

11.5. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

11.6. Bushings of identical rating of different makes shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at **Annexure – C**.

11.7. Porcelain used in bushing manufacture shall be homogenous, 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.

11.8. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. 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 technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded 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 weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

11.9. Clamps and fittings shall be of hot dip galvanised/stainless steel.

11.10. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

11.11. No arcing horns shall be provided on the bushings.

11.12. Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. In case of RIP bushing

with polymer housing, Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

11.13. The terminal marking and their physical position shall be as per IEC: 60076.

11.14. Tan delta at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at reactor manufacturing works / bushing manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

11.15. Tan δ value of RIP / RIS condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warrantee period.

Tan delta value of OIP Bushing shall be 0.004 (Max) measured at ambient temperature. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results during warrantee period.

12. Neutral Formation and Earthing Arrangement.

12.1. **For 1-Phase Unit (if specified in BPS)**

The contractor shall connect the neutrals of three (3) 1-phase reactor by overhead connection using IPS Al tube / Cable of suitable size. The neutral formation shall be such that neutral winding of single-phase spare reactor can be disconnected or connected to the three phase banks. The connection from the neutral bushing to neutral bus shall be through IPS Al tube / cable of suitable size and wherever flexible jumper needs to be provided, same shall be through twin conductor. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided.

12.2. **For 3-Phase Unit:**

The neutral of the shunt reactor shall be brought out through neutral bushing. The Contractor shall provide Aluminium clamps & connectors suitable for conductor between neutral of the shunt reactor, surge arrester and the neutral grounding reactor (NGR) as applicable.

12.3. The neutral of shunt reactor shall be grounded either directly or through a neutral grounding reactor (NGR) as the case may be. The neutral terminal of Reactors and NGR shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

13. Cooling Equipment

13.1. The reactor shall be designed for Oil Natural Air Natural Cooling (ONAN)

13.2. The radiator bank of the shunt reactor shall be either tank mounted. For neutral grounding reactor, the radiator, if required, may be tank mounted.

13.3. Design of cooling system shall satisfy the performance requirements. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1.2 mm. Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve
(b) Drain Valve and sampling valve
(c) Air release plug
(d) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised steel flats.
(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(f) Lifting lugs

13.4. Each radiator bank (tank mounted) shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection for separately mounted radiator bank.

13.5. If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.

13.6. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14. Valves

14.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

14.2. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

14.3. Each valve shall be provided with the indicator to show clearly the position of the valve.

14.4. All valves flanges shall have machined faces.

14.5. All valves in oil line shall be suitable for continuous operation with Reactor oil at 115 deg C.

14.6. Gland packing/gasket material shall be of “O” ring of nitrile rubber for all the valve’s flanges. All the flanges shall be machined.

14.7. The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

14.7.1. Valves or other suitable means shall be provided to fix various on line monitoring systems to facilitate continuous monitoring.

Type of valves shall be used for Reactor as per following table. The location, size of valves for other application shall be finalised during design review.

Sr. No.	Description of Valve	Type
1	Drain Valve	Gate
2	Filter valve	Gate
3	Sampling Valve	Globe
4	Radiator isolation valve	Butterfly
5	Buchholz relay isolation valve	Gate
6	Sudden pressure relay	Gate
7	Valve for vacuum application on Tank	Gate
8	Conservator Drain valve	Gate
9	Aircell equalizing valve	Gate/Globe/Ball
10	Valve for Conservator vacuum (top)	Gate
11	Valve for N2 injection (NIFPS)	Gate
12	Valve for NIFPS Drain	Gate
13	Valve for UHF Sensors (for 400kV Reactor)	Gate

14.7.2. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

14.8. All hardware used shall be hot dip galvanised / stainless steel.

14.9. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in Reactor, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

b) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

14.10. All valves shall be painted with a shade (preferably red or yellow distinct and different from of main tank surface and as per the painting system and procedure specified.

14.11. All hardware used shall be hot dip galvanised / stainless steel.

15. Cabling

15.1. Buchholz Relay, Magnetic Oil Level Gauge, Pressure Relief Device & Sudden pressure relay to be wired through unarmoured cable of 1.5 sq.mm (minimum), inside GI conduit, with no part exposed. Cable shall be protected by flexible stainless steel pipe, at both ends as per requirement. Proper sealing arrangement to be provided at both ends to avoid ingress of water.

The cross section of "control cable" shall be 1.5 sq.mm (minimum) except for CT circuits which should be 2.5 sq.mm (minimum).

All other cables shall be armoured type and shall be routed through covered cable tray or GI conduit and shall be properly dressed.

15.2. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at Annexure-I. All cables should be provided from approved sources with valid type test report. However, charges for type testing is not envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.

15.3. Cabling of spare unit with isolator switching arrangement shall be in such a way that spare unit of Reactor can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Purchaser's Control panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Purchaser's C & R panels / SCADA level.

16. Individual Marshalling Box and Common Marshalling Box

16.1. Each single phase reactor unit shall be provided with Individual Marshalling Box and Common Marshalling (for a bank of three single phase unit) Box shall be provided.

16.2. Common marshalling box shall be floor mounted and of size, not less than 1600 mm (front) X 650 mm (depth) X 1800 mm (height). Individual Marshalling Box and Cooler Control Box shall be tank mounted.

16.3. The Individual Marshalling Box, Common Marshalling Box, Junction box and all other outdoor cubicles shall be made of stainless-steel sheet of minimum grade of SS304 (SS 316 for coastal area) and of minimum thickness of 1.6 mm.

16.4. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

16.5. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

16.6. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof. All the control cabinets shall be provided with suitable lifting arrangement. Individual Marshalling Box shall be tank mounted only.

16.7. All the contacts of various protective devices mounted on the reactor and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Marshalling box. All the CT secondary terminals in the Marshalling box shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Employer's panel shall be wired upto the Common Marshalling box.

16.8. A space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

16.9. Control and power supplies are to be given after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Employer's approved scheme.

16.10. All the control circuit connections from Individual Marshalling Box and of three single phase units of a bank including spare reactor unit to Employers Control panels shall be routed through common marshalling box. Common marshalling box shall be floor mounted and of size not less than 1600mm (front) X 650mm (depth) X 1800mm (height).

16.11. Details of station auxiliary power supply are mentioned in Section - GTR. Common marshalling box shall have following arrangement:

16.12. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Employer at Common Marshalling Box (for Single Phase unit) or Marshalling Box (for Three Phase unit).

16.13. Suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply system including distribution to marshalling boxes, Online DGA monitoring system, Online drying system and Fibre optic sensor Box etc., shall be provided by contractor. For each circuit separate MCBs / MCCBs shall be provided in the Common Marshalling Box.

16.14. In case auxiliary power supply requirement is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Auxiliary power supply distribution scheme shall be submitted for approval.

16.15. For 1-Ph Reactor Unit, supply and laying of Power, Control and special cables from Common Marshalling Box to Individual units (including spare unit) is in the scope of the contractor.

16.16. All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer scheme housed in the common marshalling box. Design features of the transfer scheme shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at marshalling box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

17. SCADA Integration

17.1.1. All required power & control cables including optical cable, patch chord (if any) upto Common MB shall be in the scope of contractor. Further, any special cable between CMB to switchyard panel room/control room shall be under the present scope.

17.1.2. Fiber optic cable, power cable, control cables, as applicable, between CMB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of EPC contractor.

17.1.3. SCADA Integration of online monitoring equipment (**if applicable**):

All the online monitoring equipment i.e. Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for individual Reactor unit including Spare (if any), are IEC 61850 compliant (either directly or through a Gateway). The monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C.

18. Current Transformer (Bushing & Outdoor Neutral Current Transformer)

18.1. Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

18.2. It shall be possible to remove the turret mounted current transformers from the Reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

18.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

18.4. For 1-Phase Reactor, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of reactor and shall be located in the neutral conductor connecting common neutral point with earth.

18.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

18.6. Secondary resistance and magnetising current characteristics of PX / PS class (protection) (as per IS or IEC) CT of same rating shall match. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

19. Surge Arrester

19.1. General

The surge arresters (if specified in BPS) shall conform in general to IEC-60099-4 except to the extent explicitly modified in the specification. The bidder shall offer surge arresters of gapless type without any series or shunt gap. Arresters shall be hermetically sealed units, of self supporting construction, suitable for mounting on structures.

19.2. Duty Requirements

The surge arresters shall be of heavy duty station class type. It shall be physically located between the neutral of shunt reactor (brought out at bushing) and neutral grounding reactor and shall be electrically in parallel with the latter.

The surge arresters shall be capable of discharging over voltage occurring during switching of unloaded reactors. It shall be capable of spark over on severe switching surges and multiple strokes. It shall be able to withstand wind load calculated at 195 kg/sq.m.

19.3. Constructional Features

19.3.1. The non linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent electrical and mechanical properties even after repeated operations.

19.3.2. The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

19.3.3. The surge arresters shall be fitted with pressure relief devices and arc diverting parts suitable for preventing rupture of polymer housing and providing path for flow of rated fault currents in the event of arrester failure.

19.3.4. The arresters shall incorporate anti-contamination feature to prevent arrester failure consequent to uneven voltage gradient across the stack in the event of contamination of the arrester housing.

19.3.5. Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

19.3.6. Outer insulator shall be polymer / composite insulator housing. Details specification of polymer/composite insulators are given in clause 11.7

19.3.7. The end fittings shall be made of non-magnetic and corrosion proof material.

19.3.8. The name plate shall conform to the requirement of IEC incorporating the year of manufacture.

19.3.9. The arrester shall be supplied with suitable support structure either of tubular GI pipe or lattice steel galvanised.

19.3.10. The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block to be furnished. Metallised coating thickness for reduced resistance between adjacent discs to be furnished along-with procedure for checking the same.

19.3.11. Technical parameters of Surge Arrester is enclosed at **Annexure-H**

19.4. **Fittings and Accessories**

19.4.1. Each arrester shall be complete with insulating base, support structure and terminal connector. The height of the support structure shall not be less than 2500 mm. The structure would be made of galvanized steel generally conforming to IS: 802. The surge arrester can also be mounted on the neutral grounding reactor in lieu of separate support structure.

19.4.2. Self contained discharge counter, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation along with necessary connection, shall be provided for each unit. The counter shall be visible through an inspection window from ground level. The counter terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. One no. potential free change over type contacts (rated for 220V DC) shall be provided for monitoring of surge counter operation in substation automation system.

19.4.3. Suitable milli-Ammeter on each arrester with appropriate connections shall be supplied to measure the resistor grading leakage current. The push buttons shall be mounted such that it can be operated from ground level.

19.4.4. Discharge counter and milli-ammeter shall be suitable for mounting on support structure of the arrester with minimum protection class IP 55.

19.4.5. Grading/Corona rings shall be provided on each complete arrester unit as required for proper stress distribution.

19.5. **Tests**

19.5.1. The surge arresters shall conform to type tests and shall be subjected to routine tests as per IEC-60099-4.

19.5.2. Surge arrester shall be subjected to additional acceptance tests.

(i) Polymer insulator test as per IEC 61462
(ii) Construction check (visual check)
(iii) Measurement of insulation resistance by 1kV megger.

20. Hand Tools (if specified in BPS)

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

21. Test Kit (if specified in BPS)

BDV Kit as per Annexure-J of specification
Portable DGA Kit as per Annexure-J of specification

22. Fittings

The following fittings & accessories (as applicable) shall be provided with each Reactor & NGR covered in this specification. The fittings listed below are not exhaustive and other fittings, which are required for satisfactory operation of the Reactor, are deemed to be included.

22.1. **Shunt Reactor**

i) Conservator for main tank of reactor with aircell, isolating valves, drain valve, magnetic oil level gauge (with canopy) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather

ii) Pressure relief devices with trip contact

iii) Sudden pressure relief relay with alarm contact (for 400kV Reactor only)

iv) Buchholz relay with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

v) Air release plug

vi) Conservator air cell rupture detection relay

vii) Inspection openings and covers

viii) Bushing of each type with metal parts and gaskets to suit the termination arrangement

ix) Winding & Oil temperature indicators

x) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

xi) Rating and diagram plates on reactors and auxiliary apparatus

xii) Roller Assembly (as per clause 7.4)

xiii) Marshalling Box, Common Marshalling Box (applicable for 1-Ph unit), Fibre optic sensor box as applicable

xiv) Cooling equipment

xv) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

xvi) Bushing Current Transformers, Neutral CT (if applicable)

xvii) Terminal marking plates

xviii) Valves schedule plate

xix) Bottom oil sampling valve, Drain valves, Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank and reactor tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Valve for UHF sensors, valves for NIFPS system (if applicable) etc.

xx) Suitable terminal connectors on bushings and surge arrester

xxi) Ladder to climb up to the Reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

xxii) Suitable Platform or ladder for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from Reactor top.

xxiii) Haulage lugs

xxiv) Fibre optic sensor based temperature measuring system (applicable for 400kV Reactor)

xxv) Two earthing terminals each on shunt reactor tank, radiators & marshalling boxes, SA structures etc.

xxvi) Neutral bus connection arrangement (3-Phase Reactor)

xxvii) Online Dissolved Gas (Multi-gas) and Moisture Analyser (if specified in BPS) as per **Annexure-K**

xxviii) On Line Dissolved Hydrogen and Moisture Monitor (if specified in BPS) as per **Annexure-L**

xxix) On-line insulating oil drying system (Cartridge type) as per **Annexure-M**

xxx) Nitrogen Injection Type Fire Protection System (NIFPS) (if specified in BPS) as per **Annexure-N**

xxxi) Oil Sampling Bottle & Oil Syringe (if specified in BPS) as per **Annexure-O**

xxxii) All Cables (Power, control and shielded / twisted pair for 4-20mA cable from Reactor MB, Cooler control cubicle, etc. (as applicable) to CMB (if

applicable) shall be under the present scope. Any special cable if required to be included upto employer's C&R panel.

xxxiii) Managed Ethernet switch, LIU patch cords etc. (if applicable). shall be provided in CMB/MB (as per clause 17). All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

22.2. **NGR**

i) Conservator for NGR main tank with drain valve, isolating valve, vent pipe and prismatic oil level gauge.

ii) Pressure relief devices with trip contact

iii) Buchholz relay with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

iv) Air release plug

v) Inspection openings and covers

vi) Bushings with metal parts and gaskets to suit the termination arrangement

vii) Oil temperature indicators

viii) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

ix) Rating and diagram plates

x) Roller Assembly (if applicable as per clause 7.4)

xi) Marshalling Box (Tank mounted)

xii) Cooling equipment as applicable

xiii) Bushing Current Transformers, Neutral CT (if applicable)

xiv) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

xv) Terminal marking plates

xvi) Valves schedule plate

xvii) Bottom oil sampling valve with threaded male adaptors, Drain valves, Filter valves at top and bottom, shut off valves on both sides of Buchholz relay at accessible height, sampling gas collectors for Buchholz relay at accessible height, Valve for vacuum application etc.

xviii) Suitable terminal connectors on bushings

xix) Ladder to climb up to the tank cover with suitable locking arrangement to prevent climbing during charged condition.

xx) Haulage lugs

xxi) Two earthing terminals each on tank, marshalling boxes etc.

22.3. All hardware used shall be hot dip galvanised / stainless steel.

23. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is

given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation. All accessories and components of reactor shall be purchased from approved soured of Employer. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by Employer.

23.1. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests, which are not possible to carry out at his own works.

The contractor shall carry out type & routine tests as per "**Annexure-B & Standard Test Procedure".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

23.2. **Type Tests on fittings:**

Type test reports of following Bushing & accessories shall be furnished by the contractor along with drawings.

a) Bushing Type Test as per IS/ IEC:60137 for all voltage class (Seismic test on 400kV Bushings)
b) Marshalling & Common Marshalling Box and other outdoor cubicle (IP-55)

23.3. **Pre-Shipment Checks at Manufacturer's Works**

23.3.1. Check for inter-changeability of components of similar reactor for mounting dimensions.

23.3.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, control cubicle, connecting pipes, conservator etc.

23.3.1. Before dispatch of Reactor from factory, following impact recorder settings are to be implemented for graphical analysis:

>1g: Start recording

>2g: Warning

>3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 3g to 10g.

23.3.2. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

23.3.3. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

23.4. **Inspection and Testing at Site**

The Contractor shall prepare a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative inspection programme as envisaged by the Employer is given below. Testing of oil sample at site shall be carried out as per specification. Contractor shall follow Employer Field Quality Plan (FQP).

23.5. **Receipt and Storage Checks**

23.5.1. Check and record condition of each package, visible parts of the reactor etc. for any damage.

23.5.2. Check and record the gas pressure in the reactor tank as well as in the gas cylinder.

23.5.3. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

23.6. **Installation Checks**

23.6.1. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

23.6.2. Check whole assembly for tightness, general appearance etc.

23.6.3. Oil leakage test

23.6.4. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

23.6.5. Leakage check on bushing before erection.

23.6.6. Measure and record the dew point of gas in the main tank before assembly.

23.7. **Commissioning Checks**

23.7.1. Check the colour of silicagel breather.

23.7.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

23.7.3. Check the bushing for conformity of connection to the lines etc,

23.7.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil level indication

23.7.5. Check for the adequate protection on the electric circuit supplying the accessories.

23.7.6. Check resistance of all windings. Insulation resistance measurement for the following:

i) Control wiring
ii) Main windings
iii) Bushing Current Transformer

23.7.7. 2 kV for 1 minute test between bushing CT terminal and earth.

23.7.8. Check for cleanliness of the reactor and the surroundings

23.7.9. Measure vibration and noise level

23.7.10. Capacitance and Tan delta measurement of winding and bushing

23.7.11. Frequency response analysis (FRA). FRA equipment shall be arranged by Employer.

23.7.12. DGA of oil just before commissioning and after 24 hours energisation at site.

23.7.13. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures and handover to Employer for future record.

Annexure – A

1.0 Technical Particulars / Parameters of 420kV Shunt Reactor

Clause No.	Description	Unit	Parameters			
1.1	Rated Voltage, U_r (1p.u)	kV	420			
1.2	Rated Capacity at 420 kV	MVAR	50	63	80	125
1.3	Standard		IEC 60076-6			
1.4	Connection (3 Phase)		Star			
1.5	Cooling System		ONAN			
1.6	Frequency	Hz	50			
1.7	No of Phases		3 (THREE)			
1.8	Service		Outdoor			
1.9	System Fault Level	kA	63			
1.10	Permissible current unbalance among different phases	%	±2			
1.11	Crest value of Third Harmonic content in phase current at rated voltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental			
1.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u. voltage			
1.13	Tolerance on current	%	0 to +5%			
1.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0			
1.15	Temperature rise over 50 deg C Ambient Temp at rated voltage					
a)	Top oil measured by thermometer	^{O}C	40			
b)	Average winding measured by resistance method	^{O}C	45			
c)	Winding hot spot temperature rise over yearly weighted average temperature of 32 °C	^{O}C	61			
d)	Max. tank surface temperature	^{O}C	110			
1.16	Max. design Ambient temp	^{O}C	50			
1.17	Windings					
a)	Lightning Impulse withstand Voltage					
	HV	kV_p	1300			
	Neutral	kV_p	550			
	Chopped Wave Lightning Impulse Withstand Voltage					
	HV	kV_p	1430			
b)	Switching Impulse withstand Voltage					
	HV	kV_p	1050			
c)	Power Frequency withstand Voltage					
	Line	kV_{rms}	570			
	Neutral	kV_{rms}	230			

d)	Tan delta of windings		< 0.005	
1.18	Bushing			
a)	Rated voltage			
	HV	kV	420	
	Neutral	kV	145	
b)	Rated current (Min.)			
	HV	A	800	
	Neutral	A	800	
c)	Lightning Impulse withstand Voltage			
	HV	kVp	1425	
	Neutral	kVp	650	
d)	Switching Impulse withstand Voltage			
	HV	kVp	1050	
e)	Power Frequency withstand Voltage			
	HV	kVrms	695	
	Neutral	kVrms	305	
f)	Minimum total creepage distances		(Specific Creepage Distance: of 31mm/kV corresponding to highest line to line voltage)	
	HV	mm	13020	
	Neutral	mm	4495	
h)	Partial discharge level at U_r			
	HV	pC	< 10	
	Neutral	pC	< 10	
1.19	Maximum Partial discharge level at 1.58 U_r / √3	pC	100	
1.20	Vibration and Tank stress level at rated voltage and frequency		Max : ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point on tank.	
1.21	Maximum Noise level at rated voltage and frequency	dB	80	
1.22	Maximum Permissible Losses of Reactor		Maximum Total Load Loss at rated Voltage, Frequency and at 75^{O} C (kW)	Max. I2R Loss at rated current and frequency and at 75°C
i)	50MVAR, 420kV 3-Ph Reactor	kW	85	45
ii)	63MVAR, 420kV 3-Ph Reactor	kW	100	57
iii)	80MVAR, 420kV 3-Ph Reactor	kW	115	65
iv)	125MVAR, 420kV 3-Ph Reactor	kW	160	90

2.0 Technical Particulars / Parameters of 245kV Shunt Reactor

Clause No.	Description	Unit	Parameters
2.1	Rated Voltage, U_r (1p.u)	kV	245
2.2	Rated Capacity at 245 kV	MVAR	25 | 50
2.3	Standard		IEC 60076-6
2.4	Connection (3 Phase)		Star
2.5	Cooling System		ONAN
2.6	Frequency	Hz	50
2.7	No of Phases		3 (THREE)
2.8	Service		Outdoor
2.9	System Fault Level	kA	40
2.10	Permissible current unbalance among different phases	%	±2
2.11	Crest value of Third Harmonic content in phase current at rated voltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental
2.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u. voltage (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)
2.13	Tolerance on current	%	0 to +5%
2.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0
2.15	Temperature rise over 50 deg C Ambient Temp at rated voltage		
a)	Top oil measured by thermometer	^{O}C	40
b)	Average winding measured by resistance method	^{O}C	45
c)	Winding hot spot temperature rise over yearly weighted average temperature of 32 °C	^{O}C	61
d)	Max. tank surface temperature	^{O}C	110
2.16	Max. design Ambient temp	^{O}C	50
2.17	Windings		
a)	Lightning Impulse withstand Voltage		
	HV	kV_p	950
	Neutral	kV_p	170
	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kV_p	1430
b)	Switching Impulse withstand Voltage		
	HV	kV_p	750
c)	Power Frequency withstand Voltage		
	Line	kV_{rms}	395

	Neutral	kV_{rms}	70	
d)	Tan delta of windings		< 0.005	
2.18	Bushing			
a)	Rated voltage			
	HV	kV	245	
	Neutral	kV	36	
b)	Rated current (Min.)			
	HV	A	1250	
	Neutral	A	800	
c)	Lightning Impulse withstand Voltage			
	HV	kVp	1050	
	Neutral	kVp	170	
d)	Switching Impulse withstand Voltage			
	HV	kVp	850	
e)	Power Frequency withstand Voltage			
	HV	kVrms	505	
	Neutral	kVrms	77	
f)	Minimum total creepage distances			
	HV	mm	7595	
	Neutral	mm	1116	
h)	Partial discharge level at U_r			
	HV	pC	< 10	
2.19	Max. Partial discharge level at 1.58 U_r / √3	pC	100	
2.20	Vibration and Tank stress level at rated voltage and frequency		Max : ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point on tank.	
2.21	Maximum Noise level at rated voltage and frequency	dB	75	
2.22	Maximum Permissible Losses of Reactor		Maximum Total Load Loss at rated Voltage, Frequency and at 75^{O} C (kW)	Max. I2R Loss at rated current and frequency and at 75°C
i)	25MVAR, 245kV 3-Ph Reactor	kW	50	28
ii)	50MVAR, 245kV 3-Ph Reactor	kW	80	45

4.0 Technical Particulars / Parameters of Neutral Grounding Reactor (NGR)

The neutral grounding reactors are generally used in Line Reactor between the neutral end of the Reactor and ground to limit the secondary arc current and the recovery voltage to a minimum value.

Following are the Technical particulars/ parameters envisaged for NGR:

Clause No.	Description	Unit	Parameters
4.	Technical Parameters		
	Rated voltage from insulation	kV	**145**
4.1	Connection		Between neutral of reactor and ground
4.2	Cooling System		Natural oil cooling (ONAN)
4.3	Cooling medium		Insulating oil
4.4	Frequency	Hz	50
4.5	No of Phases		1 (SINGLE)
4.6	Service		Outdoor
4.7	Type		Oil filled outdoor application
4.8	Insulation		Graded
4.9	Max. continuous current (rms)		10 A
4.10	Rated short time current (rms) (10secs.)		60A
4.11	Rated impedance at rated short time and continuous current		As specified in section project
4.12	Max. temperature rise over ambient temperature of 50^{ø}C at rated voltage		
i)	of winding measured by resistance	Deg C	45
ii)	of top oil measured by thermometer	Deg C	50
4.13	Insulation level for winding		
	Lightning Impulse withstand Voltage		
i)	Line side	kV_p	550
ii)	Ground side	kV_p	95
iii)	Chopped Wave Lightning Impulse Withstand Voltage		
iv)	Line End	kVp	605
	One Minute Power Frequency withstand Voltage		
v)	Line side	kV_{rms}	230
vi)	Ground side	kV_{rms}	38
4.14	**Bushing**		
	Rated Voltage		
i)	Line side	kV	145
ii)	Ground side	kV	24

	Lightning Impulse withstand Voltage	kV_p	
iii)	Line side		650
iv)	Ground side		125
	One Minute Power Frequency withstand Voltage		
v)	Line side	kV_{rms}	305
vi)	Ground side	kV_{rms}	55
	Creepage (total minimum)		31mm/kV
vii)	Line side	mm	4495
viii)	Ground side	mm	744
4.15	Method of grounding		Solidly connected between neutral of shunt reactor and earth.
4.16	Whether neutral is to be brought out		Yes (through 24kV Porcelain bushing

Annexure -B

Test Plan

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	Routine
3.	Measurement of insulation resistance & Polarization Index	Routine
4.	Measurement of insulation power factor and capacitance between winding and earth	Routine
5.	Measurement of insulation power factor and capacitance of bushings	Routine
6.	Core assembly dielectric and earthing continuity test	Routine
7.	High voltage withstand test on auxiliary equipment and wiring after assembly	Routine
8.	Chopped wave lightning impulse test for the line terminals (LIC)	Routine
9.	Lightning impulse test on Neutral	Routine
10.	Switching impulse test	Routine
11.	Applied voltage test (AV)	Routine
12.	Induced Over Voltage Test with Partial Discharge Measurement	Routine
13.	Gas-in-oil analysis	Routine
14.	2-Hour excitation test except type tested unit	Routine
15.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Um for reference only on one unit of each type)	Routine
16.	Measurement of mutual reactance on 3-phase reactor	Routine
17.	Temperature rise test	Type
18.	Measurement of harmonic content of current (Measured in Cold state)	Type
19.	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	Type
20	Knee point voltage measurement of reactor (Measured in Cold state)	Type
21.	Measurement of zero-sequence reactance (Applicable for three phase shunt reactor only)	Type
22.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine
23.	Appearance, construction and dimension check	Routine
24.	Oil leakage test on Reactor tank	Routine
25.	Tank vacuum test	Routine
26.	Tank pressure test	Routine

Test on NGR	
Item	**Test**
Measurement of winding resistance	Routine
Measurement of Impedance by V/I	Routine
Measurement of insulation resistance	Routine
Measurement of Capacitance & Tan delta of winding insulation to earth and	Routine
Lightning impulse test	Routine
Separate source voltage withstand test	Routine
Isolation Test	Routine
Oil leakage test	Routine
Appearance, construction and dimension check	Routine
High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
Tank Vacuum test	Routine
Tank Pressure test	Routine

Annexure –D

Reference Drawings

The list of drawings indicated below form a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Typical Foundation Drawing	0000-000-T-E-G-001, R01
ii)	Arrangement of Current Transformer on Shunt Reactor & NGR	0000-000-T-E-J-001, REV 01
iii)	Standard details for RIP Condenser bushings (Lower portion)	Annexure-R
iv)	Conceptual Drawing for Optical Fibre Sensor	C/ENGG/STD/OPTICAL FIBRE SENSOR/AT-SR/REV 00
v)	Conceptual drawing for showing power and control cable connection for operation of 1-ph unit with spare unit	C/ENGG/RT/SPARE/CABLE/STD; REV 01
vi)	Conceptual drawing for showing power and control cable connection for operation of 3-ph unit	C/ENGG/STD/CABLE/RT
vii)	Standard Test Procedure of Transformer & Reactor	POWERGRID/STD/TEST PROCEDURE/TR-RT/REV02

Annexure – D

Design Review Document for Shunt Reactor

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing and Linear characteristics
3.	Inrush-current characteristics while charging
4.	Winding and winding clamping arrangements
5.	Short-circuit withstand capability considering inrush current.
6.	Thermal design including review of localised potentially hot area
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Protective devices
15.	Radiators
16.	Sensors and protective devices– its location, fitment, securing and level of redundancy
17.	Oil and oil preservation system
18.	Corrosion protection
19.	Electrical and physical Interfaces with substation
20.	Earthing (Internal & External)
21.	Processing and assembly
22.	Testing capabilities
23.	Inspection and test plan
24.	Transport and storage
25.	Sensitivity of design to specified parameters
26.	Acoustic Noise
27.	Spares, inter-changeability and standardization
28.	Maintainability
29.	PRD and SPR (number & locations) and selection
30.	Conservator capacity calculation
31.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
32.	Conductor insulation paper details
33.	Location of Optical temperature sensors
34.	The design of all current connections
35.	Location & size of the Valves

Note: Design review document for NGR shall be decided during detailed engineering.

Annexure – E

Painting Procedure:

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank & DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30μm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy base Zinc primer (30-40μm)	PU paint (Minimum 50μm)	Minimum 100μm	Matching shade of tank/ different shade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40μm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Control cabinet / Marshalling Box/Common Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – G

UNUSED INHIBITED HIGH GRADE INSULATING OIL PARAMETERS

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 40degC	IS 1448 Part 25 or ISO 3104 or ASTM D7042	(Max.)12 mm^2/s
1b.	Viscosity at -30degC		(Max.)1800 mm^2/s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	IS 1448 Part 10/Sec 2 or ISO 3016	(Max.) - 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	(Min.) 50kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	Max 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IS 16086 or IEC 60247 or IEC 61620	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins: <50% & balance Naphthenic compounds.
B	**Refining/Stability**		
1.	Colour	ISO 2049	L0.5 (less than 0.5)
2.	Acidity	IEC 62021-2 or 62021-1	(Max) 0.01 mg KOH/g
3.	Interfacial tension at 27degC	IEC 62961 or ASTM D971	0.043 N/m (min)
4.	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)
5.	Corrosive sulphur	DIN 51353	Not-Corrosive
6.	Potentially corrosive sulphur	IEC 62535	Not-Corrosive
7.	DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)
8.	Presence of oxidation inhibitor	IS 13631 or IEC 60666	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
9.	Metal passivator additives	IEC 60666	Not detectable (<5 mg/kg)
10.	2-Furfural content and	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for

	related compound content		each individual compound
11.	Stray gassing under thermooxidative stress	Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H2) and < 50 µl/l methane (CH4) and < 50 µl/l ethane (C2H6)
C	**Performance**		
1.	Oxidation stability	IEC 61125 (method c) Test duration 500 hour	
2.	Total acidity*	4.8.4 of IEC 61125:2018	0.3 mg KOH/g (Max.)
3.	Sludge*	4.8.1 of IEC 61125:2018	0.05 % (Max.)
4.	Dielectric dissipation factor (tan delta) at 90degC	4.8.5 of IEC 61125:2018	0.05 (Max.)
	*values at the end of oxidation stability test		
D	**Health, safety and environment (HSE)**		
1.	Flash point	IS 1448 Part 21 or ISO 2719	(Min.)135deg C
2.	PCA content	IP 346	< 3%
3.	PCB content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		0.04 N/m (min)
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability		
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of EMPLOYER.			

Note: Supplier shall declare the chemical family and function of all additives and the concentrations in the cases of inhibitors, antioxidants and passivators.

Annexure – H

Technical Parameters of Current Transformers - 420 kV Shunt Reactor On each phase connection & Neutral Grounding Reactor (NGR)

(a) Ratio	**Shunt Reactor**			**NGR**
	Line Side	Neutral Side	Common Neutral Side	Earth Side
CORE 1	200/1A	200/1A	200/1A	200/1A
CORE 2	200/1A	To be decided by contractor for WTI	-	-
CORE 3	200/1A	3000-2000-500/1A	-	-
CORE 4	200/1A	3000-2000-500/1A	-	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	200V, PX / PS Class	300V, PX / PS Class	200V, PX / PS Class	200V, PX / PS Class
CORE 2	200V, PX / PS Class	To be decided by contractor for WTI	-	-
CORE 3	200V, PX / PS Class	3000-2000-500V, PX / PS Class	-	-
CORE 4	10VA, Class 1.0	3000-2000-500V, PX / PS Class	-	-
(c) Maximum CT Secondary Resistance				
CORE 1	1 Ohm	1 Ohm	1 Ohm	1 Ohm
CORE 2	1 Ohm	-	-	-
CORE 3	1 Ohm	15-10-2.5 Ohm	-	-
CORE 4	-	15-10-2.5 Ohm	-	-
(d) Exciting current (max.)				
CORE 1	250mA @ vk/4	250mA @ vk/4	-	-
CORE 2	250mA @ vk/4	-	-	-
CORE 3	250mA @ vk/4	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
CORE 4	-	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
(e) Application				
CORE 1	Reactor Differential	Reactor Differential	Restricted earth fault	Restricted earth fault
CORE 2	Restricted earth fault	Temperature Indicator (on one phase only)	-	-
CORE 3	Reactor Backup	Line Protection (Main-I)/T zone differential Protection/spare	-	-
CORE 4	Metering	Line Protection (Main-II)/T zone differential Protection/spare	-	-

NOTE:

i) For PX / PS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor & NGR.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

vi) In case of single phase reactor, Common Neutral Side shall be out door type.

Technical Parameters of Current Transformers – 245 kV Shunt Reactor
On each phase connection

(a)	**Ratio**			
		Line Side	Neutral Side	Common Neutral Side
	CORE 1	200/1A	200/1A	200/1A
	CORE 2	200/1A	200/1A	-
	CORE 3	200/1A	200/1A	-
	CORE 4	-	To be decided by contractor for WTI	-
(b)	**Minimum knee point voltage or burden and accuracy class**			
	CORE 1	200V, PX / PS Class	10 VA, 1.0	200V, PX / PS Class
	CORE 2	200V, PX / PS Class	200V, PX / PS Class	-
	CORE 3	200V, PX / PS Class	200V, PX / PS Class	-
	CORE 4	-	To be decided by contractor for WTI	-
(c)	**Instrument security factor (max.)**			
	CORE 1	-	20	-
	CORE 2	-	-	-
	CORE 3	-	-	-
	CORE 4	-	-	-
(d)	**Maximum CT Secondary Resistance**			
	CORE 1	1 Ohm	-	1 Ohm
	CORE 2	1 Ohm	1 Ohm	-
	CORE 3	1 Ohm	1 Ohm	-
	CORE 4	-	-	-
(e)	**Exciting current(max.) at 50V**			
	CORE 1	60mA	-	60mA
	CORE 2	60mA	60mA	-
	CORE 3	60mA	60mA	-
	CORE 4	-	-	-
(f)	**Application**			
	CORE 1	Differential protection(High impedance)	Metering	Restricted earth fault protection
	CORE 2	Restricted earth fault protection	Restricted earth fault	-
	CORE 3	Backup impedance protection	Differential protection(High impedance)	-
	CORE 4	-	Winding temp. Indication (on one phase only)	-

Note:

i) For PX / PS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor & NGR.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

vi) In case of single phase reactor, Common Neutral Side shall be out door type.

ANNEXURE - H

Gapless Surge Arrester – Technical parameters

Clause No.	Description	Parameters
a.	Rated arrester voltage	120 kV
b.	Rated system voltage	145 kV
c.	Rated system frequency	50Hz
d.	System neutral earthing	Earthed through NGR
e.	Installation	Outdoor
f.	Nominal discharge current	10kA of 8/20 microsec wave.
g.	Class of arrester	10kA heavy duty type
h.	Minimum discharge capacity	3.5 kJ/kV (referred to rated voltage)
i.	Continuous operating voltage at 50^{ø}C	102 kV
j.	Maximum switching surge residual voltage (1kA)	280kVp
k.	Maximum residual voltage at	
	i) 10kA	320kVp
	ii)20kA nominal discharge current	340kVp
l.	Long duration discharge class	2
m.	High current short duration test value (4/10micro-sec.wave)	100kAp
n.	Current for pressure relief test	40kArms
o.	Low current long duration test value (2000microsec.)	1000Apeak
p.	Min. total creepage distance	3625 mm.
q.	One minute dry power frequency withstand voltage of arrester housing	275kVrms
r.	Impulse withstand voltage of arrester housing with 1.2/50 micro-sec. wave	+ 650KVp
s.	Pressure relief class	A
t.	RIV at 92 kVrms.	Less than 500microvolts
u.	Partial discharge at 1.05 continuous over voltage	Not more than 50pC
v.	Seismic acceleration	As specified in section project
w.	Reference ambient temperature	50 deg C

ANNEXURE - I

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from Employer's approved vendors.

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade and shall conform to IS 8130.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be ±2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC insulated 1100V grade power cables shall be of Fire Retardant Low Smoke Halogen (FRLSH) type, C2 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 85°C. The conductor shall be stranded aluminium H2 grade conforming to IS 8130. The Insulation shall be extruded PVC to type-C of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all cables. The copper cable of required size can also be used.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FRLSH type, C2 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC of type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The outer sheath shall be extruded PVC of type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the purchaser to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS: 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 °C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 °C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50

B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 ^{o}C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0.868	0.868/1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable	18	28.4	21	16.3	12.2	10.2

	over inner sheath (under armour), mm						
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

	insulation(mm)								
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data

ANNEXURE - J

Technical Specification of Oil BDV Test Set (Applicable as per BPS)

Item	Specification
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Reactor oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Emplyer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

Technical Specification of Portable Dissolved Gas Analysis of Oil (Applicable as per BPS)

S.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records
06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
07	Operating Temperature, Relative humidity	01. Temperature 0-50 Deg. C 02. 85% non-condensing

	& Dimensions	03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - K

Online Dissolved Gas (Multi-gas) and Moisture Analyser (Applicable as per BPS)

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of five (5) years manufacturer's Warranty.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if

applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included in the scope of supply

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	± 10%
Repeatability	±3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

ANNEXURE - L

On Line Dissolved Hydrogen and Moisture Monitor (Applicable as per BPS)

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display H_2 and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10 psi.

7.0 Technical Parameters:

Sr. No.	Parameters	Requirements
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C

	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Communications	USB&IEC 61850 compliant

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:
Fault indication:

iii) IEEE, IEC or user configurable levels of dissolved gases
iv) Rate of change trending

9.0 The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

v) Software
vi) Operation Manual (2 set for every unit),
vii) Software Manual and
viii) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

ANNEXURE - M

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each reactor shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - N

Nitrogen Injection Type Fire Prevention & Extinguishing System (If specified in BPS)

1. Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults/arc.

   The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

   Electrical isolation of transformer shall be an essential pre-condition for activating the system.

2. Operational Controls
   The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

2.1 Prevention of transformer from explosion and fire
   To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays (Differential / Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

2.2 Prevention of transformer from fire in case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

3. Operation of System
   On receiving activation signal, the following shall take place:
   i) Open the quick opening drain valve to drain the top layer oil
   ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
   iii) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

   There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.
   There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

4. Technical Particulars

   The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe

and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from POWERGRID.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

5. Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:
   - Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
   - Oil Drain Assembly including oil drainpipe extension of suitable size for connecting pipes to oil pit
   - Mechanical release device for oil drain and nitrogen release
   - Limit switches for monitoring of the systems
   - Panel lighting
   - Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
   - Back up pressure switch to operate nitrogen gas valve
   - Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
   - Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.
   - shall have minimum IP55 degree of protection

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP-67 class degree of protection.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is being provided by the transformer/reactor supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

6. Under Ground Oil Storage Tank
Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below:**

Painting	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thick-ness (DFT)**	**Colour shade**
Oil Storage Tank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

7. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the system.

8. Installation and pre-commissioning test After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

ANNEXURE - O

Oil sampling bottles (Applicable as per BPS)

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Reactors and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

Oil Syringe (Applicable as per BPS)

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

ANNEXURE - P

Oil Storage Tank (Applicable as per BPS)

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS 10987 (1992). Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of thickness as per standard. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100°C.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. The following accessories shall also form part of supply along with each Oil storage tank.

5.1 Four numbers of 50NB suitable rubber hoses for Reactor oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

5.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

5.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

5.4 The painting of oil storage tank and its control panel shall be as per technical specification.

5.5 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

Annexure–Q

Spare Reactor Unit Storage & Connection Arrangement

1.1. **Reactor with Isolator switching arrangement:** Employer intends to replace any of the Reactor unit by the spare Reactor unit using isolator switching arrangement so as to avoid physical shifting the Reactor.

Connection of spare unit of Reactor with other units shall be made by isolator switching arrangement. Neutral formation for spare unit of Reactor shall be done by manual connection. The spare Reactor unit shall be completely erected and commissioned similar to the other Reactor units. The contractor shall carry out all pre-commissioning tests on the spare Reactor similar to the unit kept in service.

For this purpose if specified in BPS, HV and Neutral Connections of spare unit shall be extended upto the other unit(s) by forming auxiliary buses connection through flexible/rigid conductor. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor. However, the detail configuration and hardware shall be finalised during detailed engineering and shall be subject to Employer's approval.

Any special maintenance procedure required shall be clearly brought out in the instruction manual.

1.2. **Reactor without isolator switching arrangement:** Employer intends to keep the spare Reactor unit without isolator switching arrangement due to space limitation. In case of failure of any of the running unit, this spare reactor shall be physically shifted to replace faulty reactor.

The spare Reactor shall be placed on the elevated foundation block to facilitate quick movement. The Reactor unit may be required to be stored for long duration. The spare Reactor unit shall be completely erected and commissioned similar to the other Reactor units. However, erection of separate cooler bank is not envisaged. In case conservator is cooler bank mounted, suitable arrangement for mounting of conservator on tank top cover shall be provided. The contractor shall carry out all pre-commissioning tests on the spare Reactor similar to the unit kept in service.

All other items shall be suitably packed in reusable boxes. Arrangement shall be made to minimize moisture ingress inside the boxes. All pipes and radiators shall be provided with blanking plates during long duration storage to prevent entry of foreign material/ water.

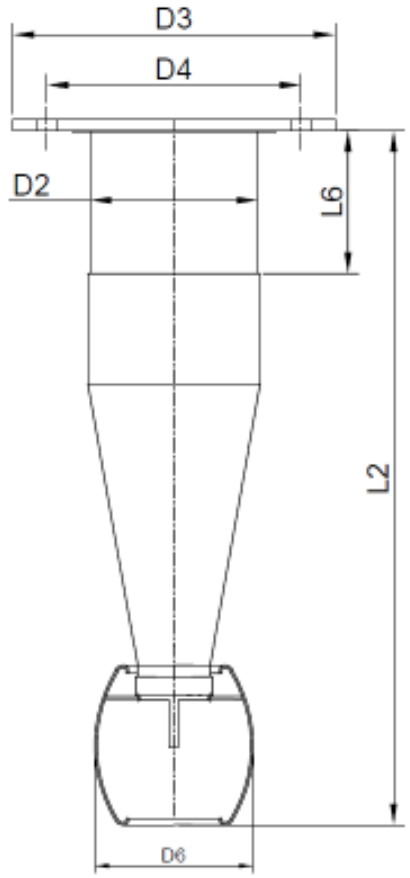
In case spare Reactors needs to be commissioned in switchyard bay (as advised by Engineer in-charge), the contractor shall erect, test and commission the spare reactor unit similar to other units in service. However packaging material as above for long-term storage shall be included in the scope of bidder.

---------- X ----------

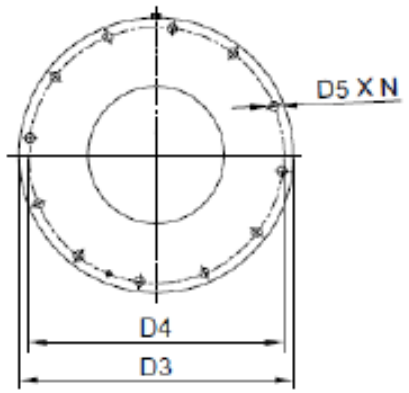
Annexure-R

STANDARD DIMENSION FOR LOWER PORTION OF CONDENSER BUSHINGS

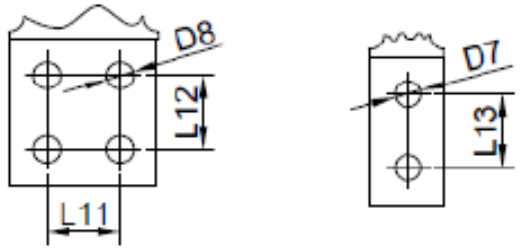
(For 420 kV and below voltage class Bushings)



Bushing Mounting Flange Details



Bottom Connection Details



Symbol	Description
L2	Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest
L6	Length for accommodating Bushing Current Transformer (BCT)
D2	Maximum diameter of oil immersed end
D3	Outside diameter of fixing flange
D4	Pitch Circle Diameter of fixing holes of flange
D5	Diameter of fixing hole
N	Number of fixing holes
D6	Maximum diameter of oil end shield/stress relieving electrode
L11	Horizontal Distance between holes for bushing bottom connection for 4 hole connection
L12	Vertical Distance between holes for bushing bottom connection for 4 hole connection
L13	Vertical Distance between holes for bushing bottom connection for 2 hole connection
D7	Diameter of hole for bushing bottom connection for 2 hole connection
D8	Diameter of hole for bushing bottom connection for 4 hole connection

Annexure-R

Voltage Rating (kV)	420	245		145		72.5		52
BIL kVp	1425 1550(for GT)	1050		650		325		250
Creepage Distance (mm)	13020	7595		4495		2248		1612
Current Rating (A)	1250	1250	2000	1250	2000	800	2000	1250
Type of lead	Solid Stem (SS)	SS	SS	SS	SS	SS		SS
L2 ±5	1640	1130	1230	800/ 1250[a]	1030	695		450
L6 (min.)	400	300		300/500 [a]	300	300		100
D2 (max.)	350	270		165	180	115	165	115
D3±2	720	450		335	335	225	335	225
D4±1 (PCD)	660	400		290	290	185	290	185
D5xN	24x12	20x12		15x12	15 x12	15x6	15x12	15x6
D6 (max.)	350	270		180		115		115
L11	-	-	45	-	45	-	55	-
L12	-	-	40	-	40	-	40	-
L13	40	40	-	40	-	40	-	40
D7	Φ14	Φ14		Φ14	Φ14	Φ14	Φ14	Φ14
D8	-	-	Φ 14	-	-	-	-	-
Length & Diameter of Air End Terminal	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60

[a] for 765 kV class shunt reactor

Notes:

1. All dimensions are in mm.
2. No positive tolerance where maximum dimension specified and no negative tolerance where minimum dimension is specified.
3. For other details of oil end terminal for 2000 A (145 kV/245 kV) solid stem type bushing, refer Fig 4 of IS 12676.
4. For other details of oil end terminal for 2000 A, 72.5 kV solid stem type bushing, refer Fig 3B of IS 12676.
5. For other details of oil end terminal for 800 A and 1250 A (52kV/72.5 kV/145 kV/245 kV/420 kV) solid stem type bushing, refer Fig 3A of IS 12676.

ANNEXURE-S

Standard Test Procedure of Transformer & Reactor

1401648/2023/TBG-TB_HVDC

STANDARD TEST PROCEDURE FOR TRANSFORMER & REACTOR

DOC. No.: POWERGRID/STD/TEST PROCEDURE/TR-RT

Revision-02

June 2021

INDEX

Sr. No.	Test	Page No
1.	General	4
2.	Low Voltage tests	5-11
2.1.	Voltage ratio measurement & Polarity check (Vector Group)	5
2.2	Measurement of insulation power factor and capacitance between winding and earth and Bushings	6-7
2.3	Measurement of insulation resistance & Polarization Index	8
2.4	Core assembly dielectric and earthing continuity test	9
2.5	Measurement of winding resistance	10
2.6	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	11
3.	Measurement of no-load loss and current & harmonic level in no load current	12
4.	Magnetic balance test (for three phase Transformer only)	13
5.	On-load tap changer test	14
6.	Measurement of short-circuit impedance and load loss	15
7.	Dielectric tests	16-34
7.1	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	17-24
7.2	Switching impulse test for the line terminal (SI)	25-26
7.3	Applied voltage test (AV)	27
7.4	Line terminal AC withstand voltage test (LTAC)	28
7.5	Induced voltage withstand test (IVW)	29
7.6	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	30-31
7.7	Induced voltage test with PD measurement (IVPD)	32-34
8.	Temperature rise test	35-41
9.	Overload testing in short-circuit method	42-43
10.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	44
11.	Over excitation test	45
12.	Measurement of Zero seq. reactance (for three phase Transformer only)	46-47
13.	Measurement of acoustic noise level	48
14.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	49
15.	High voltage with stand test on auxiliary equipment and wiring after assembly	50
16.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	51
17.1	Oil leakage test on transformer tank	52
17.2	Tank vacuum test	52
17.3	Tank pressure test	52
18.	Appearance, construction and dimension check	53
19.	Dynamic Short circuit withstand test (If specified in BPS)	54-57
20	Check Lists for Transformer & Reactor Tests	68-69

Test procedure for transformer & Reactor are similar. Hence, same method as mentioned for transformer shall be applicable for reactor also. However, few tests which only to be performed in Reactor are given below:

Sr. No.	Test (Only for Reactor)	Page No
20.	Short time over voltage Test (830kVrms) (765kV Reactor)	58
21.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	59-61
22.	2-Hour excitation test except type tested unit	62
23.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Um for reference only on one unit of each type)	63
24.	Measurement of harmonic content of current (Measured in Cold state)	64
25.	Knee point voltage measurement of reactor (Measured in Cold state)	65
26.	List of reference standards	66

1. General

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer/reactor unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) (excluding ODS, DGA, Fire protection system) assembled.

RTCC and Common Marshalling Box testing may be carried during routine testing of any one unit (Transformer/Reactor). In case of only one unit is being manufactured, RTCC and Common Marshalling Box testing may be carried out along with that unit.

All measuring systems used for the tests shall have certified traceable accuracy and be subjected to periodic calibration, according to the rules given in ISO 9001. Specific requirements on the accuracy and verification of the measuring systems are described in IEC 60060 series and IEC 60076-8.

Latest IEC standards (as applicable) shall be followed for all the tests.

1.1. Before start of FAT following tests shall be carried out on insulating oil:

Break Down voltage (BDV), Moisture content, Tan-delta, Interfacial tension and Particle count

Acceptance Criteria: POWERGRID Specification of Insulating Oil

2. Low Voltage Tests

2.1. Voltage ratio measurement & Polarity check (Vector Group)

Refer IEC 60076-1for procedure and acceptance criteria. Manufacturer's standard practice may be followed.

2.2. Measurement of insulation power factor and capacitance between winding and earth and Bushings

Standards: IEC 60076-1 & POWERGRID Technical Specification for Transformers & Reactors.

Capacitance & tan delta of HV bushings, IV bushings, LV bushings and neutral shall be measured at 5kV & 10kV. It is applicable only for condenser type bushing (having test tap)

Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz, at multiple of 17 Hz and applied voltage shall be 2 – 5kV) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before dispatch for reference and the result shall be compared at site during commissioning to verify the healthiness of the bushing. No temperature correction factor shall be applicable for tan delta.

Further winding capacitances & tan delta shall also be measured in the following modes as per the table given below:-

Transformer

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV-IV)/LV (C_{HL})	(UST)	5		
			10		
2	(HV-IV)-E (LV GUARD) (C_H)	(GSTg)	5		
			10		
3	(HV-IV)/(LV+E) (GST) ($C_{HL} + C_H$)	(GST)	5		
			10		
4	LV/(HV-IV) (C_{HL})	(UST)	5		
			10		
5	LV-E (HV+IV GUARD) (C_L)	(GSTg)	5		
			10		
6	LV/(HV + IV+GROUND) ($C_{HL} + C_L$)	(GST)	5		
			10		

Test Criteria

The test is successful if tan delta measured is less than 0.5% or as mentioned in specification. The capacitances measured for above combinations (C_H, C_L, $C_{HL} + C_H$, $C_{HL} + C_L$, C_{HL}) may be compared.

Reactor

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV+N) - E (C_H)	(GST)	5		
			10		

For bushings and neutral the following table shall be filled:-

Configuration		Voltage (in kV)	Capacitance in pF	% tan delta
HV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
IV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
LV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
Neutral		5		
		10		

2.3. Measurement of insulation resistance & Polarization Index

Measurement of insulation resistance between winding & earth by 5 kV megger.

Insulation resistance tests are made to determine the insulation resistance from individual winding to ground or between individual windings. The insulation resistance in such tests is commonly measured in mega-ohms, or may be calculated from measurements of applied voltage and leakage current. The dc voltage applied for measuring insulation resistance to ground shall not exceed a value equal to the half of the rated voltage of the winding or 5 kV whichever is lower.

Note

1. The insulation resistance of electrical apparatus is subjected to wide variation in design, temperature, dryness, and cleanliness of the parts. When the insulation resistance falls below prescribed values, it can, in most cases of good design and where no defect exists, be brought up to that required standard by cleaning and drying the apparatus. The insulation resistance, therefore, may offer a useful indication as to whether the apparatus is in suitable condition for application of dielectric tests.

2. Under no conditions, test should be made while the transformer is under vacuum.

Polarisation Index (PI)

The purpose of polarisation index test is to determine if equipment is suitable for operation or even for an overvoltage test. The polarisation index is a ratio of insulation resistance value at the end of 10 min test to that at the end of 1 min test at a constant voltage. The total current that is developed when applying a steady state dc voltage is composed of three components:

(1) Charging current due to the capacitance of the insulation being measured. This current falls off from maximum to zero very rapidly.

(2) Absorption current due to molecular charge shifting in the insulation. The transient current decays to zero more slowly.

(3) Leakage current which is the true conduction current of the insulation. It has a component due to the surface leakage because of the surface contamination.

The advantage of PI is that all of the variables that can affect a single IR reading, such as temperature and humidity, are essentially the same for both the 1 min and 10 min readings. Since leakage current increases at a faster rate with moisture present than does absorption current, the IR readings will not increase as fast with insulation in poor condition as with insulation in good condition. After 10 min the leakage current becomes constant and effects of charging current and absorption current die down.

Acceptable PI value for power transformer shall be better than 1.3.

2.4. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 AC Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 0.5 GΩ for all cases mentioned above.

2.5. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 h, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps shall be done.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

If fibre optic sensors are installed, temperature of winding and oil by FO sensors are also to be recorded in the test report. Further ensure that the FO reading should approx. match with RTD temperature reading.

Type tested unit:

Test engineer (manufacturers) add terminal cables/tube for taking immediate reading of hot resistance of winding. In that case the reference value of cold resistance of the same circuit to be measured and witnessed. Average oil temperature is also to be measured. The above is required for calculation of temperature at shut down condition.

2.6. Measurement of no load current & short circuit Impedance with 415 V, 50 Hz AC.

Measurement of no load current

415V, 50HZ 3-Ph supply (controlled) shall be supplied LV side (Tertiary side for Auto) and magnetising current shall be measured.

Voltage			Current		
U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ

Short circuit Impedance with 415 V, 50 Hz AC

Impedances shall be measured for all combinations and at Maximum, Minimum & Normal Voltage Tap – HV/IV, HV/LV & IV/LV

HV/IV – Connection

Applied Voltage at HV, IV Short circuited, Tertiary Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

HV/LV – Connection

Applied Voltage at HV, LV Short circuited, IV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

IV/LV – Connection

Applied Voltage at IV, LV Short circuited, HV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Normal							

Measured impedance shall be approximately matched with the impedances measured at rated current. The current at all the phases shall be approximately same.

3. No-load loss and current & harmonic measurement

As per IEC 60076-1:2011 clause 11.5. The transformer shall be approximately at factory ambient temperature. Measurement should be carried out at rated specified voltage of the transformer. Harmonics in no load current shall be measured during No Load Loss measurement.

Check points:

- The value of CT measurement range should be kept sufficiently high (3 to 5 times of measuring value) for better measurement and take care of distortions.
- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.

Note: After No load loss measurement Load loss measurement shall be commenced immediately and shall be carried out as per procedure mentioned at Sr. No. 6 below.

4. Magnetic Balance Test on 3-phase Transformers

This test is conducted only in three phase transformers to check the imbalance in the magnetic circuit. In this test, no winding terminal should be grounded; otherwise results would be erratic and confusing. Applied Test voltage shall be 415V.

Evaluation criteria

The voltage induced in the centre phase shall be 40% to 90% (approx.) of the applied voltage on the outer phases. However, when the centre phase is excited then the voltage induced in the outer phases shall be 30 to 70% (approx.) of the applied voltage. Zero voltage or very negligible voltage induced in the other two windings should be investigated. The purpose of this test basically is to ensure that there is no inter turn fault in the winding which is generally reflected in high excitation current in faulty winding.

5. Tests on On-load Tap-Changers

Operation Test

With the tap-changer fully assembled on the transformer the following sequence of operations shall be performed without failure:

a) With the transformer un-energised, eight complete cycles of operations (a cycle of operation goes from one end of the tapping range to the other, and back again).

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

d) With one winding short circuited and, as far as practicable, two rated current according to IEC 60076-1 in the winding, 10 tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping(the tap changer will pass 20 times through the changeover position). Total tap change operations shall be 80.

6. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

If fibre optic sensors are installed, hotspot temperature of winding and oil may be recorded for reference.

Following parameters shall be recorded:
Current, voltage (RMS & Average), power factor, apparent power, active power, reactive power etc.

Current measured at all the phases shall be approximately same. If more variation is observed between current values of all phases measured, test circuit shall be reviewed and test shall be repeated.

Check points:

- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.
- Current can also be verified from one of the measuring type bushing CTs.

7. Dielectric Tests

Dielectric tests shall be carried in the following sequence as per IEC 60076-3:2013 clause 7.2.3:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable). This test may be carried out followed by LI & SI test.
f) Short time over voltage Test (830kVrms) for 765kV Reactor
g) Induced voltage test with partial discharge measurement (IVPD)

Oil Sample shall be taken before starting and after completion of dielectric tests for DGA. In case any abnormality during testing, oil samples may also be taken for DGA.

7.1 **Full wave lightning impulse test (LI) & chopped wave lightning impulse test (LIC)**

Reference Standard:

IEC 60076-3:2013, IEC 60060-1(General definitions of terms related to impulse tests and requirements for test circuits), IEC 60060-2 (measuring devices) & IEC 60076-4 & IEEE Std C57.98-1993

General
For liquid-immersed transformers, the test voltage is normally of negative polarity, because this reduces the risk of erratic external flashovers in the test circuit.

Tap positions
If the tapping range is ± 5 % or less and the rated power of the transformer is ≤ 2 500 kVA then, the lightning impulse tests shall be made with the transformer connected on the **principal tapping**.

If the tapping range is larger than ± 5 % or the rated power of the transformer is > 2 500 kVA then, the two extreme tappings and the principal tapping shall be used, one tapping for each of the three individual phases of a three-phase transformer or the three single-phase transformers designed to form a three-phase bank.

Records of tests

1. Applied Voltage; the records obtained shall clearly show the applied voltage impulse shape (front time, time-to-half value and amplitude).

   The recorded curve and the extreme value of the recorded curve (as defined in IEC 60060-1) shall be presented in the test record.

   The value of the test voltage (after the application of any filtering or correction for overshoot, U_t see IEC 60060-1) shall be reported in the test record.

2. At least one more measurement channel shall be used. In most cases an oscillogram of the current flowing to earth from the tested winding (neutral current). Further recommendations about failure detection, suitable time-base durations, etc. are given in IEC 60076-4.

Test connections

Test connections for lightning impulse on the Line Terminals

The impulse test sequence is applied to each of the line terminals of the tested winding in succession. The other line terminals of the transformer shall be earthed directly or, if needed to achieve the required wave shape, through an impedance. The impedance shall not exceed the surge impedance of the connected line (if a value is supplied by the purchaser) or 400 Ω whichever is lower. In all circumstances, the voltage appearing during the impulse test at the other line terminals shall not be more than 75 % of their rated lightning impulse withstand voltage for star-connected

windings, or 50 % for delta-connected windings. The lowest value of impedance at each terminal needed to achieve the required wave shape shall be used.

If the winding has a neutral terminal, the neutral shall be earthed directly or through low impedance such as a current measuring shunt. The tank shall be earthed. If the required wave shape cannot be obtained without the use of a resistor between neutral and earth, then an additional complete impulse test sequence shall be applied. In this case the first impulse test sequence tests the winding at the full voltage without the resistor but the required wave shape may not be achieved and the second sequence with the resistor achieves the wave shape. Chopped waves, if required, would not be repeated in the second sequence.

When a transformer is fitted with internal non-linear elements such as surge arresters which will limit the voltage on internal parts during the impulse test then the provisions of Clause 13.2.3 of IEC 60076-3 apply. Any such internal non-linear elements which are present in the service condition shall be present during the tests. External non-linear elements and other external voltage control elements such as capacitors shall be disconnected for test.

The impulse circuit and measuring connections shall remain unchanged during reference and full voltage tests

Test connections for lightning impulse on Line terminals

Lightning impulses are applied directly to the neutral with all other terminals earthed.

Full wave lightning impulse test (LI)

Wave shape, determination of test voltage value and tolerances

The test impulse shall be a full standard lightning impulse: 1.2 ± 30 % / 50 μs ± 20 %.

The test voltage value shall be the test voltage value as defined specification If the maximum relative overshoot magnitude is 5 % or less, the test voltage value may be taken as the extreme value as defined in specification.

The tolerance on the test voltage value is ± 3 %.

If the standard impulse shape cannot reasonably be obtained because of low winding inductance or high capacitance to earth and the resulting impulse shape is oscillatory so that the relative overshoot magnitude exceeds 5 % then for windings that will receive a chopped wave lightning impulse test, the front time may be increased to reduce the overshoot. In all cases with Um ≤ 800 kV the front time shall not exceed 2.5 μs. If the relative overshoot magnitude exceeds 5 % at the full wave voltage level, then a test voltage function shall be applied in accordance with IEC 60060-1 to determine the test voltage value. It is permissible to apply the requirements of IEC 60060-1 Annex B to the evaluation of the parameters of the lightning impulse irrespective of the overshoot value.

NOTE
Case of overshoot of more than 5 % the peak voltage of the impulse (maximum value of the recorded curve) shall be increased and the frequency of oscillation is higher than about 100 kHz by the application of the test voltage function in accordance with IEC 60060-1.

Tests on transformers without non-linear elements

Test sequence

The test sequence shall consist of:

a) one reference impulse of a voltage between 50 % and 70 % of the full test voltage
b) Three subsequent impulses at full voltage.

If, during any of these applications, an external flashover in the circuit or across a bushing spark gap occurs, or if the recording fails on any of the specified measuring channels, that application shall be disregarded and a further application made.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report.

Test acceptance criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference impulse and those recorded at the full test voltage.

NOTE

The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure shall be clearly stated in the report. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

If non-linear elements or surge arresters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold. The test sequence shall consist of:

a) one reference impulse at between 50 % and 60 % of the full test voltage;
b) one reference impulse at between 60 % and 75 % of the full test voltage;
c) one reference impulse at between 75 % and 90 % of the full test voltage;
d) three consecutive 100 % full wave impulses;
e) a comparison impulse at as nearly as possible the same voltage as c) above;

f) a comparison impulse at as nearly as possible the same voltage as b) above;
g) A comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage record of the reference impulse records, then impulses e), f) and g) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full
test voltage. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and g)
– b) and f)
– c) and e)
– all the 100 % level impulse records.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records are progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE
Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Chopped wave lightning impulse test (LIC)

Wave shape

The chopped wave lightning impulse shall have a time to chopping between 3 μs and 6 μs. The time to first voltage zero after the instant of chopping shall be as short as possible. The test shall be made without the deliberate addition of impedance in the chopping circuit, but if the overswing observed during a reduced voltage application is more than 30 % then the minimum impedance required to bring the over swing below 30 % may be added to the chopping circuit.

NOTE

Transformers are normally designed to withstand an over swing to the opposite polarity of 30 % of the amplitude of the chopped wave lightning impulse. Usually, the same settings of the impulse generator and measuring equipment are used, and only the chopping gap equipment is added.

Different time bases may be used to record the chopped wave lightning impulses. It is recommended to use a triggered-type chopping gap with adjustable timing, although a plain rod-rod gap is allowed. The peak value of the chopped wave lightning impulse shall be 110 & of rated impulse voltage.

Tests on transformers without non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence. The order of the different impulse applications shall be:

a) one full wave reference impulse at between 50 % and 70 % of the full wave lightning
b) impulse test voltage;
c) one full wave impulse at the full wave lightning impulse test voltage;
d) two chopped impulses at the chopped wave lightning impulse test voltage;
e) Two full wave impulses at the full wave lightning impulse test voltage.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. As far as possible the same time to chop shall be used for all chopped wave lightning impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference reduced level full impulse and those recorded at the full test voltage including the chopped impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap.

NOTE
The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure requires a great deal of skill and experience. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence.
If non-linear elements or surge diverters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold.

The test sequence shall consist of:
a) one full wave reference impulse at between 50 % and 60 % of the full wave lightning impulse test voltage;
b) one full wave reference impulse at between 60 % and 75 % of the full wave lightning impulse test voltage;
c) one full wave reference impulse at between 75 % and 90 % of the full wave lightning impulse test voltage;
d) one full wave impulse at the full wave lightning impulse test voltage;
e) two chopped impulses at the chopped wave lightning impulse test voltage;
f) two full wave impulses at the full wave lightning impulse test voltage;
g) a comparison impulse at as nearly as possible the same voltage as c) above;
h) a comparison impulse at as nearly as possible the same voltage as b) above;
i) a comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage of the reference impulse record then impulses g), h) and i) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than 75 % of the full level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. The same types of measuring channels and oscillographic records are specified as for the full wave impulse test. As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full test voltage including the chopped wave impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and i);
– b) and h);
– c) and g);
– all the 100 % level impulse records;
– both the chopped wave records up to the time of chop.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records should be progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE

Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

NOTE

The information given in IEC 60076-4 with reference to waveshape evaluation is based on the visual observation of oscillographic records. Under certain circumstances it might be appropriate to evaluate the waveshape parameters of non-standard waveshapes and perform the interpretation of deviations manually rather than relying completely on software tools.

Lightning impulse test on a neutral terminal (LIN)

General
Full wave lightning impulses at the impulse voltage level specified for the neutral are applied directly to the neutral with all other terminals earthed.

Waveshape
The wave shape of the full wave impulses shall be as given in 13.2.1 of IEC-60076-3 except that the duration of the front may be up to a maximum of 13 μs.

Test sequence
The test sequence shall be as given in clause 13.2.2.1 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.1 of IEC-60076-3for transformers with a non-linear element.

Test criteria

The test criteria shall be as given in clause 13.2.2.2 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.2 of IEC-60076-3 for transformers with a non-linear element.

7.2 **Switching impulse test**

Standards:

IEC 60076-3, 60076-4, IEC 60060-1 (for Reactor IEC 60076-6) & IEEE Std C57.98-1993

General

During switching impulse tests, the voltages developed across different windings are approximately proportional to the ratio of numbers of turns. The switching impulse test voltage shall be as specified for the winding with the highest *U*m value. If the ratio between the windings is variable by tappings, the tappings shall be used to bring the test voltage for the winding with lower *U*m as close as possible to the corresponding test value given in Table 2 of IEC-60076-3.

The windings with lower *U*m values may not receive their full test voltage; this shall be accepted. In a three-phase transformer, the voltage developed between line terminals during the test shall be approximately 1.5 times the voltage between line and neutral terminals.

Test Connection

The impulses are applied either directly from the impulse voltage source to a line terminal of the highest voltage winding, or to a lower voltage winding so that the test voltage is inductively transferred to the highest voltage winding. The specified test voltage shall appear between the line terminal of the highest voltage winding and earth. The voltage shall be measured at the line terminal of the highest voltage winding. A three-phase transformer shall be tested phase by phase.

Star connected windings with the neutral brought out shall be earthed at the neutral terminal either directly or through a low impedance such as a current measuring shunt. A voltage of opposite polarity and about half amplitude appears on the two remaining line terminals which may be connected together but not connected to earth. To limit the voltage of opposite polarity to approximately 50 % of the applied level, it is permissible to connect high resistance damping resistors (5 kΩ to 20 kΩ) to earth at the non-tested phase terminals.

For delta connected windings the terminal corresponding to the end of the phase under test shall be earthed either directly or through a small measuring impedance, the other terminals shall be open circuit. Tests on a three-phase transformer shall be arranged so that a different terminal of the delta is earthed for each phase test. Delta connected windings with more than three terminals brought out shall have the delta closed for the test.

For a single phase transformer with one or more windings which will have both ends connected to a line in service and with a switching impulse test specified, then the switching impulse test shall be applied to both ends of the winding.

Bushing spark gaps may be removed or their spacing increased to prevent spark over during the test.

Reactor shall also be tested by the method mentioned above. However, additionally for reactor, clause 8.3 of IEC 60076-4 may also be referred. Since there is only one winding per phase, the application point for the test voltage is the line terminal of the phase winding which is to be tested. The other terminal of this phase winding should be earthed.

For three-phase reactors, the normal impulse test procedures as used for lightning impulse tests are required.

Wave shape

The test voltage is normally of negative polarity to reduce the risk of erratic external flashover in the test circuit.
The voltage impulse shall have a time to peak (*T*p as defined in IEC 60060-1) of at least 100 μs, a time above 90 % (*T*d as defined in IEC 60060-1) of the specified amplitude of at least 200 μs, and a time to zero (*T*z as defined in IEC 60060-1) of a minimum of 1000 μs.

Normally the transformer characteristic of Td ≥ 200 μs is not a problem for small reactors (<100 Mvar for three-phase reactors with relatively high impedances). For large reactors, Td and Tz as specified for transformers would require excessive impulse generator extension. For such cases, a minimum value for Td and Tz should be 120 μs and 500 μs respectively to assure adequate volt-time stress.

Test Sequence

The test sequence shall consist of one reference impulse of a voltage between 50 % and 70 % of the full test voltage and three impulses at full voltage. Sufficient reverse polarity applications shall be made before each full impulse to ensure the magnetization of the core is similar before each full wave impulse in order to make the time to first zero as uniform as possible.

Oscillographic records shall be made of the impulse wave-shape on the line terminal under test and the current between the tested winding and earth. If during any of these applications an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

Acceptance Criteria

The test is successful if there is no sudden collapse of voltage or discontinuity in the voltage or current indicated on the oscillographic records.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the oscillographic records, but they do not constitute evidence in themselves.

7.3 Applied voltage test (AV)

The test shall be carried out on each separate winding of the transformer in turn.

The full test voltage shall be applied for 60 s between all accessible terminals of the winding under test connected together and all accessible terminals of the remaining windings, core, frame and tank or casing of the transformer, connected to earth.

The test shall be made with an approximately sinusoidal single-phase alternating voltage at rated frequency. The peak value of voltage shall be measured. The peak value divided by √2 shall be equal to the test value.

NOTE
Approximately sinusoidal can be taken to mean that the peak value divided by √2 does not differ from the r.m.s value of the waveform by more than about 5 % (see IEC 60060-1), but wider deviations may be accepted.

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

For windings with non-uniform insulation, the test is carried out with the test voltage specified for the neutral terminal. In transformers where windings having different U_m values are connected together within the transformer (usually auto-transformers), the test voltages shall be determined by the insulation of the common neutral and it's assigned U_m.

7.4 Line terminal AC withstand test (LTAC)

The test shall be arranged so that the test voltage appears between the tested terminal and earth. Each phase terminal of the tested winding shall be tested in turn. The test time, frequency and voltage application shall be same as Induced voltage withstand test (IVW).

$$\text{Test time in Seconds} = 120 \times \frac{\text{rated frequency}}{\text{test frequency}}, \text{ but not less than 15 s}$$

For transformers with taps and a non-uniformly insulated lower voltage winding, the tap position for test shall be selected so that when the required test voltage appears on the highest voltage winding terminals, the voltage appearing on the lower voltage winding terminals shall be as close as possible to the required test value. For transformers with a uniformly insulated lower voltage winding subject to an applied voltage test, the tap position may be chosen by the manufacturer.

The test is successful if no collapse of the test voltage occurs.

NOTE
This test is intended only as a withstand test for each line terminal of a non-uniformly insulated transformer to earth, it is not intended to test the phase to phase or turn to turn insulation so the test arrangement can be made in any convenient way, for example with voltage at the neutral to reduce the turn to turn voltage and the test will normally be carried out as three single phase tests. Partial discharge measurements can be made during this test.

7.5 Induced voltage withstand test (IVW)

The test time at full test voltage shall be 60 s for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

$$120 \times \frac{\text{rated frequency}}{\text{test frequency}}, \text{ but not less than 15 s}$$

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

7.6 Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse

The voltage shall be applied on the phase for which transferred surge shall be measured in the same phase of tertiary (i.e. if voltage is applied on 1W, the transferred surge shall be measured at 3W terminal). The above process shall be repeated for the remaining HV & IV terminals.

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap (if applicable). However, applied voltage shall be selected such a way that induced voltage at other winding should not go more than the SI limit of that winding.

Following tests shall be carried out with applying 50% to 80% of rated Impulse & Switching impulse (upto 60% for IV to limit the max. limit of HV SI level) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

For each tap position, atleast 2 nos. shots (for LI - one at approx. 50% and other at approx. 80% and for SI – one at approx. 40% & at approx. 60%*) shall be applied and measured values shall be extrapolated to 100%. Measured and extrapolated values shall be recorded.

Transformer with non-linear element in the winding

If Lightning Arrestor (or **non-linear element)** is connected with tertiary or LV to limit the surges, transfer surge shall be carried out with LA (as to be connected in service) during Test at factory for HV and IV lightning & switching impulse Test. In that case applied voltage shall be raised gradually to the level where the LA shall operate/actuate. It shall be below the impulse / SI level of LV or tertiary winding.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

1-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1.1	2.1, N & 3.2	-	3.1
2	FW	1.1	2.1, N & 3.1	-	3.2
3	FW	2.1	1.1, N & 3.2	-	3.1
4	FW	2.1	1.1, N & 3.1	-	3.2

Where,

1.1 : HV Terminal
2.1 : IV Terminal
3.1 & 3.2 : LV or Tertiary Terminal

(*): Should not reach beyond the SI limit of HV winding

3-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
5	FW	1U	1V, 1W, 2U, 2V, 2W, N, 3V & 3W	-	3U
6	FW	1V	1U, 1W, 2U, 2V, 2W, N, 3U & 3W	-	3V
7	FW	1W	1U, 1V, 2U, 2V, 2W, N, 3V & 3U	-	3W
8	FW	2U	1U, 1V, 1W, 2V, 2W, N, 3V & 3W	-	3U
8	FW	2V	1U, 1V, 1W, 2U, 2W, N, 3U & 3W	-	3V
9	FW	2W	1U, 1V, 1W, 2U, 2V, N, 3V & 3U	-	3W

Acceptance criteria

Transfer surge at Tertiary should not exceed the rated impulse level of that winding. The extrapolated values measured at 50% and 80% (for LI) or 40% and 60% (for SI) as stated above shall be approximately matched.

When non-linear element is connected in the winding, the non-linear element should limit the transferred voltage below the rated impulse level of that winding. LA / nonlinear element shall operate/actuate below the impulse level of Tertiary or LV winding.

7.7 Induced voltage test with partial discharge measurement (IVPD)

Standards

IEC 60076-3, IEC 60270 & POWERGRID Technical Specification for Transformers & Reactors.

General

This test is intended to verify that the transformer will be free of harmful partial discharges under normal operating conditions. The test voltage is applied in the same way as the voltage that the transformer will experience in service. During the test, symmetrical voltages appear at all the line terminals and between turns, **with no voltage at the neutral**. The test is performed with a three phase voltage on three phase transformers

Each PD measurement channel including the associated bushing or coupling capacitor shall be calibrated in terms of apparent charge (pC) according to the method given in IEC 60270.

Voltage calibration to be done to check the test voltages to be applied as per test sequence given below before start of PD Test as there is no option of keeping the voltage divider connected to the transformer for voltage measurement continuously during PD test.

The PD measurement shall be given in pC and shall refer to the highest steady-state repetitive impulses indicated by the measuring instrument**. Occasional bursts of high partial discharge level may be disregarded.**

If high partial discharge is coming repeatedly, and may be due to external reason, manufacturer should improve the system and bring the value to ambient level before starting the PD cycle.

For each required PD measurement step in the test sequence, PD measurements shall be made and recorded on all the line terminals equipped with bushings with a Um ≥ 72.5 kV, during the test, however if there are more than six such terminals then only six measurements need to be made (one on each of the highest voltage terminals) unless otherwise specified.

Test sequence

The test sequence shall be as follows:

a) The voltage shall be switched on at a voltage not higher than $(0.4 \times Ur)/\sqrt{3}$.
b) The voltage shall be raised to $(0.4 \times Ur)/\sqrt{3}$ and a background PD measurement shall be made and recorded.
c) The voltage shall be raised to $(1.2 \times Ur)/\sqrt{3}$ and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
d) The PD level shall be measured and recorded.
e) The voltage shall be raised to the one hour PD measurement voltage and held there for a minimum duration of 5 min and only long enough to make a stable PD measurement.
f) The PD level shall be measured and recorded.
g) The voltage shall be raised to the enhancement voltage and held there for the test time mentioned below.

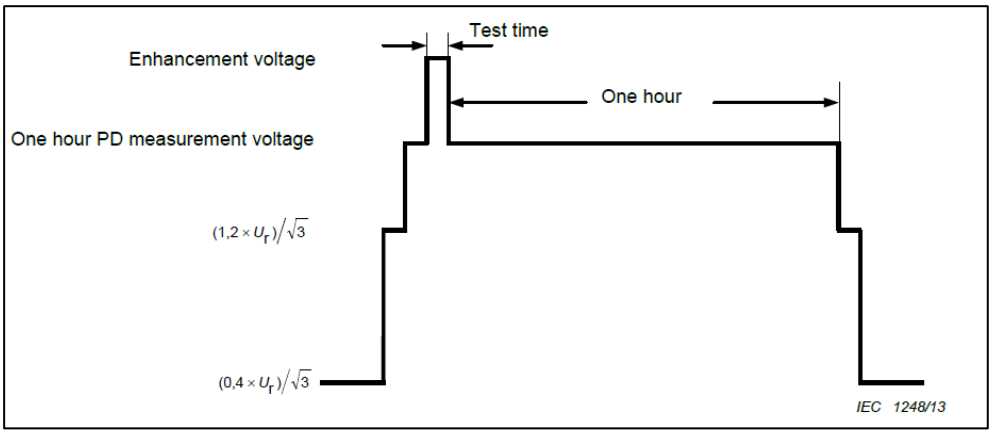
h) Immediately after the test time, the voltage shall be reduced without interruption to the one hour PD measurement voltage.
i) The PD level shall be measured and recorded.
j) The voltage shall be held at the one-hour PD measurement voltage for a duration of at least one hour following the PD measurement.
k) The PD level shall be measured and recorded every 5 min during the one hour period.
l) After the last PD measurement in the one hour period the voltage shall be reduced to (1.2 × Ur) /√3 and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
m)The PD level shall be measured and recorded.
n) The voltage shall be reduced to (0.4 × Ur) /√3 and the background PD level shall be measured and recorded.
o) The voltage shall be reduced to a value below (0.4 × Ur) /√3.
p) The voltage shall be switched off.

An enhancement (phase to earth) voltage level of (1.8 × Ur) /√3 and a one hour PD measurement voltage of (1.58 × Ur) /√3. Alternative higher voltage levels may be used if specified by the purchaser. In particular an enhancement voltage of Um and a one hour PD measurement voltage of (1.5 × Um) /√3 may be used if higher.

The partial discharge level shall be continuously observed on at least one measuring channel for the entire duration of the test.

During the test sequence the inception and extinction voltages of any significant PD activity should be noted to aid the evaluation of the test result if the test criteria are not met.

Test sequences are illustrated in below figure.



Test Duration & Frequency

The test time at the enhancement voltage shall be 60 s in case *U*m ≤ 800 kV and 300 s in case U_m > 800 kV for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

120 × rated frequency / test frequency, but not less than 15 s for *U*m ≤ 800 kV

The duration of the test, except for the enhancement level, shall be independent of the test Frequency.

Test acceptance criteria

The test can only be considered valid if the measured background PD level does not exceed 50 pC at both the beginning and the end of the test. For tests on shunt reactors a background PD level higher than 50pC may be accepted.

The test is successful if all the following criteria are fulfilled:

a) No collapse of the test voltage occurs;
b) None of the PD levels recorded during the one hour period exceed 100 pC;
c) The PD levels measured during the one hour period do not exhibit any rising trend and no sudden sustained increase in the levels occur during the last 20 min of the test;
d) The measured PD levels during the one hour period do not increase by more than 50 pC;
e) The PD level measured at a voltage level of $(1.2 \times U\text{r})/\sqrt{3}$ after the one hour period does not exceed 100 pC.
f) If the criteria c) or d) are not met, the one hour period may be extended and these criteria will be considered to have been met if they are fulfilled for a continuous period of one hour.

Check points:

1. For 3-Ph Transformer/Reactor, IVPD test shall be carried out by 3-Phase supply

2. Before start of the test, all parameters / data used for PD testing and mentioned in the computer software to be checked with calibrated result of the instrument.

3. In case of doubt, change of PD measuring channel, creating PD temporarily, and check the healthiness of the measuring channel.

4. Before and after the PD test, calibration of the channel and measuring circuit to be repeated.

5. Continuous PD recording (if facility available) to be carried out for reference.

8. Temperature Rise Test on Transformer

Reference Standard:

IEC 60076-1 Edition 3.0 2011-04 Clause 11.4 Measurement of short-circuit impedance and load loss & IEC 60076-2 Edition 3.0 2011

For each cooling combination with cooler bank, tests shall be done for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.

The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181. The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

Temperature of the cooling media

Ambient temperature

For the temperature rise test, the cooling air temperature should be in the range between 10 °C and the maximum ambient temperature 50 °C for which the transformer is designed.

At least four sensors shall be provided and the average of their readings shall be used to determine the ambient temperature for the evaluation of the test results.

Around an ONAN transformer, the ambient sensors shall be placed at a level about half-way up the cooling surfaces. The sensors shall be distributed around the tank, about 2 m away from the perimeter of tank and cooling surfaces, and protected from direct heat radiation.

For a forced-air-cooled (ONAF, OFAF, ODAF) transformer the sensors shall be placed in the air at about 0.5 m from the intake of the coolers.

Readings should be taken at regular intervals (30 minutes). Automatic continuous recording may be used.

In the case of separate cooling equipment placed at a distance of at least 3 m from the transformer tank, the ambient temperature shall be measured around the cooling equipment applying the same

rules given above. For separate cooler bank arrangement (distance of at least 3 m from the transformer tank) 4 numbers sensors shall be used to measure the ambient temperature.

Attention shall be paid to possible recirculation of hot air. The transformer should be placed so as to minimize obstructions to the air flow and to provide stable ambient conditions.

Total loss injection

The Contractor before carrying out this test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that result in highest temperature rise for the test. The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

2-Winding Transformer

Load Loss measurement for HV-LV connection and at Normal & extreme taps) shall be carried out. For 2-winding transformer, total losses to be fed during temperature rise test shall be **2-Winding Loss at tap corresponding to maximum measured loss and No load loss.**

2-Winding Loss = [HV-LV] (Max MVA)

The total losses to be injected during the first part of the test shall be equal to the highest value of total loss appearing at any tapping (corresponding to the particular tapping). This tapping is also often, but not always, the maximum current tapping. This part of the test determines the maximum top-liquid temperature rise. For the determination of winding temperature rise at the maximum current tapping, the value of liquid temperature rise to be used in the evaluation shall correspond to the total losses of that tapping.

3-Winding Transformer

Load Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps) shall be carried out. The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer. Total losses to be fed during temperature rise test shall be **3-Winding Loss and No load loss.**

3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (Max MVA)

The injection of total loss for the determination of liquid temperature rise may be made in an approximate manner by not short-circuiting or closing certain windings. The total losses shall be fed to HV or IV while LV winding is left open and raise the current until the correct total loss is obtained.

The top-liquid temperature and cooling medium temperature are monitored, and the test is continued until steady-state liquid temperature rises are established. The first part of the test may be terminated when the rate of change of top-liquid temperature rise has fallen below 1 K/h and has remained there for a period of 4 h. If discrete readings have been taken at regular intervals, the mean value of the readings during the last hour is taken as the result of the test. If continuous automatic recording is applied, the average value during the last hour is taken.

After the top-liquid temperature rise has been established, the test shall be continued without a break with the test current reduced to rated current for the winding combination connected. This condition is maintained for 1 h, during which time continuous temperature records of top-liquid, winding hot-spot (if measured) and external cooling medium should be taken at least every 15 min.

At the end of the hour, the resistances of the windings are measured, either after a rapid disconnection of the supply and short circuits (IEC 60076-2 clause 7.8 and Annex C) or, without switching off the supply, by means of the superposition method which consists of injecting into the windings and measuring direct current of low value superimposed on the load current. In the similar way winding hotspot, average winding rise etc. shall be measured for tertiary winding for various cooling.

Determination of liquid temperatures

Top-liquid temperature

The top-liquid temperature (θo) is conventionally determined by one or more sensors immersed in the insulating liquid at the top of the tank or, in pockets in the cover. The recommended number of pockets is the following:

− rated power ≥ 100 MVA: 3 pockets;
− rated power from 20 MVA to <100 MVA: 2 pockets;
− rated power < 20 MVA: 1 pocket.

The position of the sensors should be chosen to present the top-liquid temperature possibly in correspondence to the wound columns.

If more than one pocket is used, the readings of the sensors shall be averaged in order to obtain a representative temperature value.

Bottom and average liquid temperatures

The bottom liquid temperature (θb) shall be determined by sensors placed at the return headers from coolers or radiators. If several banks of cooling equipment are fitted, more than one sensor should be used and the reading average assumed as bottom liquid temperature.

Average liquid temperature (θom) is used for the calculation of the average winding gradient and correction of certain temperature rise test results. The average liquid temperature is:

$\theta om = (\theta o + \theta b)/ 2$

Determination of top, average and bottom liquid temperature rises

The top-liquid temperature rise ($\Delta\theta o$) shall be determined by difference between the top-liquid temperature measured at the end of the test period with total losses (θo) and the external cooling medium temperature at the end of the test period with total losses (θa), that is:

$\Delta\theta o = \theta o - \theta a$

The average liquid temperature rise (Δθom) shall be determined by difference between the average liquid temperature (θ om) calculated according to 4.2 and the external cooling medium temperature (θa), that is:

Δθom =θom –θa

The bottom liquid temperature rise (Δθb) shall be determined by difference between the bottom liquid temperature (θb) defined according to clause 7.4.2 of IEC 60076-2 and the external cooling medium temperature (θa), that is:

Δθb =θb –θa

Determination of average winding temperature

The average winding temperature is determined by measurement of winding resistance. On three-phase transformers, the measurement should be normally performed including the middle phase of the windings.

For star connected, low voltage and high current windings, the measurement should be made between line terminals in order to exclude the neutral connection from the test circuit. A reference measurement (R1,θ1) of all winding resistances is made with the transformer at ambient temperature, in a steady-state condition (see IEC 60076-1).

When the resistance (R2) is measured after disconnection of the power supply, extrapolated to the instant of shutdown, this yields the temperature value:

$$\theta_2 = \frac{R_2}{R_1}(235 + \theta_1) - 235 \qquad \text{for copper}$$

Where θ2 is the average temperature of the winding at the instant of shutdown. In the formula, the temperatures are expressed in Celsius degrees.

Determination of winding resistance at the instant of shutdown

The winding resistance (R2) before shutdown shall be determined using the rules indicated below.

Immediately after disconnection of the test power supply and removal of the short-circuiting connection, a direct current measuring circuit shall be connected across the winding terminals corresponding to the resistance to be measured.

As the resistance of the winding varies with time as the winding cools down, it shall be measured for a sufficient time to permit extrapolation back to the instant of shutdown.

As the windings have a large electrical time constant (L/R), accurate readings are therefore obtained only after a certain delay.

The delay can be reduced by minimizing as much as possible the time between the shutdown and the switching on the resistance circuit, as well as reducing the electrical time constant by an adequate choice of the parameters of the circuit.

The cooling conditions should preferably not be disturbed during the time the resistance measurements are made. If pumps are operating during the temperature rise test, they should be maintained during the measurements.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. Resistance shall be measured for atleast 30 minutes.

Determination of average winding temperature rise at the instant of shutdown

The average winding temperature rise shall be determined using the value of resistance at the instant of shutdown. The corrected winding average temperature rise of the winding ($\Delta\theta w$) is:

$\Delta\theta\ w = \theta 2 + \Delta\theta\ ofm - \theta\ a$

where $\theta 2$ is the average winding temperature at the instant of shutdown, θa is the external cooling medium temperature at the end of the test period with total losses, $\Delta\theta ofm$ the fall of the temperature of the average liquid during the 1 h test at rated current.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. The calculation details, Graph with Annexure C (duly filled) shall be submitted with temperature rise test result.

After hot resistance measurement of HV and IV winding, Tertiary winding shall be loaded at rated MVA (of LV) for 1 hour. After it, hot resistance measurement shall be carried for LV winding. The above sequence shall be followed for all cooling combinations (ONAN/ONAF/OFAF as applicable).

Determination of the average winding to liquid temperature gradient

The average winding to average liquid temperature gradient (g) shall be determined as the difference between the uncorrected average winding temperature ($\theta 2$) and the average liquid temperature θom at shutdown:

$g = \theta 2 - \theta om.$

Determination of the hot-spot winding temperature rise

Direct measurement during the temperature rise test

A number of thermal sensors (e.g., optical fibre sensors) shall be mounted inside the windings in positions where it is supposed the hot-spots are located.

When more than one sensor is used on the same winding, the maximum reading shall be taken as the hot-spot winding temperature.

The hot-spot winding temperature rise ($\Delta\theta h$) is then obtained by:

$\Delta\theta h = \theta h + \Delta\theta of - \theta a$

where θh is the temperature reading at shutdown, Δθ of the fall of the top-liquid temperature during the 1 h test at rated current, and θa the ambient temperature at the end of the total loss test period.

Determination by calculation

The hot-spot winding temperature rise can be determined using the following equation:

$\Delta\theta h = \Delta\theta o + Hg$

The average thermal gradient between each winding and liquid along the limb (g) is taken as the difference between the average winding temperature rise ($\Delta\theta w$) and average liquid temperature rise ($\Delta\theta om$).

(g)= ($\Delta\theta w$) - ($\Delta\theta om$).

H = Hotspot factor = 1.3 (As per existing practice) and also furnish the design calculate of this factor in line with IEC. Derive winding hotspot rise based on above factors and values should not exceed the guaranteed parameters for both the cases.

Hotspot temperature rise shall be measured by direct FO sensors and shall be recorded for reference only.

Calculation of Hotspot factor as per IEC 60076-2 shall also be furnished during design review.

The format of measuring parameters is attached at Annexure-I.

ANNEXURE-I

TRANSFORMER SR. NO.			
TRANSFORMER RATING :			WNDING
COOLING :			
The top-liquid temperature (θo)	(θo)	^{o}C	
The bottom liquid temperature (θb)	(θb)	^{o}C	
External cooling medium temperature at the end of the test period with total losses (θa)	(θa)	^{o}C	
The average liquid temperature θom	= (θo +θb)/ 2	^{o}C	
The top-liquid temperature rise (Δθo)	Δθo =θo −θa	^{o}C	
The average liquid temperature rise (Δθom)	=θom −θa	^{o}C	
Winding			
Average winding temperature at the instant of shutdown, θ2	θ2	^{o}C	
Fall of the temperature of the average liquid during the 1 h test at rated current , Δθofm	Δθ ofm	^{o}C	
The corrected winding average temperature rise of the winding Δθw	=θ2 + Δθofm −θa	^{o}C	
The average winding to average liquid temperature gradient (g) (Uncorrected)	g =θ2 −θom	^{o}C	
Temperature reading at shutdown by fiber optic sensor (direct reading), θh	θh	^{o}C	
The top-liquid temperature during the 1 h test at rated current, Δθof	Δθof	^{o}C	
The average winding to average liquid temperature gradient (g) (corrected)	g =g (uncorrected)+Δθofm	^{o}C	
The hot-spot winding temperature rise (Δθh)	=θh + Δθof −θa	^{o}C	
The average thermal gradient of Winding, (g)	= (Δθw) - (Δθom)	^{o}C	
Calculated Hotspot rise (Δθh) [where Hotspot factor, H = 1.3]	=Δθo +H g	^{o}C	
Hotspot rise (Δθh) [where design Hotspot factor, H = to be furnished by manufacturer]	=Δθo +H g	^{o}C	
Top liquid temperature rise		**^{o}C**	
HV Winding average temperature rise		**^{o}C**	
The hot-spot winding temperature rise (Δθh) by fiber optic sensor (reference purpose)		**^{o}C**	
The hot-spot winding temperature rise (Δθh) by conventional method		**^{o}C**	
The hot-spot winding temperature rise (Δθh) considering design hotspot factor and measured top oil rise.		**^{o}C**	

9. Overload testing in short-circuit method

The test shall be carried out on the tapping position that will cause the highest current under normal conditions. Hot spot temperature measurement shall be done by using temperature probes or sensors in approved locations.

The transformer shall be fully erected as for service with all cooling equipment.

I. Testing option 1:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with cooling as for service conditions.

- Increase the loading to 120% overload rating. Forced cooling shall be activated as per service conditions.
- Scan and record infra-red images of all four sides and the top of the transformer at the interval of every one hour.
- Hold the overload current for a period of 4 hours.
- Measure and record the hotspot temperatures (by resistance method & fiber optic sensors).

II. Testing option 2:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with 100% cooling as per service conditions.

- Increase the loading to 130% overload rating.
- Scan and record infra-red images of all four sides and the top of the transformer every 30 minutes.
- Hold the current at 130% for a period of 2 hours.
- Measure and record the hotspot temperature (by resistance method & fiber optic sensors).

III. Acceptance criteria:

Winding hotspot temperatures shall not exceed 130°C for option 1 and 135 °C for option 2.
The temperature rise recorded by infra-red shall be not more than 10°K above top oil temperature or 15°K above the local oil temperature.
The rate of gas development as determined from oil samples shall be determined. Samples shall be taken before and after the test and acceptance criteria shall be in accordance with IEC/IEEE guidelines.

IV. Test records:

Full details of the test arrangements, procedures and conditions shall be supplied with the test certificates and shall include the following:

- Purchaser’s reference number and site designation
- Manufacturer’s name and transformer serial number
- MVA rating and voltage ratio
- Vector group

- Altitude of test bay
- Designation of terminals supplied and terminals strapped
- Colour photographs of the four sides and top of the transformer.

V. Overload test:

A log of the following quantities taken at a minimum of 30-minute intervals:

- time
- voltage between phases
- current in each phase
- power in each phase and total power
- ambient temperature
- top oil temperature
- FO sensors readings

10. Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

The cooling down trend shall be observed by recording top and bottom oil temperature and winding resistance.

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow. FO sensors data shall be recorded during the test.

11. Over excitation test

A routine over excitation test at 1.05 p.u voltage for 12 hours shall be done on the tap position giving the highest flux. This test shall be carried out immediately after the routine short-term heat run test on the transformer. The rate of gas development during the test shall be evaluated using IEEE /IEC/CIGRE guidelines. FO sensors data shall be recorded during the test.

12. Measurement of zero-sequence impedance(s) on three-phase transformers/reactors

Standards: IEC 60076-1:2011, IEC 60076-8

General

In the case of transformers having more than one star-connected winding with neutral terminal, the zero-sequence impedance is dependent upon the connection.

The zero-sequence impedance may have several values because it depends on how the terminals of the other winding or windings are connected and loaded.

The zero-sequence impedance may be dependent on the value of the current and the temperature, particularly in transformers without any delta-connected winding.

The zero-sequence impedance may also be expressed as a relative value in the same way as the (positive sequence) short-circuit impedance

Test Procedure

The zero-sequence impedance is measured at rated frequency between the line terminals of a star-connected or zigzag-connected winding connected together, and its neutral terminal. It is expressed in ohms per phase and is given by $(3U/I)$, where U is the test voltage and I is the test current. The test current per phase $(I/3)$ shall be stated in the test report.

It shall be ensured that the current in the neutral connection is compatible with its current carrying capability.

In the case of a transformer with an additional delta-connected winding, the value of the test current shall be such that the current in the delta-connected winding is not excessive, taking into account the duration of application.

If winding balancing ampere-turns are missing in the zero-sequence system, for example, in a star-star-connected transformer without delta winding, the applied voltage shall not exceed the phase-to-neutral voltage at normal operation. The current in the neutral and the duration of application should be limited to avoid excessive temperatures of metallic constructional parts.

For autotransformers and YY transformers, there are several combinations of tests to perform:
– HV with LV open circuit;
– HV with LV short circuit;
– LV with HV open circuit;
– LV with HV short circuit.
– For YD transformers, the zero sequence impedance is measured from the Y side only.
– Auto-transformers with a neutral terminal intended to be permanently connected to earth shall be treated as normal transformers with two star-connected windings.

Thereby, the series winding and the common winding together form one measuring circuit, and the common winding alone forms the other. The measurements are carried out with a current not exceeding the difference between the rated currents on the low-voltage side and the high voltage side.

For Reactor, this measurement shall be carried out at a voltage corresponding to a neutral current equal to the rated phase current.

NOTE 1 In conditions where winding balancing ampere-turns are missing, the relation between voltage and current is generally not linear. In that case, several measurements at different values of current may give useful information.

NOTE 2 The zero-sequence impedance is dependent upon the physical disposition of the windings and the magnetic parts, measurements on different windings may therefore not agree. In particular, for a transformer with a zigzag winding the zero sequence impedance measured between line terminals connected together and the neutral may result in a different value to that obtained when a three phase symmetrical voltage is applied and one line terminal is connected to the neutral.

NOTE 3 An additional zero-sequence impedance test may be required for transformers with delta windings with two connections to one corner brought out so that it can be either open or closed.

NOTE 4 Further guidance is given in IEC 60076-8.

315MVA, 500MVA 400/220/33kV Transformer Connections

Tap No.	**Current Applied**	**Open Terminals**	**3xU/I**	**%ZO**
1	Between HV (1U, 1V & 1W Shorted) and Neutral	2U, 2V, 2W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		
1	Between IV (2U, 2V & 2W Shorted) and Neutral	1U, 1V, 1W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		

The above measurements shall be repeated with Tertiary terminals shorted. Voltage and current shall be measured and recorded.

13. Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)

Test shall be performed as per IEC 60076-10 and clause 7.8.12 of IEC 60076-6 (for reactor). The measured value shall not be exceeded the limit as specified at Annexure-A of this specification. Sound pressure levels shall be established in line with specification. Sound power level shall be calculated from sound pressure level using the method described in IEC 60076-10. Location of microphones shall be in line with IEC 60076-10.

Important check points

The available frequency response of the measuring instrument shall range from below the rated power frequency to above the upper limit of the human ear capability of 20 kHz.

The upper limit for the actual measurement shall be chosen in accordance with the highest emitted significant frequency, usually below 10 kHz. The selected frequency range for background noise measurements and the test measurement shall be the same.

Sound pressure measurements shall be made using a type 1 sound level meter complying with IEC 61672-1 and IEC 61672-2 and calibrated in accordance with 5.2 of ISO 3746:2010.

The sound pressure method of measurements described in this standard is based on ISO 3746. Measurements made in conformity with this standard tend to result in standard deviations of reproducibility between determinations made in different laboratories which are less than or equal to 3 dB.

The measuring equipment shall be calibrated in accordance with manufacturer's instructions immediately before and after the measurement sequence. If the calibration changes by more than 0.3 dB, the measurements shall be declared invalid and the test repeated.

All measurements shall be made using the energetic average over the measurement duration of the sound quantity (pressure). Statistically derived sound quantities such as percentiles shall not be applied.

The fast response indication of the meter shall be used to identify and avoid measurement errors due to transient background noise.

The sound level measurement is usually of manual operation but the errors introduced by varying distances will tend to average out. Their impact on the final measurement is of less significance than other acoustical factors. Nevertheless, all effort shall be made to keep the measurement distance as constant as possible.

Test Report shall be in line with Annexure-B of IEC 60076-10.

14. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps including spare shall be measured at rated voltage (415V) and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, Applied voltage, measured current, frequency and make shall be furnished in the test report.

15. High voltage with stand test on auxiliary equipment and wiring after assembly

The wiring for auxiliary power, and control circuitry shall be subjected to a 1 min AC separate source test of 2 kV to earth. The test is passed if no voltage collapse or other sign of breakdown occurs.

The wiring for current transformer secondary windings shall be tested at 2.5 kV AC to earth for 1 min. The test shall be carried out at the manufacturer's works. If the current transformer knee-point voltage exceeds 2 kV AC the test shall be performed at 4 kV AC. The test is passed if no voltage collapse or other sign of breakdown occurs.

16. Frequency Response analysis (SFRA)

Frequency Response Analysis (FRA) is conducted to assess the mechanical integrity of the transformer. FRA signatures will be taken at works in oil filled condition after completion of all tests.

It is recommended to follow the standard procedure for the SFRA measurement as per the below Table. It should be done on maximum, normal and minimum tap of the transformer.

Combination of test for Autotransformer

Test Type	Test	3- Phase	1-Phase
Series Winding (Open circuit) All other terminals floating	Test 1	H1-X1	H1-X1
	Test 2	H2-X2	
	Test 3	H3-X3	
Common Winding (Open circuit) All other terminals floating	Test 4	X1-H0X0	X1-H0X0
	Test 5	X2-H0X0	
	Test 6	X3-H0X0	
Tertiary Winding (Open circuit) 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-Y0)
	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	

H1: HV Terminal; X1: IV Terminal; H0X0: Neutral

In case of Shunt Reactor, FRA to be done in following combinations:

- H1-H0
- H2-H0
- H3-H0

17. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil during which no leakage shall occur. Pressure may slightly vary with ambient temperature change during 12 hours.

ii. Vacuum Test

All transformer tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

18. Appearance, construction and dimension check

At Complete assembled transformer, Dimensions, fittings/accessories, clearances shall be verified in line with approved General Arrangement drawing, Bill of material, drawings of other accessories (OLTC, Bushing, Online DGA, Drying system, Buchhoolz relay, PRD, SPR, OTI, WTI, etc. as applicable).

19. Dynamic Short circuit withstand Test

19.1 Reference Standard: IEC 60076-5 (Latest Standard)

19.2 The tests shall be carried out on a new transformer ready for service. Protection accessories, such as gas-and-oil-actuated relay and pressure-relief device, shall be mounted on the transformer during the test. However, Detachable type cooler bank may not be required to install during short circuit test.

19.3 Prior to the short-circuit tests, the transformer shall be subjected to the routine tests and type tests as per POWERGRID specification (including routine tests which are specified in IEC 60076-1). If the windings are provided with tappings, the reactance and, if required, also the resistance shall be measured for the tapping positions at which short-circuit tests will be carried out. All the reactance measurements shall be to a repeatability of better than ±0.2 %. A report containing the result of the routine tests shall be available at the beginning of short-circuits tests.

Manufacturers shall compare the reactance measured at short circuit test lab with the value measured at their manufacturing works before proceeding to short circuit test.

19.4 At the beginning of short-circuit tests, the average temperature of the oil/winding shall preferably be between 10 °C and 40 °C (see 4.2.2.3 of IEC 60076-5).

19.5 During the tests, winding temperature may increase owing to the circulation of the short-circuit current. This aspect shall be taken into consideration when arranging the test circuit for transformers of category I.

19.6 **Test current peak value *î* for two-winding transformers**

The test shall be performed with current holding maximum asymmetry as regards the phase under test. The amplitude $\hat{\imath}$ of the first peak of the asymmetrical test current is calculated as follows:
$\hat{\imath} = I \cdot k \cdot \sqrt{2}$, where I the is symmetrical short-circuit current (see 4.1.2 of IEC 60076-5).
The factor k accounts for the initial offset of the test current and $\sqrt{2}$ accounts for the peak to-r.m.s. value of a sinusoidal wave. The factor $k\sqrt{2}$, or peak factor, depends on the ratio X/R

Where, X is the sum of the reactances of the transformer and the system (Xt + Xs), in ohms (Ω);
R is the sum of resistances of the transformer and the system (Rt + Rs), in ohms (Ω), where Rt is at reference temperature (see 10.1 of IEC 60076-1).

In the case X/R >14 the factor $k \cdot \sqrt{2}$ is assumed to be equal to

1.8 $\sqrt{2}$ = 2.55 for transformers of category II;

1.9 $\sqrt{2}$ = 2.69 for transformers of category III.

19.7 **Tolerance on the asymmetrical peak and symmetrical r.m.s. value of the short-circuit test current**

If the duration of the short-circuit test is sufficiently long, the asymmetrical current having first peak amplitude î will change into the symmetrical current having r.m.s. value I (see 4.1.2 of IEC 60076-5). The peak value of the current obtained in testing shall not deviate by more than 5 % and the symmetrical current by more than 10 % from the respective specified value. However any positive tolerance may be acceptable subject to meeting the other requirements as per IEC.

The short-circuiting of the winding may either follow (post-set short circuit) or precede (pre-set short circuit) the application of the voltage to the other winding of the transformer.

If the post-set short circuit is used, the voltage shall not exceed 1.15 times the rated voltage of the winding

19.8 In order to avoid injurious overheating, an appropriate time interval (minimum 15 minutes between two consecutive shots) shall occur between successive overcurrent applications.

19.9 In order to check the values î and I of the test currents, oscillographic records shall always be taken.

19.10 The frequency of the test supply shall be, in principle, the rated frequency of the transformer.

19.11 Test connection shall be followed as per Clause 4.2.5.4 of IEC 60076-5.

19.12 The number of tests on three-phase and single-phase transformers is determined as follows, not including preliminary adjustment tests carried out at less than 70 % of the specified current to check the proper functioning of the test set-up with regard to the moment of switching on, the current setting, the damping and the duration.

19.13 For categories I, II & III single-phase transformers, the number of tests shall be three. The three tests on a single-phase transformer with tappings are made in a different position of the tap-changer, i.e. one test in the position corresponding to the highest voltage ratio, one test on the principal tapping and one test in the position corresponding to the lowest voltage ratio.\

19.14 For categories I, II & III three-phase transformers, the total number of tests shall be nine, i.e. three tests on each phase. Unless otherwise specified, the nine tests on a three-phase transformer with tappings are made in different positions of the tap changer, i.e. three tests in the position corresponding to the highest voltage ratio on one of the outer phases, three tests on the principal tapping on the middle phase and three tests in the position corresponding to the lowest voltage ratio on the other outer phase (manufacturer may change sequence).

19.15 For particular winding combination (HV-IV, HV-LV or HV-LV) number of shots shall be as per the following:

– for single-phase transformers: three;

– for three-phase transformers: nine.

19.16 For Tertiary winding dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation.

19.17 The duration of each test shall be 0.5 s for transformers of category I & 0.25 s for transformers of categories II and III, with a tolerance of ±10 %.

19.18 Detection of faults and evaluation of test results including acceptance criteria shall be followed as Clause 4.2.7 of IEC 60076-5. However, variations of short-circuit reactance (Acceptable limit) values shall be as per the following :

19.18.1 Transformers of categories I and II

2% for transformers with circular concentric coils and sandwich non-circular coils. However, for transformers having metal foil as a conductor in the low-voltage winding and with rated power up to 10 000 kVA, higher values, not exceeding 4 %,are acceptable for transformers with a short-circuit impedance of 3 % or more.

7,5 % for transformers with non-circular concentric coils having a short-circuit impedance of 3 % or more.

19.18.2 Transformers of categories III

The short-circuit reactance values, in ohms, evaluated for each phase at the end of the tests do not differ from the original values by more than 1 %.

Detail information pertaining to sort circuit test shall be furnished as per the format attached in Annexure-A.

STANDARD TEST PROCEDURE-TRANSFORMER & REACTOR

ANNEXURE-A

Sr. No.	Parameters	Data
1	MVA Rating	
2	Phase	
3	Voltage Rating	
4	Tapping Range & Variation	
5	Fault MVA	
6	Fault Current	
7	Short circuit current feed to HV/LV	*Ex. From HV side for HV-IV Combination* *From LV side for HV-LV combination*

Tap Position	Maximum Voltage Tap	Normal Voltage Tap	Minimum Voltage Tap
Combination	HV-IV		
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
k .√2 Value			
Asymmetrical short circuit current			
No of Shots			
Combination	IV-LV		
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
k .√2 Value			
Asymmetrical short circuit current			
No of Shots			

20. Short time over voltage Test (830kVrms)

The test duration is 5 minutes at rated frequency. When the test frequency exceeds the rated frequency, the test time in seconds of the test shall be:

300 × rated frequency / test frequency

21. Shunt reactor loss measurement & temperature rise test

Reference Standard:

IEC 60076-6:2007 Clause 7.8.6 & Annex D (Temperature correction of losses for liquid-immersed gapped-core and magnetically-shielded air-core reactors)

Losses are based on reactor operation with rated current at rated frequency and at reference temperature. Measured losses shall be corrected to rated current and reference temperature.

For three-phase reactors, the measurement of loss shall be performed under three-phase excitation and loss shall be measured phase wise.

Method

Reactor shall be assembled with all accessories, cooling system as per approved GA drawing (Unit being offered for Type test). No deviation shall be accepted. The tests shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours. DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC61181. Please also refer temperature rise test procedure of transformer.

Full details of the test arrangements, procedures and conditions shall be provided with the test certificates and the following shall at least be included.

All the parameters as per specification shall be measured and recorded.

After completion of temperature rise test (24 hours) hot resistance shall be measured. During this period of hot winding resistance measurement, preparation for loss measurement at hot state shall be made. After completion of resistance measurement (atleast for 20 minutes) connection shall be made for loss measurement at hot state. During this complete process oil temperature shall be recorded.

Calculation methodology:

Average oil temperature at cold state: θ_c

Top oil temperature after 24 hours: θ_1

Average winding temperature at shut-down
(measured by resistance): θ_2

Difference between Average winding & Top oil temperature: $\theta_2 - \theta_1$

Rated voltage shall be supplied during hot loss measurement. The supply shall continue for at least 30 minutes and subsequently loss shall be measured.

Top oil temperature during loss measurement: $\theta_{3\,(U, V,W)}$

Average winding temperature during loss measurement: $\theta_4 = \theta_3 + (\theta_2 - \theta_1)$

Calculation of Temperature co-efficient phase wise
Following parameters shall be measured during Loss measurement;

Rated Voltage KV	Current $I_{measured}$ A		Loss (Measured or calculated)		Top Oil Temperature $\theta_{3\,(U, V,W)}$		Tan Delta	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
90%								
100%								
110%								

Loss measured at cold state: W_c

Cold Loss at rated current: $W_{cr} = W_c \times (I_{rated}/I_{measured})^2$

Loss measured at hot state: W_h

Hot Loss at rated current: $W_{hr} = W_h \times (I_{rated}/I_{measured})^2$

Establishing the temperature coefficient of loss for individual phase:
$\Delta Ptot / \Delta\theta = (W_{hr} - W_{cr})$ kW / $(\theta_4 - \theta_c)$ °C = α kW / °C

Recalculation to reference temperature 75 °C with temperature coefficient:
$Ptot\ (75\ °C) = Ptot\ (\theta_4) + \alpha\ (75 - \theta_4)$ °C

The same process shall be followed for other 2 phases for calculation of temperature coefficient of individual phase.

Measurement of loss on a second identical unit at ambient temperature (routine test):

Measured mean oil temperature at cold state: θt
Loss measured at cold state: W_c
Cold Loss at rated current Ptot (θt °C): $W_c \times (I_{rated}/I_{measured})^2$

Total losses, Ptot (Measured)	I^2R loss (at rated current)	Additional losses
Ptot (θt °C) = W_1+W_2	W_1 (Calculated)	W_2 (Calculated)

Re-calculation to reference temperature 75 °C with temperature coefficient derived after temperature rise test:

Ptot (75 °C) = Ptot (θt °C) + α × (75 – θt) °C

The loss shall be calculated for each phase at reference temperature (75 Deg C) and shall be added for total losses of all three phases. This value is the measured loss value against the guaranteed loss value for the second identical unit.

Check Points:

Inputs like – Value of Standard Capacitor, constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.

22. Two hours excitation test

a) Each reactor to be excited at Um for 2 hours except type tested unit.
b) Measure Vibration at Um and 1.05Um
c) DGA rate interpretation shall be as per IEC/ CIGRE/ IEEE guidelines
d) Test shall be performed before partial discharge test
e) Reactance & Loss measurement shall be carried out after completion of the above test to check the healthiness of the reactor

23. Stress measurement

After all dielectric test reactor shall be energized and Stress will be measured at one point (please refer specification for no. of points) of each wall where vibration reordered is maximum. Measurement shall be carried out at Um and 1.05Um voltage.

24. Measurement of harmonic content of current (Measured in Cold state) - Reactor

The harmonics of the current in all three phases are measured at rated voltage, by means of a harmonic analyser. The magnitude of the relevant harmonics is expressed as a percentage of the fundamental component. For more information on the magnetic characteristic, see Annex B of IEC 60076-6. The harmonics of the applied voltage shall be adequately measured at the same time.

25. Knee point voltage measurement of reactor (Measured in Cold state)

The test shall be carried out as per IEC 60076-6 clause B.7.1 "DC current charging – discharging method (theory)" or applying AC voltage from 0.7p.u, 0.8p.u, 0.9p.u and so on upto the level as per specification and measure the current at various voltages and calculate the tolerance of reactance as per annexure-A of this specification.

26. Standards:

IEC Standards	Latest IEC
Power transformers - Part 1: General	Edition 3.0 2011 -04
Power transformers - Part 2: Temperature rise for liquid-immersed transformers	Edition 3.0 2011-02
Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	Edition 3.1 2018-03
Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors	First edition 2002-06
Power transformers - Part 5: Ability to withstand short circuit	Third edition 2006-02
Power transformers - Part 6: Reactors	Edition 1.0 2007-12
Power transformers - Part 7: Loading guide for mineral-oil-immersed power transformers	Edition 2.0 2018-01
Power transformers - Part 8: Application guide	First edition 1997-10
Power transformers - Part 10: Determination of sound levels	Edition 2. 0 201 6 -03
Power transformers - Part 14: Liquid-immersed power transformers using high-temperature insulation materials	Edition 1.0 2013-09
Power transformers - Part 18: Measurement of frequency response	Edition 1.0 2012 -07
Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors	Edition 1.0 2013-03

Check Lists for Transformer & Reactor Tests

Sr. No.	Test	Acceptance Criteria*	Check list (✓ if conducted)
1.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Insulation power factor for windings < 0.5% Insulation power factor for Bushing as per GTP/TS	
2.	Measurement of insulation resistance & Polarization Index	PI > 1.3	
3.	Core assembly dielectric and earthing continuity test	IR >1 GΩ	
4.	Measurement of winding resistance	As per GTP	
5.	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	Refer procedure	
6.	Switching impulse test for the line terminal (SI)		
7.	Applied voltage test (AV)	No collapse of voltage or other sign of breakdown	
8.	Induced voltage withstand test (IVW)		
9.	Induced voltage test with PD measurement (IVPD)	Refer procedure	
10.	Temperature rise test	As per GTP/ TS	
11.	Measurement of acoustic noise level	As per GTP/ TS	
12.	High voltage with stand test on auxiliary equipment and wiring after assembly	No voltage collapse or other sign of breakdown	
13.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	For record	
14.	Oil leakage test on transformer/ Reactor tank	No oil leakage	
15.	Tank vacuum test	Refer procedure	
16.	Tank pressure test	Refer procedure	
17.	Appearance, construction and dimension check	Dimensions measured shall match with approved GA drawing	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

Check lists for additional tests applicable only for Transformer

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Voltage ratio measurement & Polarity check (Vector Group)	≤0.5% as per IEC 60076-1 for Voltage ratio. Vector group as per specification.	
2.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC	For record	
3.	No-load loss and current measurement	As per GTP / TS	
4.	Measurement of harmonic level in no load current	For record	
5.	Magnetic balance test (for three phase Transformer only)	Refer procedure	
6.	On-load tap changer test	Refer procedure	
7.	Measurement of short-circuit impedance and load loss	As per GTP/ TS	
8.	Line terminal AC withstand voltage test (LTAC)	No collapse of voltage or other sign of breakdown	
9.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Refer procedure	
10.	Overload testing in short-circuit method	Refer procedure	
11.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Refer procedure	
12.	Over excitation test	Refer procedure	
13.	Measurement of Zero seq. reactance (for three phase Transformer only)	As per GTP/ TS	
14.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	As per GTP/ TS	
15.	Dynamic Short circuit withstand test (If specified in BPS)	Refer procedure	

Check lists for additional tests applicable only for Reactor

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Short time over voltage Test (830kVrms) (765kV Reactor)	No voltage collapse or other sign of breakdown	
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	As per GTP/ TS	
3.	2-Hour excitation test except type tested unit	Refer procedure	
4.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Ur for reference only on one unit of each type)	As per GTP/ TS	
5.	Measurement of harmonic content of current (Measured in Cold state)	As per TS	
6.	Knee point voltage measurement of reactor (Measured in Cold state)	As per GTP/ TS	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

Technical Specification

SECTION- TRANSFORMER
(UPTO 400 KV CLASS)

REV 13

JUNE' 2021

Major changes in the latest Technical Specification
Section – Transformer (Upto 400kV Class) REV 13

Sr. No.	Clause	Brief description of major changes
1.	1.2	*Clause revised (previous clause 1.1)*
2.	1.3 & 1.4	*New clause added*
3.	2.3, 2.6, 3.2, 3.3	*Clause revised*
4.	3.7	*Fault level of 220kV and 132kV system revised.*
5.	3.10, 3.12, 3.13	*Clause revised*
6.	5.2	*CIGRE guideline (latest) updated*
7.	5.4	*Type test requirement and it's vaidity revised.*
8.	6.1.6	*Specification of tank base plate revised*
9.	6.1.7, 6.1.8, 6.1.10	*New clauses added*
10.	6.2.3, 6.3	*Clause revised*
11.	6.5.11	*Conservator protection relay added*
12.	6.6.3, 6.7	*Clause revised*
13.	6.8	*No. of PRDs based on oil quantity revised*
14.	6.11 & 6.12	*Accuracy of OTI & WTI revised.*
15.	6.14.4, 6.15.3, & 6.15.9	*Clause revised*
16.	6.15.11	*New clause added*
17.	6.16.1, 6.16.2, 6.16.3, 6.16.9	*Winding area (atmosphere), conductor and pressboard and Kraft paper details revised*
18.	6.16.14	*Clause revised*
19.	6.16.5	*New clause added*
20.	8.	*Insulating oil specification revised*
21.	8.1	*Clause revised*
22.	10.2, 10.4, 10.17	*RIF bushing removed, Tan delta measurement at variable frequency added.*
23.	12.2.6, 12.7.6, & 12.7.9, 13.1	*Clause revised*
24.	15	*SCADA Integration and Interconnection revised*
25.	16.3, 16.4	*SS 316 grade material added for coastal are*
26.	17.1	*Clause revised*
27.	20	*List of fittings revised*
28.	21.3.1	*Clause revised*
29.	Annexure-A	*Creepage distance of Bushing revised from 25mm/kV to 31mm/kV (min)*
30.	Annexure-B	*Table revised*
31.	Annexure-F	*Insulating oil parameters revised.*
32.	Annexure-G	*CT parameters revised.*
33.	Annexure-H	*Cable specification revised.*
34.	Annexure-M	*On-line insulating oil drying system is included with each transformer*

Disclaimer:
Major changes are listed above. However, for details of all major and minor modifications, please refer the complete technical specification Section - Transformer (Upto 400kV Class) Rev 13.

CONTENTS

SECTION- TRANSFORMER (UPTO 400 KV CLASS)

Clause No.	Description
1.	General
2.	Transportation
3.	Performance
4.	Measurable Defects
5.	Design review
6.	Construction Details
7.	Paint system and procedures
8.	Insulating Oil
9.	Spare Transformer Units Connection Arrangement
10.	Bushings
11.	Neutral Formation and Earthing Arrangement.
12.	Cooling Equipment and its Control
13.	Cabling
14.	Tap Changing Equipment
15.	Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel
16.	Current Transformer
17.	Hand Tools
18.	Test Kit
19.	Fittings & accessories
20.	Inspection and Testing
Annexure –A	Technical Particulars / Parameters of Transformers
Annexure –B	Test Plan
Annexure –C	Reference Drawings
Annexure –D	Design Review Document
Annexure –E	Painting Procedure
Annexure –F	Insulating Oil Parameters
Annexure –G	Technical parameters of Current Transformers
Annexure–H	Cable specification
Annexure–I	Spare Transformer Units Connection Arrangement
Annexure–J	BDV Test Set & Portable Dissolved Gas Analysis of Transformer Oil
Annexure–K	Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment
Annexure–L	Online Hydrogen and Moisture Measuring Equipment
Annexure–M	On-line insulating oil drying system (Cartridge type)
Annexure–N	Nitrogen Injection Type Fire Prevention & Extinguishing System
Annexure –O	Oil sampling bottles & Oil Syringe
Annexure –P	Oil Storage Tank
Annexure –Q	Condition Controlled Maintenance Free Type Breather
Annexure-R	Standard dimensions for lower portion of condenser bushings
Annexure-S	Standard Test Procedure of Transformer & Reactor

TECHNICAL SPECIFICATION
SECTION: TRANSFORMER (UPTO 400kV CLASS)

1. General

1.1. This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The Transformer 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. If the IS standard is not available, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted.

1.3. Any material and equipment not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

1.4. Components having identical rating shall be interchangeable.

2. Transportation

2.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the contractor.

2.3. The inland transportation of the Transformer shall be on trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. Contractor shall monitor / track the location of the trailer on regular basis and also provide tracking details to respective site/RHQ at the time of despatch of Transformer from factory to designated site. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Contractor shall despatch the transformer filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. Generally, the duration of the storage of transformer at site with dry air, shall

preferably be limited to three months, after which the Transformer shall be processed as per the recommendation of manufacturer if not filled with oil. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

In case turret, having insulation assembly, is transported separately then positive dry air pressure shall be ensured.

2.6. The Transformer shall also be fitted with atleast 2 numbers of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed"3g" for 50mSec (20Hz) or as per contractor standard, whichever is lower.

3. Performance

3.1. The transformers shall be used for bi-directional flow of rated power. The major technical parameters of single phase and three phase transformer units are defined at **Annexure – A.**

3.2. Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially ONAF (or ONAF1, as specified) up to specified load and then as OFAF (ONAF2 or ODAF or ODWF, as specified). Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140^0 C. If the Transformer is fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, it shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140^0 C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

3.3. The transformer shall be free from any Electrostatic Charging Tendency (ECT) under all operating conditions and maximum oil velocity shall be such that it does not lead to static discharges inside the transformer while all coolers are in operation.

3.4. The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of ±10% corresponding to the voltage of that tapping.

3.5. The transformers shall be capable of being over loaded in accordance with IS 2026 (PART 7) IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

3.6. Tank hotspot shall not exceed 110 Deg. Celsius. The above condition shall be verified during temperature rise test.

3.7. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any

external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

400kV system	- 63kA for 1 sec (sym, rms, 3 phase fault)
220kV system	- 50 kA for 1 sec (sym, rms, 3 phase fault)
132kV system	- 40 kA for 1 sec (sym, rms, 3 phase fault)
66kV system	- 31.5 kA for 1 sec (sym, rms, 3 phase fault)
33kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_s = 0$).

3.8. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

3.9. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

3.10. Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds

Withstand time for 150% & 170% over fluxing condition shall be indicated. Over fluxing characteristics up to 170 % shall be submitted.

3.11. The air core reactance of HV winding of transformer of 400 kV and above voltage class shall not be less than 20%.

3.12. **Tertiary Windings (if applicable as per Annexure - A)**

The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding the stresses which may be caused by such switching. The tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals and for 1/3rd of the MVA capacity of the transformer although the cooling for

continuous thermal rating of the tertiary winding shall be for 5MVA capacity. Tertiary, if not loaded, i.e. not connected to reactor, capacitor or LT transformer etc., its terminals shall be insulated to avoid any accidental short circuiting.

If required, the surge arrester (with polymer housing) shall be provided externally in proximity with bushings mounted suitably on the transformer tank. Alternatively, if required, the surge arrester may be mounted internally (as per standard practice of manufacturer), in order to limit the transfer surge within the BIL specified. Further, in case external surge arresters are required, same shall be mounted on Transformer tank.

3.13. **Radio Interference and Noise Level**

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at **Annexure - A**, when measured under standard conditions.

3.14. **Dynamic Short Circuit Test requirement**

3.14.1. **For 400 kV Class Auto transformer**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit test on 315MVA or above rating 400/220/33kV or 400/230/33kV, 3-Phase Auto transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report/certificate along with bid. In case bidder/manufacturer has not successfully tested 315MVA or above rating 400/220/33kV or 400/230/33kV, 3-Phase Auto transformer for Dynamic Short Circuit test, their bid shall be considered technically non responsive. Further, design review of offered 400kV Class Auto transformer shall be carried out based on the design of short circuit tested 315MVA or above rating 400/220/33kVor 400/230/33kV, 3-Phase Auto transformer.

3.14.2. **For 220 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 220 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer.

Further, design review of offered transformer shall be carried out based on the design of short circuit tested transformer.

3.14.3. **For 132 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case bidder has not successfully tested 132 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive.

The offered transformer should comply the requirement of similarity clause specified in IS 2026 (PART 5) / IEC 60076-5 with respect to short circuit tested transformer.

Further, design review of offered transformer shall be carried out based on the design of short circuit tested transformer.

4. Measurable Defects

The following shall constitute as Measurable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

5. Design review

5.1. The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at Annexure – D.

5.2. Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for transformers; however, the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

The design review will commence after placement of award and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope. It shall be conducted generally following the "CIGRE TB 529: Guidelines for conducting design reviews for power transformers".

5.3. The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and

durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

5.4. **Type test requirement & it's validity**

The offered transformer or the transformer, the design of which is similar to the offered transformer, should have been successfully type tested. Manufacturer may use same or different approved make of Bushings and other accessories used in type tested or short circuit tested unit in their transformer. Further, type test report of transformer shall only be acceptable provided the offered transformer has been manufactured from the same plant. The Transformer Type test validity period shall be as per Technical Specification Section-General Technical Requirement (GTR).

Central Electricity Authority's "Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission system" shall be followed regarding the validity of type tests of Bushings and other accessories.

6. Construction Details

The construction details and features of transformer shall be in accordance with the requirement stated hereunder.

6.1. Tank

6.1.1. Tank shall be of welded or bolted construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

6.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of IS 10801.

6.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

6.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

6.1.5. The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

6.1.6. The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without damage when using plates or rails and the base plate shall have following minimum thickness.

Length of tank (m)	Minimum plate thickness (mm)
Flat bases	
Over 2.5 m but less than 5m	20
Over 5 m but less than 7.5m	26
Over 7.5 m	32

6.1.7. Tank shall be capable of withstanding, without damage, severe strains that may be induced under normal operating conditions or forces encountered during lifting, jacking and pulling during shipping and handling at site or factory. Tank, tank cover and associated structure should be adequately designed to withstand, without damage or permanent deflection / deformation, the forces arising out of normal oil pressure, test pressures, vacuum, seismic conditions and short circuit forces specified.

6.1.8. Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

6.1.9. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. 04 nos. of Gate valves of 50 NB (min.) shall be provided for UHF sensors for PD Measurements (applicable for 400kV Transformer only) at suitable locations. Location of valves shall be finalized during design review.

e. Suitable provision (valves, etc.) as required for installation of Nitrogen Injection Fire Protection System in transformer shall be provided.

f. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

6.1.10. All pipes connected to Transformer shall follow IS 1239.

6.2. Tank Cover

6.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the Buchholz relay.

6.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

6.2.3. The tank cover shall be provided with pockets for OTI, WTI and RTDs including 2 spare pockets. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

6.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

6.2.5. To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

6.2.6. The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

6.2.7. **Gas venting** - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

6.3. **Gasket for tank & cover**

All gasketed joints in contact with oil shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

All tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) Material selected shall suit temperature conditions expected to be encountered. Neoprene / cork sheets gaskets are not acceptable. The Gaskets and O-rings shall be replaced every time whenever the joints are opened.

6.4. **Foundation of Roller Assembly, Cooler Banks other supports**

Transformer shall be rested on foundation on roller assembly. The rollers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676 mm. To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

For foundation of cooler bank (Separately mounted) of Transformer, fixing of cooler support shall be through Anchor Fastener with chemical grouting and no pockets for bolting shall be provided.

Regarding cooler pipe supports, Buchholz pipe (if required) and fire-fighting pipe supports shall be fixed on concrete block through Anchor Fastener with chemical grouting and no pockets for bolting shall be provided.

All control cubicles shall be mounted at least one meter above FGL (Finished Ground Level) to take care of water logging (if any) during flooding. Suitable arrangement (ladder and platform) shall be provided for safe access to control cubicles.

All fittings (Foundation bolts, supports, embedded plates if any) including anchor fastener with chemical grouting are in the scope of contractor.

6.5. **Conservator**

6.5.1. Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay

6.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

6.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

6.5.4. Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

6.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

6.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110^{O}C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

6.5.7. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

6.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

6.5.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long-life characteristics shall be preferred.

6.5.10. OLTC shall have conventional type conservator (without aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

6.6. **Piping works for conservator**

6.6.1. Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

6.6.2. The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The. feed pipe diameter for the main conservator shall be not less than 80mm. The Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

6.6.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm

6.6.4. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

6.6.5. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

6.7. **Dehydrating Silica gel Filter Breather**

Conservator of Main Tank and OLTC shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Passage of air is through silicagel.

b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) for 220kV and above voltage class transformer and two breathers (of identical size) for below 220kV class transformer shall be connected in series for main tank conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.
f) To minimise the ingress of moisture, two breathers in series of identical size shall be connected to OLTC Conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.

6.8. **Pressure Relief Device**

One PRD of 150 mm Diameter is required for every 30000 Litres of oil. However, at least two numbers PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to bushing turret or cover. PRD operating pressure selected shall be verified during design review. PRD shall be provided with special shroud to direct the hot oil in case of fault condition. It shall be provided with an outlet pipe which shall be taken right up to the soak pit of the transformer. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. Following routine tests shall be conducted on PRD:.

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

6.9. **Sudden Pressure Relay**

One number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement**) shall be provided on tank of transformer. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable is not acceptable at site.

6.10. **Buchholz Relay**

One number Double float, reed type Buchholz relay complying to IS 3637 shall be provided in the connecting pipe between the oil conservator and the Transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in

the Transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable is not acceptable at site.

It should be possible to inspect Buchholz relay or Oil surge relay, standing on tank cover and suitable arrangement shall be made to access Buchholz relay safely.

The Buchholz relay shall not operate during starting/stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

6.11. **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication with angular sweep of 270°. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI instrument by means of flexible capillary tubing with stainless-steel armoured. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. The setting of alarm and tripping contacts shall be adjustable at site. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947/IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with Pt100 sensor

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IS/IEC 61850 compliant communications.

6.12. **Winding Temperature Indicator (WTI)**

All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication with angular sweep of 270° and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. The setting of alarm and tripping contacts shall be adjustable at site. A temperature sensing bulb located in a thermometer pocket on tank cover should be provided to sense top oil. This shall be connected to the WTI instrument by means of flexible capillary tubing with stainless-steel armoured. WTI shall have image coil and auxiliary CTs, if required to match the image coil, shall be mounted in the Marshalling Box / cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2^0C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947 /IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of winding temperature:

Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IS / IEC 61850 compliant communications.

6.13. The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

6.14. **Earthing Terminals**

6.14.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

6.14.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/

Online DGA etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper links.

6.14.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper links.

6.14.4. Each transformer unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, all line Terminals shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above. 1.1kV Grade PVC FR type cable of 16 sq.mm (minimum) shall be used for above connection. Neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

6.15. **Core**

6.15.1. The core shall be constructed from non-ageing, cold rolled high permeability grade (as per BIS) or better grain-oriented silicon steel laminations. Core material as per above specification with BIS certification is only acceptable.

6.15.2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

6.15.3. The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

6.15.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

6.15.5. All steel sections used for supporting the core shall be thoroughly sand / shot blasted after cutting, drilling and welding.

6.15.6. Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

6.15.7. The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

6.15.8. Adequate lifting lugs will be provided to enable the core and windings to be lifted.

6.15.9. Single point core earthing should be ensured to avoid circulating current. Core earth should be brought separately on the top of the tank to facilitate testing after installation on all transformers. The removable links shall have adequate section to carry ground

fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp'. Cross section of Core earthing connection shall be of minimum size 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

6.15.10. In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

6.15.11. The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 500MΩ for all cases mentioned above.

6.16. **Windings**

6.16.1. The manufacturer shall ensure that windings of all transformerss are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity controlled environment with positive atmospheric pressure.

6.16.2. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.

6.16.3. Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.

6.16.4. The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.

6.16.5. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

6.16.6. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

6.16.7. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

6.16.8. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

6.16.9. The barrier insulation including spacers shall be made from high density pre-compressed pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.

6.16.10. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

6.16.11. Wherever required, electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit.

6.16.12. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

6.16.13. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

6.16.14. Either brazing/crimping type of connections are permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including line to line and line to ground faults /Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.

6.16.15. Winding paper moisture shall be less than 0.5%.

6.17. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

6.18. **Winding terminations into bushings**

6.18.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

6.18.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

6.18.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

6.18.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

6.18.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

7. Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure –**

E. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

8. Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IS 335 / IEC-60296 & all parameters specified at **Annexure – F**, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – F**, prior to despatch of oil from refinery to site. The Unused Inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at **Annexure – F**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil which shall be supplied at site and shall meet parameters as per specification.

8.1. Particles in the oil

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration the oil is to be flushed and particle count to be measured.

Limiting value for the particle count are 1000 particle/100 ml with size $\geq$ 5 μm; 130 particle/100 ml with size $\geq$ 15 μm.

8.2. Oil filling

8.2.1. Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Field Quality Plan (FQP).

8.2.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the transformer tank and should be less than 1mbar.

8.2.3. Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

8.2.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Transformer shall be oil filled under vacuum, shall be indicated in the manual.

8.2.5. The Ultra High Vacuum type oil treatment plant (on returnable basis) of adequate capacity (**generally 6000** litres per hour and above) suitable for treatment of oil in EHV class Transformer shall be used. The plant shall be capable of treatment of new oil (as per IS 335 / IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
vi) Processing temperature shall be automatically controlled and have an adjustable range from 40°C to 80°C.

The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

8.2.6. **Transportation of Oil**

The insulating oil for the Transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in Transformer due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / stainless steel tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case, before contract closing. However, the spare oil shall be delivered in non-returnable drums.

9. Spare Transformer Units Connection Arrangement

Detail procedure for storage of spare transformer unit with and without **isolator switching arrangement** is enclosed at **Annexure-I.**

10. Bushings

10.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

10.2. 420kV, 245kV, 145kV and 52kV Bushings shall be either of the following type:

a) RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing)
b) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing).

However, OIP (Oil impregnated Paper) with porcelain / composite polymer housing type is also acceptable for 52kV Bushings

36kV and below voltage class bushing shall be solid or oil communicating type with porcelain housing.

10.3. Oil filled condenser type bushing shall be provided with at least following fittings:

a) Oil level gauge

b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable

c) Oil filling plug & drain valve (if not hermetically sealed)

10.4. RIP/RIS type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

10.5. Oil filled condenser type bushing shall be provided with at least following fittings:

a) Oil level gauge
b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable
c) Oil filling plug & drain valve (if not hermetically sealed)

10.6. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

10.7. Bushings of identical rating of different makes shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at **Annexure – C**.

10.8. Porcelain used in bushing manufacture shall be homogenous, 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.

10.9. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. 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 technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IS/IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded 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 weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

10.10. Clamps and fittings shall be of hot dip galvanised/stainless steel.

10.11. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

10.12. No arcing horns shall be provided on the bushings.

10.13. RIP/RIS Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable.

10.14. RIP/RIS Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

10.15. The terminal marking and their physical position shall be as per IS 2026 / IEC: 60076.

10.16. Tan δ value of RIP / RIS condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warrantee period.

Tan delta value of OIP Bushing shall be 0.004 (Max) measured at ambient temperature. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results during warrantee period.

10.17. Tan delta at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at transformer manufacturing works / bushing manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

11. Neutral Formation and Earthing Arrangement

11.1. For 3-Phase Unit

The neutral of the transformer shall be brought out through bushing. The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

12. Cooling Equipment and its Control

12.1. Cooling Equipment for Radiator Bank

12.1.1. The cooler shall be designed using radiator banks or tank mounted radiators. Design of cooling system shall satisfy the performance requirements.

12.1.2. In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank without the need of any extra member/pipe maintaining the electrical clearances.

12.1.3. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1.2 mm. Each radiator bank shall be provided with the following accessories:

(a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
(b) Top and bottom shut off valve
(c) Drain Valve and sampling valve
(d) Top and bottom oil filling valves
(e) Air release plug
(f) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised steel flats.
(g) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(h) Lifting lugs

12.1.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

12.2. If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators / cooler bank shall be provided to record temperature during temperature rise test. Suitable arrangement shall be made for bank mounted cooler arrangement.

12.2.1. One number standby fan shall be provided with each radiator bank.

12.2.2. Cooling fans shall not be directly mounted on radiator. It may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

12.2.3. Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be

taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

12.2.4. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

12.2.5. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

12.2.6. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall be of premium efficiency class IE3 conforming to IS: 12615. Each cooling fan and oil pump motors shall be provided with starter, thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS/IEC 60034-5.

12.2.7. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

12.2.8. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

12.3. **Cooling Equipment Control for Radiator banks**

12.3.1. Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

12.3.2. Suitable manual control facility for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.

12.3.3. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

12.3.4. In addition to the traditional starting of fan and pump by oil / winding temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds.

12.3.5. Once started, the cooling shall remain in operation for a minimum duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Furthermore, a one-week timer is required to check the healthiness of the cooling system on a routine basis for one hour at a time. Starting the pumps on load shall provide the cooling system a lead on the temperature that is about to follow during high loading conditions. Spurious operation should however be avoided by appropriate settings. All settings shall be adjustable.

12.3.6. Adequate warning/ safety labels are required to indicate that the fans may start at any time.

12.3.7. If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other radiator banks.

12.3.8. Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan failure for each bank
f) Cooling pump failure for each pump
g) Common thermal overload trip
h) Thermal overload trip for each fan/pump
i) No oil flow/reverse flow for pumps
j) Stand by fan/pump ON

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

12.3.9. Redundant Programmable Logic Control (PLC) based control of cooling system, meeting all specified functional requirements, shall also be acceptable.

12.3.10. The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

12.3.11. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box (in case of 1-Ph unit) or Marshalling Box (3-Ph unit).

12.3.12. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Details of station auxiliary power supply are mentioned in GTR.

12.4. **Unit cooler arrangement for transformer (if applicable)**

12.4.1. The cooler shall be designed using Unit Cooler arrangement with capacity as specified in Annexure-A. Design of cooling system shall satisfy the performance requirements.

12.4.2. Each Unit Cooler shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom of at least 80 mm size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

12.4.3. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.

12.4.4. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

12.4.5. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 12615/IEC34. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS/IEC60034-5.

12.4.6. The cooler, pipes, support structure and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

12.4.7. Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.

12.4.8. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

12.5. **Cooling Equipment Control (OFAF or ODAF) for Unit Coolers (if applicable)**

i) Suitable manual control facility for unit cooler shall be provided.

ii) The changeover to standby unit cooler bank oil pump in case of failure of any service unit cooler shall be automatic.

iii) Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the unit cooler manually.

iv) Cooler fans & oil pumps of all unit coolers (except standby cooler) shall operate continuously. The starting of unit cooler shall be done as soon the Circuit Breaker of HV/IV/LV (as applicable) side is switched on.

v) Once started the cooling shall remain in operation as long as the transformer is in service. When the transformer is switched off the cooling shall continue to run for a further duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Further, a one-week timer is required to check the healthiness of the complete cooling system on a routine basis for one hour at a time. Spurious operation should however be avoided by appropriate settings. All settings shall be adjustable

vi) Adequate warning/ safety labels are required to indicate that the fans may start at any time.

vii) If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other unit cooler.

viii) Following lamp indications shall be provided in cooler control cabinet:
- Cooler Supply failure (main)
- Cooler supply changeover
- Cooler Supply failure (standby)
- Control Supply failure

- Cooler unit failure for each unit cooler
- No oil flow/reverse oil flow for pumps
- Thermal overload trip for each fan / pump

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

12.6. **Auxiliary Power Supply for OLTC, Cooler Control and Power Circuit**

12.6.1. **For Single Phase unit**

12.6.1.1. Two auxiliary power supplies, 415-volt, three phase four (4) wire shall be provided at common marshalling box through bus bar arrangement. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.

12.6.1.2. For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system and Online drying system etc.(as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes. POWER from CMB (through bus bar at CMB) to IMB (at bus inside) through cable shall be provided by contractor.

12.6.1.3. Auxiliary power supply distribution scheme shall be submitted for approval.

12.6.1.4. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Owner's Control Panels/Digital RTCC panels is also in the scope of the contractor.

12.6.2. **For Three Phase Transformer**

12.6.2.1. Two auxiliary power supplies, 415-volt, three phase four (4) wire shall be provided by the Purchaser at cooler control cabinet / Marshalling Box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the cooler control cabinet / Marshalling.

12.6.2.2. For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system and Online drying system etc. (as applicable), shall be provided by contractor in cooler control cabinet/ Marshalling.

12.6.2.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the contractor. Further any special cable (if required) from MB to Owner's Control Panels/Digital RTCC panels is also in the scope of the contractor.

12.6.3. **Design features of the transfer scheme** shall include the following:

a) Provision for the selection of one of the feeders as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at cooler control cabinet/Individual Marshalling Box/Common Marshalling Box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

12.6.4. For spare unit which is not connected through isolator switching arrangement, 415 volt, three phase four (4) wire AC supply shall be provided for heater, On line drying system, On line DGA etc. as applicable. Necessary cabling in this regard shall be done by the Contractor.

12.7. **Valves**

12.7.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

12.7.2. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

12.7.3. Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.

12.7.4. All valves flanges shall have machined faces. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

12.7.5. All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

12.7.6. Gland packing/gasket material shall be of "O" ring of nitrile rubber for all the valve's flanges. All the flanges shall be machined.

12.7.7. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

12.7.8. Valves or other suitable means shall be provided to fix various on line condition monitoring systems to facilitate continuous monitoring.

Type of valves shall be used for transformer as per following table. The location, size of valves for other application shall be finalised during design review.

Sr. No.	Description of Valve	Type
1	Drain Valve	Gate
2	Filter valve	Gate

3	Sampling Valve	Globe
4	Radiator isolation valve	Butterfly
5	Buchholz relay isolation valve	Gate
6	Sudden pressure relay	Gate
7	OLTC- tank equalizing valve	Gate / Needle
8	OLTC Drain cum filling valve	Gate
9	Valve for vacuum application on Tank	Gate
10	Conservator Drain valve	Gate
11	Aircell equalizing valve	Gate/Globe/Ball
12	Valve for Conservator vacuum (top)	Gate
13	Filter valve for Cooler Bank (Header)	Gate
14	Cooler Bank isolation valve	Butterfly
15	Pump Isolation valve	Butterfly
16	Valve for N2 injection (NIFPS)	Gate
17	Valve for NIFPS Drain	Gate
18	Valve for UHF Sensors	Gate

12.7.9. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

b) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

12.7.10. All hardware used shall be hot dip galvanised / stainless steel.

13. Cabling

13.1. Buchholz Relay, Magnetic Oil Level Gauge, Pressure Relief Device & Sudden pressure relay to be wired through unarmoured cable of 1.5 sq.mm (minimum), inside GI conduit, with no part exposed. Cable shall be protected by flexible stainless steel pipe, at both ends as per requirement. Proper sealing arrangement to be provided at both ends to avoid ingress of water.

The cross section of “control cable” shall be 1.5 sq.mm (minimum) except for CT circuits which should be 2.5 sq.mm (minimum).

All other cables shall be armoured type and shall be routed through covered cable tray or GI conduit and shall be properly dressed.

13.2. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at Annexure-H. All cables should be provided from approved sources with valid type test report. However, charges for type testing is not envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.

13.3. Cabling of spare unit with isolator switching arrangement shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Purchaser's Control panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Purchaser's C & R panels / SCADA level. Changeover of RTCC signals shall be carried out in CMB (Please refer clause 14.3.1).

14. Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment as specified elsewhere.

14.1. Off load tap Changer equipment (if applicable)

The off load / Off Circuit tap changer (OCTC) equipment shall be handle operated with a locking arrangement along with tap position indicator. The external handle shall be situated in an unobstructed position. The contacts are positively self-locating in each tapping position without constraint from the operating mechanism. The rating of the contacts shall be suitable to carry maximum current of the transformer. For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases. A warning plate indicating that OCTC shall be operated only when the transformer is de-energised, shall be fitted.

14.2. ON Load Tap Changing (OLTC) Equipment (Vacuum or Oil type)

14.2.1. Main OLTC Gear Mechanism

14.2.1.1. Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

14.2.1.2. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

14.2.1.3. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

14.2.1.4. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

14.2.1.5. Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

14.2.2. **Local OLTC Control Cabinet (Drive Mechanism Box)**

Each transformer unit of OLTC gear shall have following features:

14.2.2.1. OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

14.2.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting.
- Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
- The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

14.2.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

14.2.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

14.2.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in Section - GTR. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

14.2.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

14.2.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

14.2.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

14.2.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

14.2.2.10. Following minimum LED indications shall be provided in DM box:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection operated
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position of DM

f. OLTC upper/lower limits reached
g. 415V Main AC supply ON
h. (h) 415V Standby AC supply ON

14.2.2.11. Following minimum contacts shall be available in DM Box, which shall be wired to CMB for single phase unit. Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection operated
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position of DM
f. OLTC upper/lower limits reached

14.2.2.12. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.

14.2.2.13. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

14.3. **OLTC Control from Common Marshalling Box (CMB)**

14.3.1. It shall be possible to monitor, control/operate, the OLTC of all the three 1-phase transformers of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit (1-Ph) shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

14.3.2. 'Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

14.3.3. When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

14.3.4. In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

14.3.5. In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

14.3.6. From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single-phase transformer from CMB/ Digital RTCC/SCADA will be prevented.

14.3.7. Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM

f. OLTC upper/lower limits reached
g. 415V Main AC supply ON
h. 415V Standby AC supply ON

Following **contacts** shall be wired to TBs in CMB for further wiring to C & R Panels.

i. 415V Main AC supply Fail
j. 415V Standby AC supply Fail

Following **contacts** shall be wired to TBs in CMB for further wiring to digital RTCC Panel:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 'Independent-combined-remote' selector switch positions of CMB

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

14.4. **Digital RTCC Panel**

14.4.1. The digital RTCC relay shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**) to remotely control and monitor OLTC.

14.4.2. Each Digital RTCC relay shall be used to control 1 bank of transformers (i.e. 3 Nos. 1-Phase units or 1 No. 3-Phase unit). Quantity of the Digital RTCC relays shall be as per BPS. Digital RTCC panel, for accommodating/mounting the above Digital RTCC relays shall be supplied within the scope.

For existing substations, the requirements of RTCC relays are specified in Section Project and digital relays and associated required cables and accessories for the same shall be included in the scope.

14.4.3. Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

14.4.4. The RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ Off mode selection features for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

14.4.5. **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

14.4.6. **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

14.4.7. **Master / Follower/ Independent/ Off mode**

Master / Follower parallel operation is required with Group simultaneous feature in Digital RTCC relay. Master-follower scheme implies that controlled decision shall be taken by the Master and control actions (Raise/Lower tap position) shall be executed simultaneously by Master & Follower units. Same logic needs to be implemented in digital RTCC relays.

Master Position: If the digital RTCC relay is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the digital RTCC relay is in Follower position, control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

14.4.8. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers / 3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

14.4.9. Digital RTCC relays shall communicate with SCADA using IEC 61850 through FO port to monitor, parameterise & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication hardware shall be provided to communicate up to

distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder.

14.4.10. The Digital RTCC relay shall have additional programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

14.4.11. The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

14.4.12. Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. Local / Remote Selector switch positions in DM Box
f. OLTC upper/lower limits reached alarm
g. OLTC Tap position indications for transformer units
h. Independent-combined-remote selector switch positions of CMB (In case of single-phase transformer)
i. 415V, AC Mail Supply Fail.
j. 415V, AC Standby Supply Fail

14.4.13. In case of parallel operation or 1-Phase Transformer unit banks, OLTC out of step alarm shall be generated in the digital RTCC relay for discrepancy in the tap positions.

15. SCADA Integration and Interconnection

15.1.1. All required power & control cables including optical cable, patch chord (if any) upto MB (for 3-Ph unit) or Common MB (for 1-Ph unit) shall be in the scope of contractor. Further, any special cable between MB (for 3-Ph unit) or Common MB (for 1-Ph unit) to switchyard panel room/control room shall be under the present scope. All cable from RTCC to OLTC Drive Mechanism Box shall be provide (if applicable).

15.1.2. Fiber optic cable, power cable, control cables, as applicable, between MB (for 3-Ph unit) or Common MB (for 1-Ph unit) to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of EPC contractor.

15.1.3. Cooling and OLTC of transformers shall be monitored and controlled from SCADA

15.1.4. SCADA Integration of online monitoring equipment (**if applicable**):

All the online monitoring equipment i.e. Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for

individual transformer unit including Spare (if any), are IEC 61850 compliant (either directly or through a Gateway). The monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C.

16. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel

16.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box, Digital RTCC panel (as applicable) and common marshalling (for a bank of three 1-phase units) shall be provided.

16.2. Common marshalling box (for single phase unit) shall be floor mounted and of size, not less than 1600mm (front) X 650mm (depth) X 1800mm (height). Individual Marshalling Box and Cooler control Box shall be tank mounted or ground mounted. The gland plate shall be at least 450 mm above ground level (for ground mounted panel).

16.3. The cooler control cabinet / individual marshalling box, common marshalling box, Junction box and all other outdoor cubicles (**except OLTC Drive Mechanism box**) shall be made of stainless steel sheet of minimum grade of SS304 and of minimum thickness of 1.6 mm (SS 316 for coastal area). Digital RTCC panel shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –E**.

16.4. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

16.5. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary, to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

16.6. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

16.7. The size of Common marshalling box shall not be less than 1600mm (front) X 650mm (depth) X 1800mm (height). All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof for outdoor application.

17. Current Transformer

17.1. Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

17.2. It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

17.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

17.4. For 1-Phase Transformer, one number single phase current transformer (outdoor separately mounted) for earth fault protection shall be provided for each bank of transformer and shall be located in the neutral conductor connecting common neutral point with earth.

17.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

18. Hand Tools (if specified in BPS)

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

19. Test Kit (if specified in BPS)

BDV Kit as per Annexure-J of specification

Portable DGA Kit as per Annexure-J of specification

20. Fittings & accessories

The following fittings & accessories (as applicable) shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included.

a. Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge (with canopy) with high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather

Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather

b. Pressure relief devices including canopy with special shroud to diect oil

c. Sudden pressure relief relay (for 400kV Transformer only) including canopy

d. Buchholz relay double float, reed type with canopy and isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts (gas collecting device)

e. Air release plug

f. Conservator air cell rupture detection relay

g. Inspection openings and covers

h. Bushing of each type with metal parts and gaskets to suit the termination arrangement

i. Winding & Oil temperature indicators

j. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs

k. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable

l. Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus

m. Roller Assembly (as per clause 6.4)

n. On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, and Digital RTCC Panel as applicable

o. Cooling equipment

p. Bushing current transformers, Neutral CT (if applicable)

q. Oil flow indicators (if applicable)

r. Terminal marking plates

s. Valves schedule plate

t. All the valves as per clause 6.1.7 d), e) and 12.7 above

u. Ladder (suitably placed to avoid fouling with bushing or piping) to climb up to the transformer tank cover with suitable locking arrangement to prevent climbing during charged condition. Additional ladder for conservator in case it is not tank mounted.

v. Suitable Platform for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from transformer top.

w. Haulage lugs

x. Neutral bus connection arrangement (3-Phase Transformer)

y. Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral and Line terminals as per clause 6.15.4

z. On line insulating oil drying system as per Annexure-M

aa. Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment (if specified in BPS) as per Annexure-K

bb. On line dissolved Hydrogen and Moisture Measuring Equipment (if specified in BPS) as per Annexure-L

cc. Nitrogen Injection Type Fire Prevention & Extinguishing System (if specified in BPS) as per **Annexure – N**

dd. All Cables (Power, control and shielded / twisted pair for 4-20mA cable from Transformer MB, Cooler control cubicle, etc. (as applicable) to CMB shall be under the present scope. Any special cable if required to be included upto RTCC panel/ employer's C&R panel.

ee. Managed Ethernet switch, LIU patch cords etc. (if applicable) shall be provided in CMB/MB (as per clause 15). All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

21. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation. All accessories and components of transformer shall be purchased from approved soured of purchaser. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by purchaser.

21.1. Factory Tests

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall carry out type & routine tests as per "**Annexure-B & Standard Test Procedure".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

21.2. **Type Tests on Bushing & accessories:**

Type test reports of following Bushing & accessories, shall be furnished by the contractor along with drawings.

1) Bushing (Type Test as per IEC:60137 for all voltage class
   (additionally Snap back & Seismic test report shall be submitted for 400 kV class bushing)
2) OLTC (as per IEC:60214 including IP-55)
3) Marshalling & common marshalling box and other outdoor cubicle (IP-55 test)
4) RTCC IP-43

21.3. **Pre-Shipment Checks at Manufacturer's Works**

21.3.1. Check for inter-changeability of components of similar transformers for mounting dimensions.

21.3.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

21.3.1. Before dispatch of Transformer from factory, following impact recorder settings are to be implemented for graphical analysis:

>1g: Start recording

>2g: Warning

>3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 3g to 10g.

21.3.2. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

21.3.3. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

21.4. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

21.5. **Receipt and Storage Checks**

21.5.1. Check and record condition of each package, visible parts of the transformer etc. for any damage.

21.5.2. Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

21.5.3. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

21.6. **Installation Checks**

21.6.1. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

21.6.2. Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

21.6.3. Check the direction of rotation of fans and pumps and Check the bearing lubrication.

21.6.4. Check whole assembly for tightness, general appearance etc.

21.6.5. Oil leakage test

21.6.6. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

21.6.7. Leakage check on bushing before erection

21.6.8. Measure and record the dew point of gas in the main tank before assembly.

21.7. **Commissioning Checks**

21.7.1. Check the colour of silicagel in silicagel breather.

21.7.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

21.7.3. Check the bushing for conformity of connection to the lines etc.,

21.7.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil flow
v. Low oil level indication
vi. Fan and pump failure protection

21.7.5. Check for the adequate protection on the electric circuit supplying the accessories.

21.7.6. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings

iv) Tap changer motor and control

21.7.7. Check for cleanliness of the transformer and the surroundings

21.7.8. 2 kV AC for 1 minute test between bushing CT terminal and earth.

21.7.9. Phase out and vector group test

21.7.10. Ratio test on all taps

21.7.11. Magnetising current test

21.7.12. Capacitance and Tan delta measurement of winding and bushing

21.7.13. Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

21.7.14. DGA of oil just before commissioning and after 24 hours energisation at site.

21.7.15. Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

21.7.16. Continuously observe the transformer operation at no load for at least 24hours.

21.7.17. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures forward to Purchaser for future record.

Annexure – A

1.0 Technical Particulars / Parameters of Transformers (400/220/33 kV, 3-Phase Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
1.1	Rated Capacity			
	HV	MVA	500	167
	IV	MVA	500	167
	LV (Tertiary)	MVA	5MVA (Thermal loading)	
1.2	Voltage ratio (Line to Line)		400/220/33	
1.3	Vector Group (3-Phase)		YNaOd11	
1.4	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
1.5	Applicable Standard		IEC 60076 / IS 2026	
1.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF or ONAN / ONAF1 / ONAF2	
1.7	Rating at different cooling	%	60 / 80 / 100	
1.8	Cooler Bank Arrangement		2 X 50%	
1.9	Frequency	Hz	50	
1.10	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation	
1.11	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
1.12	Impedance at 75 Deg C			
	HV – IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV – LV			
	Principal tap (minimum)	%	60.0	
	IV – LV			
	Principal tap (minimum)	%	45.0	
1.13	Tolerance on Impedance (HV-IV)	%	As per IEC, unless specified otherwise	
1.14	Service		Outdoor	
1.15	Duty		Continuous	
1.16	Overload Capacity		IEC-60076-7	
1.17	Temperature rise over 50deg C ambient Temp			
i)	Top oil measured by thermometer	^{O}C	45	
ii)	Average winding measured by resistance method	^{O}C	50	
1.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	^{O}C	61	
1.19	Tank Hotspot Temperature	^{O}C	110	
1.20	Maximum design ambient temperature	^{O}C	50	
1.21	Windings			
i)	Lightning Impulse withstand Voltage			

	HV	kV_p	1300
	IV	kV_p	950
	LV	kV_p	250
	Neutral	kV_p	95
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1430
	IV	kVp	1045
	LV	kVp	275
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	570
	IV	kV_{rms}	395
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	≤ 0.5
1.22	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1425
	IV	kV_p	1050
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
	IV	kV_p	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	695
	IV	kV_{rms}	505
	LV	kV_{rms}	105
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the

			line to line highest system voltage)	
	HV	mm	13020	
	IV	mm	7595	
	LV	mm	1612	
	Neutral	mm	1116	
	Neutral			
vii)	Max Partial discharge level at U_m			
	HV	pC	10	
	IV	pC	10	
	LV	pC	10	
	Neutral		-	
1.23	Max Partial discharge level at 1.58 * U_r / √3	pC	100	
1.24	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80	
1.25	**Maximum Permissible Losses of Transformers**		500 MVA	167MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	90	45
ii)	Max. Load Loss between HV & IV at rated current and frequency and at 75^O C	kW	500	200
iii)	Max. I^2R Loss at rated current at 75^O C	kW	375	140
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	15	6

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

2.0 Technical Particulars / Parameters of Transformers (400/220/33 kV Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
2.1	Rated Capacity			
	HV	MVA	315	105
	IV	MVA	315	105
	LV (Tertiary)	MVA	5MVA (Thermal loading)	
2.2	Voltage ratio (Line to Line)		400/220/33	
2.3	Vector Group (3-Phase)		YNaOd11	
2.4	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
2.5	Applicable Standard		IEC 60076 /IS 2026	
2.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF or ONAN / ONAF1 / ONAF2	
2.7	Rating at different cooling	%	60 / 80 / 100	
2.8	Cooler Bank Arrangement		2 X 50%	
2.9	Frequency	Hz	50	
2.10	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation	
2.11	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
2.12	Impedance at 75 Deg C			
	HV – IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV – LV			
	Principal tap (minimum)	%	60.0	
	IV – LV			
	Principal tap (minimum)	%	45.0	
2.13	Tolerance on Impedance (HV-IV)	%	As per IEC	
2.14	Service		Outdoor	
2.15	Duty		Continuous	
2.16	Overload Capacity		IEC-60076-7	
2.17	Temperature rise over 50deg C ambient Temp			
i)	Top oil measured by thermometer	^{O}C	45	
ii)	Average winding measured by resistance method	^{O}C	50	
2.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	^{O}C	61	
2.19	Tank Hotspot Temperature	^{O}C	110	
2.20	Maximum design ambient temperature	^{O}C	50	
2.21	Windings			
i)	Lightning Impulse withstand Voltage			
	HV	kV_p	1300	
	IV	kV_p	950	
	LV	kV_p	250	

	Neutral	kV_p	95
ii)	Chopped Lightning Impulse withstand Voltage		
	HV	kV_p	1430
	IV	kV_p	1045
	LV	kV_p	275
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	570
	IV	kV_{rms}	395
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	≤ 0.5
2.22	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	245
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	1250
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1425
	IV	kV_p	1050
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
	IV	kV_p	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	695
	IV	kV_{rms}	505
	LV	kV_{rms}	105
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	mm	13020

	IV	mm	7595	
	LV	mm	1612	
	Neutral	mm	1116	
vii)	Max Partial discharge level at U_m			
	HV	pC	10	
	IV	pC	10	
	LV	pC	10	
	Neutral		-	
2.23	Max Partial discharge level at 1.58 * U_r / √3	pC	100	
2.24	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80	
2.25	**Maximum Permissible Losses of Transformers**		315MVA	105MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	75	30
ii)	Max. Load Loss between HV & IV at rated current and frequency and at 75^O C	kW	440	140
iii)	Max. I^2R Loss at rated current at 75^O C	kW	330	105
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	10	6

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

3.0 Technical Particulars / Parameters of Transformers (400/132/33 kV 3-Phase Auto Transformer)

Clause No.	Description	Unit	Technical Parameters	
3.1	Rated Capacity			
	HV	MVA	315	200
	IV	MVA	315	200
	LV (Tertiary)	MVA	5MVA (Thermal loading)	
3.2	Voltage ratio (Line to Line)		400/132/33	
3.3	Vector Group (3-Phase)		YNaOd11	
3.4	Single / Three Phase Design		3 (THREE)	1 (SINGLE)
3.5	Applicable Standard		IEC 60076 /IS 2026	
3.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF or ONAN / ONAF1 / ONAF2	
3.7	Rating at different cooling	%	60 / 80 / 100	
3.8	Cooler Bank Arrangement		2 X 50%	
3.9	Frequency	Hz	50	
3.10	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation	
3.11	Type of Transformer		Constant Ohmic impedance type (Refer note 1)	
3.12	Impedance at 75 Deg C			
	HV – IV			
	Max. Voltage tap	%	10.3	
	Principal tap	%	12.5	
	Min. Voltage tap	%	15.4	
	HV – LV			
	Principal tap (minimum)	%	45.0	
	IV – LV			
	Principal tap (minimum)	%	30.0	
3.13	Tolerance on Impedance (HV-IV)	%	As per IEC	
3.14	Service		Outdoor	
3.15	Duty		Continuous	
3.16	Overload Capacity		IEC-60076-7	
3.17	Temperature rise over 50deg C ambient Temp			
i)	Top oil measured by thermometer	^{O}C	45	
ii)	Average winding measured by resistance method	^{O}C	50	
3.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	^{O}C	61	
3.19	Tank Hotspot Temperature	^{O}C	110	
3.20	Maximum design ambient temperature	^{O}C	50	
3.21	Windings			
i)	Lightning Impulse withstand Voltage			
	HV	kV_p	1300	
	IV	kV_p	650	
	LV	kV_p	250	

	Neutral	kV_p	95
ii)	Chopped Lightning Impulse withstand Voltage		
	HV	kV_p	1430
	IV	kV_p	715
	LV	kV_p	275
iii)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	570
	IV	kV_{rms}	275
	LV	kV_{rms}	95
	Neutral	kV_{rms}	38
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	IV		Graded
	LV		Uniform
vii)	Tertiary Connection		Ungrounded Delta
viii)	Tan delta of winding	%	≤ 0.5
3.22	Bushing		
i)	Rated voltage		
	HV	kV	420
	IV	kV	145
	LV	kV	52
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	1250
	IV	A	2000
	LV	A	3150
	Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1425
	IV	kV_p	650
	LV	kV_p	250
	Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	1050
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	695
	IV	kV_{rms}	305
	LV	kV_{rms}	105
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	mm	13020
	IV	mm	4495

	LV	mm	1612	
	Neutral	mm	1116	
vii)	Max Partial discharge level at U_m			
	HV	pC	10	
	IV	pC	10	
	LV	pC	10	
3.23	Max Partial discharge level at 1.58 * U_r / √3	pC	100	
3.24	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80	
3.25	**Maximum Permissible Losses of Transformers**		315MVA	200MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	75	70
ii)	Max. Load Loss between HV & IV at rated current and frequency and at 75^O C	kW	440	400
iii)	Max. I^2R Loss at rated current at 75^O C	kW	330	320
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	10	8

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

4.0 Technical Particulars / Parameters of Transformers (220/132 kV 3-Phase Auto Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS	
4.1	Rated Capacity			
	HV	MVA	200	160
	LV	MVA	200	160
4.2	Voltage ratio	kV	220/132	
4.3	Single / Three Phase Design		Three	
4.4	Vector Group (3-Phase)		YNaO	
4.5	Applicable Standard		IEC 60076 /IS 2026	
4.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF or ONAN / ONAF1 / ONAF2	
4.7	Rating at different cooling	%	60 / 80 / 100	
4.8	Cooler Bank Arrangement		2 X 50%	
4.9	Frequency	Hz	50	
4.10	Tap changer			
i)	Type		OLTC	
ii)	Tap Range & steps		–5% to +15% in steps of 1.25% for 132 kV variation	
iii)	Location of Tap changer		On the 132 kV line end	
4.11	HV-LV Impedance at 75 Deg C			
i)	Max. Voltage tap	%	9.5	
ii)	Principal tap	%	12.5	
iii)	Min. Voltage tap	%	14	
iv)	Tolerance on Impedance	%	As per IEC	
4.12	Service		OUTDOOR	
4.13	Duty		CONTINUOUS	
4.14	Overload Capacity		IEC 60076-7	
4.15	Temperature rise over 50 deg C Ambient Temp			
i)	Top oil measured by thermometer	^{O} C	45	
ii)	Average winding measured by resistance method	^{O} C	50	
4.16	Winding hot spot rise over yearly weighted temperature of 32 O C	^{O} C	61	
4.17	Tank Hotspot Temperature	^{O} C	110	
4.18	Maximum design ambient temperature	^{O} C	50	
4.19	Windings			
i)	Lightning Impulse withstand Voltage			
	HV	kVp	950	
	LV	kVp	650	
	Neutral	kVp	95	
ii)	Switching Impulse withstand Voltage			
	HV	kVp	750	
iii)	One Minute Power Frequency withstand Voltage			
	HV	kVrms	395	
	LV	kVrms	275	
	Neutral	kVrms	38	

iv)	Neutral Grounding		Solidly grounded	
v)	Insulation			
	HV		GRADED	
	LV		GRADED	
vi)	Tan delta of winding	%	≤0.5%	
4.20	Bushings			
i)	Rated voltage			
	HV	kV	245	
	LV	kV	145	
	Neutral	kV	36	
ii)	Rated current (Min.)			
	HV	A	1250	
	LV	A	1250	
	Neutral	A	2000	
iii)	Lightning Impulse withstand Voltage			
	HV	kVp	1050	
	LV	kVp	650	
	Neutral	kVp	170	
iv)	Switching Impulse withstand Voltage			
	HV	kVp	850	
v)	One Minute Power Frequency withstand Voltage			
	HV	kVrms	505	
	LV	kVrms	305	
	Neutral	kVrms	77	
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)	
	HV	mm	7595	
	LV	mm	4495	
	Neutral	mm	1116	
viii)	Max Partial discharge level at U_m			
	HV	pC	10	
	LV	pC	10	
4.21	Max Partial discharge level at 1.5Um/√3	pC	100	
4.22	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75	
4.23	**Maximum Permissible Losses of Transformers**		200MVA	160MVA
i)	Max. No Load Loss at rated voltage and frequency	kW	35	30
ii)	Max. Load Loss between HV & LV at rated current and frequency and at 75^O C	kW	260	200
iii)	Max. I^2R Loss at rated current at 75^O C	kW	190	145
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	8	6

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

5.0 220/66 kV 3-ph Power Transformer

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
5.1	Voltage ratio (Line to Line)	kV	220/66
5.2	Rated Capacity		
	HV	MVA	160
	LV	MVA	160
5.3	No of phases		3 (Three)
5.4	Vector Group		YNyn0
5.5	Applicable Standard		IEC 60076 /IS 2026
5.6	Cooling type		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF or ONAN / ONAF1 / ONAF2
5.7	Rating at different cooling	%	60 / 80 / 100
5.8	Frequency	Hz	50
5.9	Cooler Bank Arrangement		2 X 50%
5.10	Tap changer		
i)	Type		Onload tap changer (CFVV)
ii)	Tapping range and steps		–15% to +5% in steps of 1.25% for HV variation
iii)	Location of tapping		at Neutral end of HV
5.11	HV-LV Impedance at 75^{O} C, at highest MVA base	%	
i)	Max. Voltage tap	%	16.2
ii)	Principal tap	%	15.0
iii)	Min. Voltage tap	%	14.0
5.12	Tolerance on Impedance	%	As per IEC
5.13	Service		Outdoor
5.14	Duty		Continuous
5.15	Overload Capacity		IEC 60076-7
5.16	Temperature rise over 50^{O} C Ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
5.17	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
5.18	Tank Hotspot Temperature	^{O}C	110
5.19	Maximum design ambient temperature	^{O}C	50
5.20	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kV_p	950
	LV	kV_p	325
	HV Neutral	kV_p	95
	LV Neutral	kV_p	95
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kV_p	1045
	LV	kV_p	358

iii)	Switching Impulse withstand Voltage		
	HV	kV_p	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	395
	LV	kV_{rms}	140
	HV Neutral	kV_{rms}	38
	LV Neutral		38
v)	Neutral Grounding (HV/LV)		
	HV		Solidly grounded
	LV		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Graded
vii)	Tan delta of winding	%	≤0.5%
5.21	Bushings		
i)	Rated voltage		
	HV	kV	245
	LV	kV	72.5
	HV Neutral	kV	36
	LV Neutral	kV	36
ii)	Rated current		
	HV	A	1250
	LV	A	2000
	HV Neutral	A	2000
	LV Neutral	A	2000
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1050
	LV	kV_p	325
	HV Neutral	kV_p	170
	LV Neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	505
	LV	kV_{rms}	155
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV	mm	7595
	LV	mm	2248
	Neutral	mm	1116
viii)	Max Partial discharge level at U_m		
	HV	pC	10
	LV	pC	10
5.22	Max Partial discharge level at 1.58 *Ur/√3	pC	100

5.23	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75
5.24	**Maximum Permissible Losses of Transformers**		
i)	Max. No Load Loss at rated voltage and frequency	kW	60
ii)	Max. Load Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	320
iii)	Max. I^2R Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	265
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	8

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

6.0 100 MVA, 220/33 kV 3-ph Power Transformer

Cl. No.	Description	Unit	Technical Parameters
6.1	Voltage ratio (Line-to-Line)	kV	220/33
6.2	Rated Capacity		
	HV	MVA	100
	LV	MVA	100
6.3	No of phases		3 (Three)
6.4	Vector Group		YNyn0
6.5	Type of transformer		Power transformer
6.6	Applicable Standard		IEC 60076 / IS 2026
6.7	Cooling type		ONAN / ONAF / OFAF or ONAN/ONAF / ODAF or ONAN / ONAF1 /ONAF2
6.8	Rating at different cooling	%	60 / 80 / 100
6.9	Frequency	Hz	50
6.10	Cooler Bank Arrangement		2 X 50%
6.11	Tap Changer		
i)	Type		On-load tap changer
ii)	Tap range and steps		-15% to +5% in steps of 1.25% for HV variation
iii)	Location of tap changer		On HV neutral end
6.12	Impedance at 75°C, at highest MVA base		
i)	Max. Voltage tap	%	16.2
ii)	Principal tap	%	15.0
iii)	Min. Voltage tap	%	14.0
iv)	Tolerance on Impedance		As per IEC
6.13	Service		Outdoor
6.14	Duty		Continuous
6.15	Overload Capacity		IEC-60076-7
6.16	Temperature rise over 50 deg C ambient Temp		
i)	Top oil measured by thermometer	^{O}C	45
ii)	Average winding measured by resistance method	^{O}C	50
6.17	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C	^{O}C	61
6.18	Tank Hotspot Temperature	^{O}C	110
6.19	Maximum design ambient temperature	^{O}C	50
6.20	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kV_p	950
	LV	kV_p	170
	HV Neutral	kV_p	95
	LV neutral	kV_p	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kV_p	1045
	LV	kV_p	187
iii)	Switching Impulse withstand Voltage		

	HV	kV_p	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	395
	LV	kV_{rms}	70
	HV Neutral	kV_{rms}	38
	LV neutral		70
v)	Neutral Grounding (HV & LV)		Solidly grounded
vi)	Insulation		
	HV		Graded
	LV		Uniform
vii)	Tan delta of winding	%	≤ 0.5
6.21	Bushing		
i)	Rated voltage		
	HV	kV	245
	LV	kV	36
	HV Neutral	kV	36
	LV Neutral		
ii)	Rated current		
	HV	A	1250
	LV	A	3150
	HV Neutral	A	3150
	LV neutral		3150
iii)	Lightning Impulse withstand Voltage		
	HV	kV_p	1050
	LV	kV_p	170
	HV Neutral	kV_p	170
	LV neutral	kV_p	170
iv)	Switching Impulse withstand Voltage		
	HV	kV_p	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kV_{rms}	505
	LV	kV_{rms}	77
	Neutral	kV_{rms}	77
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
	HV bushing	mm	7595
	LV bushing	mm	1116
	HV neutral / LV neutral	mm	1116
vii)	Max Partial discharge level at U_m		
	HV	pC	10
6.22	Max Partial discharge level at 1.58 * U_r / √3	pC	100
6.23	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	80
6.24	**Maximum Permissible Losses of Transformers**		

i)	Max. No Load Loss at rated voltage and frequency	kW	43
ii)	Max. Load Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	245
iii)	Max. I^2R Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	200
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	5

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

7.0 Technical Particulars / Parameters of Transformers (132/33 kV 3-Phase Auto Transformer)

S. No.	Description	Unit	TECHNICAL PARAMETERS		
7.1	Voltage ratio (Line-to-Line)	kV	132/33		
7.2	Rated capacity (HV and LV)	MVA	80	50	31.5
7.3	No of phases		3 (Three)		
7.4	Vector Group		YNynO		
7.5	Type of transformer		Power Transformer		
7.6	Applicable Standard		IEC 60076 / IS 2026		
7.7	Cooling type		ONAN/ONAF		
7.8	Rating at different cooling	%	60 / 100		
7.9	Cooler Bank Arrangement		1 X 100%		
7.10	Frequency	Hz	50		
7.11	Tap changer				
i)	Type		On-load tap changer (CFVV)		
ii)	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation		
iii)	Location of tap changer		On HV neutral end		
7.12	HV-LV Impedance at 75 °C, at highest MVA base				
i)	Max. Voltage tap	%	13.2		
ii)	Principal tap	%	12.5		
iii)	Min. Voltage tap	%	11.8		
7.13	Tolerance on Impedance	%	As per IEC		
7.14	Service		Outdoor		
7.15	Duty		Continuous		
7.16	Overload Capacity		IEC 60076-7		
7.17	Temperature rise over 50°C ambient temp.				
i)	Top oil measured by thermometer	^{O}C	45		
ii)	Average winding measured by resistance method	^{O}C	50		
7.18	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61		
7.19	Tank hot spot temperature		110		
7.20	Maximum design ambient temperature	^{O}C	50		
7.21	Windings				
i)	Lightning Impulse withstand Voltage				
	HV	kV_p	650		
	LV	kV_p	170		
	HV Neutral	kV_p	95		
	LV Neutral	kV_p	170		
ii)	Chopped Wave Lightning Impulse Withstand Voltage				
	HV	kV_p	715		

	LV	kV_p	187		
iii)	Switching Impulse withstand Voltage				
	HV	kV_p	540		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kV_{rms}	275		
	LV	kV_{rms}	70		
	HV Neutral	kV_p	38		
	LV Neutral	kV_p	70		
v)	Neutral Grounding (HV and LV)		Solidly grounded		
vi)	Insulation				
	HV		Graded		
	LV		Uniform		
vii)	Tan delta of winding	%	≤0.5%		
7.22	Bushings				
i)	Rated voltage				
	HV	kV	145		
	LV, LV Neutral & HV Neutral	kV	36		
ii)	Rated current (Min.)				
	HV	A	1250		
	LV	A	1250 for (50 & 31.5MVA) 2000 (for 80MVA)		
	HV Neutral & LV Neutral	A	1250		
iii)	Lightning Impulse withstand Voltage				
	HV	kV_p	650		
	LV, HV Neutral and LV Neutral	kV_p	170		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kV_{rms}	305		
	LV, HV Neutral and LV Neutral	kV_{rms}	77		
v)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)		
	HV	mm	4495		
	LV, HV Neutral and LV Neutral	mm	1116		
vi)	Max Partial discharge level at U_m on HV	pC	10		
7.23	Max Partial discharge level at 1.58*Ur/√3	pC	100		
7.24	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75 for 80MVA & 50MVA 70 for 31.5MVA		
7.25	**Maximum Permissible Losses of Transformers**		**80MVA**	**50 MVA**	**31.5 MVA**

i)	Max. No Load Loss at rated voltage and frequency	kW	35	25	18
ii)	Max. Load Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW	200	125	110
iii)	Max. I^2R Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW	170	105	93.5
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	5	3	2

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

8.0 66/11 kV 3-ph Power Transformer

S. No.	Description	Unit	TECHNICAL PARAMETERS		
8.1	Voltage ratio (Line-to-Line)	kV	66/11		
8.2	Rated Capacity (HV and LV)	MVA	31.5	20	12.5
8.3	No of phases		3 (Three)		
8.4	Vector Group		Dyn11		
8.5	Type of transformer		Power Transformer		
8.6	Applicable Standard		IEC 60076 / IS 2026		
8.7	Frequency	Hz	50		
8.8	Cooling type		ONAN		
8.9	Tap Changer				
i)	Type		On-load tap changer (CFVV)		
ii)	Tap Range and no. of steps		–5% to +15% of HV variation in the step of 1.25%		
iii)	Location of Tap changer		On HV neutral end		
8.10	HV-LV Impedance at 75°C,	%			
	Max. Voltage Tap		11.2		
	Principal Tap		10		
	Min. Voltage Tap		9		
8.11	Tolerance		As per IEC		
8.12	Service		Outdoor		
8.13	Duty		Continuous		
8.14	Overload Capacity		IEC 60076-7		
8.15	Temperature rise over $50^{O}C$ Ambient Temp				
i)	Top oil measured by thermometer	^{O}C	45		
ii)	Average winding measured by resistance method	^{O}C	50		
8.16	Winding hot spot rise over yearly weighted temperature of $32^{O}C$	^{O}C	61		
8.17	Tank Hotspot Temperature	^{O}C	110		
8.18	Maximum design ambient temperature	^{O}C	50		
8.19	Windings				
i)	Lightning Impulse withstand Voltage				
	HV	kV_p	325		
	LV & LV Neutral	kV_p	75		
ii)	Chopped Wave Lightning Impulse Withstand Voltage				
	HV	kV_p	358		
	LV	kV_p	83		
iii)	One Minute Power Frequency withstand Voltage				
	HV	kV_{rms}	140		
	LV & LV Neutral	kV_{rms}	28		
iv)	Insulation		Solidly grounded		
	HV		Uniform		
	LV		Uniform		
v)	Tan delta of winding	%	≤0.5		

8.20	Bushings				
i)	Rated voltage				
	HV	kV	72.5		
	LV & LV Neutral	kV	17.5		
ii)	Rated current				
	HV	A	800		
	LV & LV neutral	A	2000		
iii)	Lightning Impulse withstand Voltage				
	HV	kV_p	350		
	LV & LV Neutral	kV_p	95		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kV_{rms}	155		
	LV & LV Neutral	kV_{rms}	38		
v)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)		
	HV		2248		
	LV & LV Neutral		543		
viii)	Max Partial discharge level on HV bushing at U_m	pC	10		
8.21	Max Partial discharge level at 1.58*Ur/√3	pC	100		
8.22	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	70		
8.23	Maximum Permissible Losses of Transformers		**31.5MVA**	**20MVA**	**12.5MVA**
i)	Max. No Load Loss at rated voltage and frequency	kW	18.0	14.0	9.0
ii)	Max. Load Loss at rated current and frequency and at 75^O C, at principal tap position	kW	110.0	80.0	56.0
iii)	Max. I^2R Loss at rated current and frequency and at 75^O C, at principal tap position	kW	93.5	68.0	47.0

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3.

Annexure -B

Test Plan

No.	Test	$132 \geq U_m \leq 170kV$	$U_m > 170kV$
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
5.	Measurement of insulation resistance & Polarization Index	Routine	Routine
6.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
7.	No-load loss and current measurement	Routine	Routine
8.	Impedance and load loss measurement	Routine	Routine
9.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
10.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
11.	Applied voltage test (AV)	Routine	Routine
12.	Induced voltage withstand test (IVW)	Routine	-
13.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
14.	On-load tap changer test (Ten complete cycle before LV test)	Routine	Routine
15.	Gas-in-oil analysis	Routine	Routine
16.	Core assembly dielectric and earthing continuity test	Routine	Routine
17.	Oil leakage test on transformer tank	Routine	Routine
18.	Appearance, construction and dimension check	Routine	Routine
19.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
20	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
21.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
22.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
23.	Tank vacuum test	Routine	Routine
24.	Tank pressure test	Routine	Routine
25.	Switching impulse test for the line terminal (SI)	Type	Routine
26	Line terminal AC withstand voltage test (LTAC)	Routine	Type
27.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
28.	Lightning impulse test for the neutral terminals (LIN)	Type	Type
29.	Temperature rise test	Type	Type
30.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type	Type
31.	Measurement of harmonic level in no load current	Type	Type
32.	Measurement of acoustic noise level	Type	Type
33.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
34.	Dynamic Short circuit withstand test (If specified in BPS)	Type	Type

Annexure -B

Test Plan

No.	Test	$U_m \leq$ 72.5 kV
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity test	Routine
4.	Magnetic balance test (for three phase Transformer only)	Routine
5.	Gas-in-oil analysis	Routine
6.	Core assembly dielectric and earthing continuity test	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine
9.	No-load loss and current measurement	Routine
10.	Impedance and load loss measurement	Routine
11.	Full wave lightning impulse test for the line terminals (LI)	Routine
12.	Chopped wave lightning impulse test for the line terminals (LIC)	Type
13.	Applied voltage test (AV)	Routine
14.	Induced voltage withstand test (IVW)	Routine
15.	Induced voltage test with PD measurement (IVPD)	Type
16.	On-load tap changer test (Ten complete cycle before LV test)	Routine
17.	Oil leakage test on transformer tank	Routine
18.	Appearance, construction and dimension check	Routine
19.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine
20	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine
21.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine
22.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
23.	Tank vacuum test	Routine
24.	Tank pressure test	Routine
25.	Lightning impulse test for the neutral terminals (LIN)	Type
26	Temperature rise test	Type
27.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type
28.	Measurement of harmonic level in no load current	Type
29.	Measurement of acoustic noise level	Type
30.	Dynamic Short circuit withstand test (If specified in BPS)	Type

Annexure - C

Reference Drawings

The list of drawings indicated below forms a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Standard Foundation Drawing (315MVA & 500MVA, 400/220/33kV Auto Transformer)	STD/FDN/500MVA/400KV
ii)	Standard dimensions for Condenser bushings (Lower portion)	**Annexure-R**
iii)	Conceptual drawing for showing power and control cable connection for operation with spare unit – 1 Ph Transformer	C/ENGG/TR/SPARE/CABLE/STD REV02
iv)	Conceptual drawing for showing power and control cable for operation of 3-Ph Transformer	C/ENGG/STD/CABLE/TR REV01
v)	Standard Test Procedure of Transformer & Reactor	POWERGRID/STD/TEST PROCEDURE/TR-RT/REV02

Annexure –D

Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto $1.7U_m$
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
33.	Conductor insulation paper details
34.	The design of all current connections
35.	Location & size of the Valves

Annexure – E

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aestheticall y matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – F

UNUSED INHIBITED HIGH GRADE INSULATING OIL PARAMETERS

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 40degC	IS 1448 Part 25 or ISO 3104 or ASTM D7042	(Max.)12 mm^2/s
1b.	Viscosity at -30degC		(Max.)1800 mm^2/s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	IS 1448 Part 10/Sec 2 or ISO 3016	(Max.) - 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	(Min.) 50kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	Max 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IS 16086 or IEC 60247 or IEC 61620	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins: <50% & balance Naphthenic compounds.
B	**Refining/Stability**		
1.	Colour	ISO 2049	L0.5 (less than 0.5)
2.	Acidity	IEC 62021-2 or 62021-1	(Max) 0.01 mg KOH/g
3.	Interfacial tension at 27degC	IEC 62961 or ASTM D971	0.043 N/m (min)
4.	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)
5.	Corrosive sulphur	DIN 51353	Not-Corrosive
6.	Potentially corrosive sulphur	IEC 62535	Not-Corrosive
7.	DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)
8.	Presence of oxidation inhibitor	IS 13631 or IEC 60666	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
9.	Metal passivator additives	IEC 60666	Not detectable (<5 mg/kg)

10.	2-Furfural content and related compound content	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for each individual compound
11.	Stray gassing under thermooxidative stress	Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H2) and < 50 µl/l methane (CH4) and < 50 µl/l ethane (C2H6)
C	**Performance**		
1.	Oxidation stability	IEC 61125 (method c) Test duration 500 hour	
2.	Total acidity*	4.8.4 of IEC 61125:2018	0.3 mg KOH/g (Max.)
3.	Sludge*	4.8.1 of IEC 61125:2018	0.05 % (Max.)
4.	Dielectric dissipation factor (tan delta) at 90degC	4.8.5 of IEC 61125:2018	0.05 (Max.)
	*values at the end of oxidation stability test		
D	**Health, safety and environment (HSE)**		
1.	Flash point	IS 1448 Part 21 or ISO 2719	(Min.)135deg C
2.	PCA content	IP 346	< 3%
3.	PCB content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		0.04 N/m (min)
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability		
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of EMPLOYER.			

Note: Supplier shall declare the chemical family and function of all additives and the concentrations in the cases of inhibitors, antioxidants and passivators.

Annexure – G

Technical parameters of Current Transformers

1.0 Current Transformer Parameters (On each phase) for 3-ph 500MVA and 1-ph, 167 MVA, 400/220/33 kV Transformers

Description	**Current Transformer Parameters (Transformer)**			
	HV Side	**IV Side**	**Neutral Side**	**Outdoor type Neutral Current Transformer** (for each bank of three 1-ph units)
Ratio				
CORE 1	1600/1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	-	-
Minimum knee point voltage or burden and accuracy class				
CORE 1	1600V, PX	1600V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 20VA ISF<5	0.2S Class 20VA ISF<5	-	-
Maximum CT Secondary Resistance				
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	-	-
Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	Metering	-	-
Maximum magnetization current (at knee point voltage)				
CORE 1	25 mA	25 mA	25 mA	25 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

2.0 Current Transformer Parameters (on each phase) for 1-ph, 105 MVA, 3-ph 315 MVA 400/220/33 kV Transformers and 3-ph 200 MVA ,400/132/33 kV Transformers)

Description	**Current Transformer Parameters (Transformer)**			
	HV Side	**IV Side**	**Neutral Side**	**Outdoor type Neutral Current Transformer** (for each bank of three 1-ph units)
a) **Ratio**				
CORE 1	1000/1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-	-
b) Minimum knee point voltage or burden and accuracy class				
CORE 1	1000V, PX	1000V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 20VA ISF<5	0.2S Class 20VA ISF<5		
c) Maximum CT Secondary Resistance				
CORE 1	2.5 Ohm	2.5 Ohm	2.5 Ohm	2.5 Ohm
CORE 2	-	-	-	-
d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	Metering	-	-
e) Maximum magnetization current (at knee point voltage)				
CORE 1	60 mA	60 mA	60 mA	60 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

3.0 Parameters of Current Transformer for 315 MVA (3-ph), 400/132/33 kV Transformers

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	600/1	1600/1	-
Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 20VA ISF<5	0.2S Class 20VA ISF<5	-
Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2		-	-
Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	Metering	-
Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.
ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.
iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

4.0 Technical Parameters of Current Transformers (for 200MVA, 220/132kV & 160MVA, 220/132kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)		
	HV Side	**IV Side**	**Neutral Side**
(a) Ratio			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1000V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 15VA ISF < 5	0.2S Class 15VA ISF < 5	-
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

5.0 Parameters of Current Transformer for 160 MVA(3-Ph), 220/66 kV Transformers

Description	Current Transformer Parameters (Transformer)			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
Ratio				
CORE 1	600/1	600/1	1600/1	1600/1
CORE 2	600/1	-	1600/1	-
Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX	600V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 20VA ISF<5	-	0.2S Class 20VA ISF<5	-
Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	-	Metering	-
Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

i) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

6.0 Parameters of Current Transformer for 100MVA (3-ph), 220/33 kV Transformers

Description	Current Transformer Parameters (Transformer)			
	HV Side	**HV Neutral side**	**LV Side**	**LV Neutral Side**
Ratio				
CORE 1	600/1	600/1	2000/1	2000/1
CORE 2	600/1	-	2000/1	-
Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX	600V, PX	2000V, PX	2000V, PX
CORE 2	0.2S Class 20VA ISF<5	-	0.2S Class 20VA ISF<5	-
Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	-	Metering	-
Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

ii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

7.0 Technical Parameters of Current Transformers (for 80MVA 132/33kV 3-Ph Transformer)

Description	Current Transformer Parameters (Transformer)			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	400/1	400/1	1600/1	1600/1
CORE 2	400/1	-	1600/1	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	400V, PX	400V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 15VA ISF < 5	-	0.2S Class 15VA ISF < 5	-
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	-	Metering	-
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

8.0 Parameters of Current Transformer for 50MVA (3-ph), 132/33kV and 31.5 MVA (3-ph) 132/33kV Transformers

Description	Current Transformer Parameters (Transformer)			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(f) Ratio				
CORE 1	300/1	300/1	1000/1	1000/1
CORE 2	300/1	-	1000/1	-
(g) Minimum knee point voltage or burden and accuracy class				
CORE 1	300V, PX	300V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 15VA ISF < 5	-	0.2S Class 15VA ISF < 5	-
(h) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
(i) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering	-	Metering	-
(j) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

9.0 Parameters of Current Transformer for 31.5 MVA (3-ph), 20MVA(3-Ph), 66/11kV Transformers

Description	Current Transformer Parameters (Transformer)		
	HV Side	**LV Side**	**LV Neutral Side**
(k) Ratio			
CORE 1	400/1	2000/1	2000/1
CORE 2	400/1	1000/1	-
(l) Minimum knee point voltage or burden and accuracy class			
CORE 1	400V, PX	2000V, PX	2000V, PX
CORE 2	0.2S Class 15VA ISF < 5	0.2S Class 15VA ISF < 5	-
(m) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-
(n) Application			
CORE 1	Protection	Metering	Restricted Earth Fault
CORE 2	Metering		-
(o) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	25 mA	25 mA
CORE 2	-	-	-

NOTE:

i) Parameters of WTI CT for each winding shall be provided by the contractor.

ii) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

iii) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection

10.0 Parameters of Current Transformer for 12.5MVA (3-ph), 66/11kV Transformers

Description	Current Transformer Parameters (Transformer)		
	HV Side	**LV Side**	**LV Neutral Side**
(a) Ratio			
CORE 1	200/1	1000/1	1000/1
CORE 2	200/1	1000/1	-
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	200V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 15VA ISF < 5	0.2S Class 15VA ISF < 5	-
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-
(d) Application			
CORE 1	Protection	Metering	Restricted Earth Fault
CORE 2	Metering		-
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	25 mA	25 mA
CORE 2	-	-	-

NOTE:

iv) Parameters of WTI CT for each winding shall be provided by the contractor.

v) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

vi) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection

ANNEXURE - H

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from Employer's approved vendors.

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade and shall conform to IS 8130.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be ±2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC insulated 1100V grade power cables shall be of Fire Retardant Low Smoke Halogen (FRLSH) type, C2 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 85°C. The conductor shall be stranded aluminium H2 grade conforming to IS 8130. The Insulation shall be extruded PVC to type-C of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all cables. The copper cable of required size can also be used.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FRLSH type, C2 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC of type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The outer sheath shall be extruded PVC of type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the purchaser to be black.

1.15.1 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50^{o}C and for maximum conductor temp. of 70 ^{o}C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250^{o}C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 ^{o}C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 ^{o}C (Ω/Km)	$	0.577

14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50
B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 ^{o}C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0.868	0.868/1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					

c)	c) Calculated diameter of cable over inner sheath (under armour), mm	18	28.4	21	16.3	12.2	10.2
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							

b)	Nominal thickness of insulation(mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data

Annexure–I

Spare Transformer Unit Storage & Connection Arrangement

1.1. **Transformer with Isolator switching arrangement:** Employer intends to replace any of the Transformer unit by the spare Transformer unit using isolator switching arrangement so as to avoid physical shifting the Transformer.

Connection of spare unit of Transformer with other units shall be made by isolator switching arrangement. Neutral formation for spare unit of Transformer shall be done by manual connection. The spare Transformer unit shall be completely erected and commissioned similar to the other Transformer units. The contractor shall carry out all pre-commissioning tests on the spare Transformer similar to the unit kept in service.

For this purpose if specified in BPS, HV and Neutral Connections of spare unit shall be extended upto the other unit(s) by forming auxiliary buses connection through flexible/rigid conductor. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor. However, the detail configuration and hardware shall be finalised during detailed engineering and shall be subject to Employer's approval.

Any special maintenance procedure required shall be clearly brought out in the instruction manual.

1.2. **Transformer without isolator switching arrangement:** Employer intends to keep the spare Transformer unit without isolator switching arrangement due to space limitation. In case of failure of any of the running unit, this spare Transformer shall be physically shifted to replace faulty Transformer.

The spare Transformer shall be placed on the elevated foundation block to facilitate quick movement. The Transformer unit may be required to be stored for long duration. The spare Transformer unit shall be completely erected and commissioned similar to the other Transformer units. However, erection of separate cooler bank is not envisaged. In case conservator is cooler bank mounted, suitable arrangement for mounting of conservator on tank top cover shall be provided. The contractor shall carry out all pre-commissioning tests on the spare Transformer similar to the unit kept in service.

All other items shall be suitably packed in reusable boxes. Arrangement shall be made to minimize moisture ingress inside the boxes. All pipes and radiators shall be provided with blanking plates during long duration storage to prevent entry of foreign material/ water.

In case spare Transformers needs to be commissioned in switchyard bay (as advised by Engineer in-charge), the contractor shall erect, test and commission the spare Transformer unit similar to other units in service. However, packaging material as above for long-term storage shall be included in the scope of bidder.

ANNEXURE - J

Technical Specification of Oil BDV Test Set (If specified in BPS)

Item	Specification
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Transformer oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally, all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Employer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

Technical Specification of Portable Dissolved Gas Analysis of Oil (If specified in BPS)

S.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/-10% supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records
06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.

07	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-50 Deg. C 02. 85% non-condensing 03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - K

Online Dissolved Gas (Multi-gas) and Moisture Analyser (If specified in BPS)

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable)

shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included in the scope of supply

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

1.13. The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

ANNEXURE - L

On Line Dissolved Hydrogen and Moisture Monitor (If specified in BPS)

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on Transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility. The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display H_2 and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10 psi.

7.0 Technical Parameters:

Sr. No.	Parameters	Requirements
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C
	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Communications	USB&IEC 61850 compliant

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:
Fault indication:

iii) IEEE, IEC or user configurable levels of dissolved gases
iv) Rate of change trending

9.0 The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

v) Software
vi) Operation Manual (2 set for every unit),
vii) Software Manual and
viii) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

11.0 The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

ANNEXURE - M

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each Transformer shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

vii. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

ANNEXURE - N

Nitrogen Injection Type Fire Prevention & Extinguishing System (If specified in BPS)

1. Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults/arc.

   The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

   Electrical isolation of transformer shall be an essential pre-condition for activating the system.

2. Operational Controls
   The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

2.1 Prevention of transformer from explosion and fire
   To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays (Differential / Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

2.2 Prevention of transformer from fire in case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

3. Operation of System
   On receiving activation signal, the following shall take place:
   i) Open the quick opening drain valve to drain the top layer oil
   ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
   iii) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

   There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.
   There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

4. Technical Particulars

   The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from POWERGRID.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

5. Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:
   - Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
   - Oil Drain Assembly including oil drainpipe extension of suitable size for connecting pipes to oil pit
   - Mechanical release device for oil drain and nitrogen release
   - Limit switches for monitoring of the systems
   - Panel lighting
   - Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
   - Back up pressure switch to operate nitrogen gas valve
   - Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
   - Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.
   - shall have minimum IP55 degree of protection

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP-67 class degree of protection.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is being provided by the transformer supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

6. Under Ground Oil Storage Tank
Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below:**

Painting	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thick-ness (DFT)**	**Colour shade**
Oil Storage Tank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyuret hane (PU) (Minimu m 50µm)	Minimum 155µm	RAL 7035

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

7. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the system.

8. Installation and pre-commissioning test After installation the system pre-commissioning tests shall be carried out jointly with the Owner’s representative before the system is put in service.

ANNEXURE - O

Oil sampling bottles (If specified in BPS)

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Transformers and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

Oil Syringe (If specified in BPS)

If specified in BPS, the glass syringe of capacity 50ml (approx.) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

ANNEXURE - P

Oil Storage Tank (If specified in BPS)

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS 10987 (1992) or BS 2594. Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of thickness as per standard. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100°C.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horsepower to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. Each tank shall be thoroughly cleaned internally of all loose matter and then tested to a pressure of 0.7 bar, measured at the top of the tank as per standard. Tank shall also be tested at internal vacuum of 10mbar.

6. The following accessories shall also form part of supply along with each Oil storage tank.

7.1 Four numbers of 50NB suitable rubber hoses for Transformer oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

7.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

7.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8-meter cable so as to suitably place the Vacuum gauge at ground level.

7.4 The painting of oil storage tank and its control panel shall be as per technical specification.

7.5 The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

ANNEXURE – Q

Condition Controlled Maintenance Free Type Breather (If specified in BPS)

1. The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a microprocessor control unit and LED status indication.

2. **Dehydrating breather's operating principle:**

When the oil conservator breaths-in (e.g. at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colorless, moisture adsorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

3. Technical **Features:**

3.1 Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0o C to +80o C.

3.2 Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

a) LED for Power of control unit - ON
b) LED for Filter heater- ON
c) LED for Anti-condensation heater (of control unit) - ON
d) LED & relay contact for "Device Error"
e) LED & relay contact for Regeneration active (De-humidification in process)
f) Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).

3.3 The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.

3.4 Control unit shall be equipped with a communication port for downloading the operational data logged by the unit. All necessary software required for downloading and analysing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

3.5 The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

3.6 The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

3.7 Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.

3.8 The control unit shall be equipped with suitable heater to prevent moisture condensation.

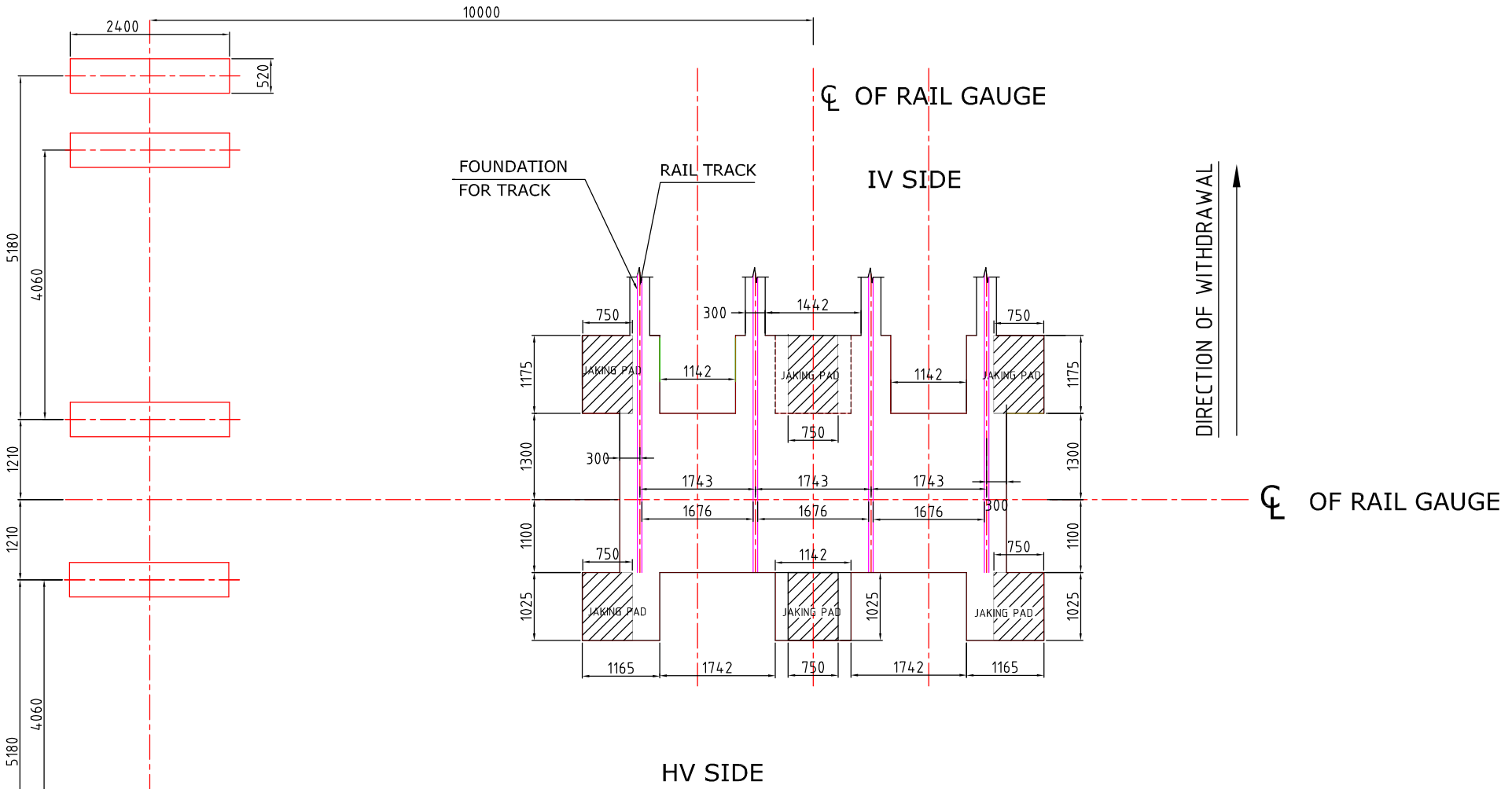
3.9 The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

4. The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over. During this period, if the equipment needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of this equipment for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

5. Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

---------- X ----------

678/811



NOTE:

1. RADIATOR BANK SHALL BE EITHER ON LHS OR RHS OF TRANSFORMER DEPENDING UPON THE SUBSTATION LAYOUT (PREFERABLY OPPOSITE OF TERTIARY TERMINALS).
2. OTHER MINOR FOUNDATION FOR SUPPORTS SHALL BE JOB SPECIFIC.
3. ON LINE DGA AND ON LINE DRYING SYSTEM ARE GROUND MOUNTED.

30/01/2015	R0	
Date	Revision	Description

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

SDE (ENGG-S/S)	DGM (ENGG-CIVIL)	DGM (ENGG-S/S)	AGM (ENGG-S/S)	AGM (ENGG-S/S)	GM (ENGG-CIVIL)	ED (ENGG-S/S, TL & CIVIL)
PREPARED BY	CHECKED BY					APPROVED BY

TITLE

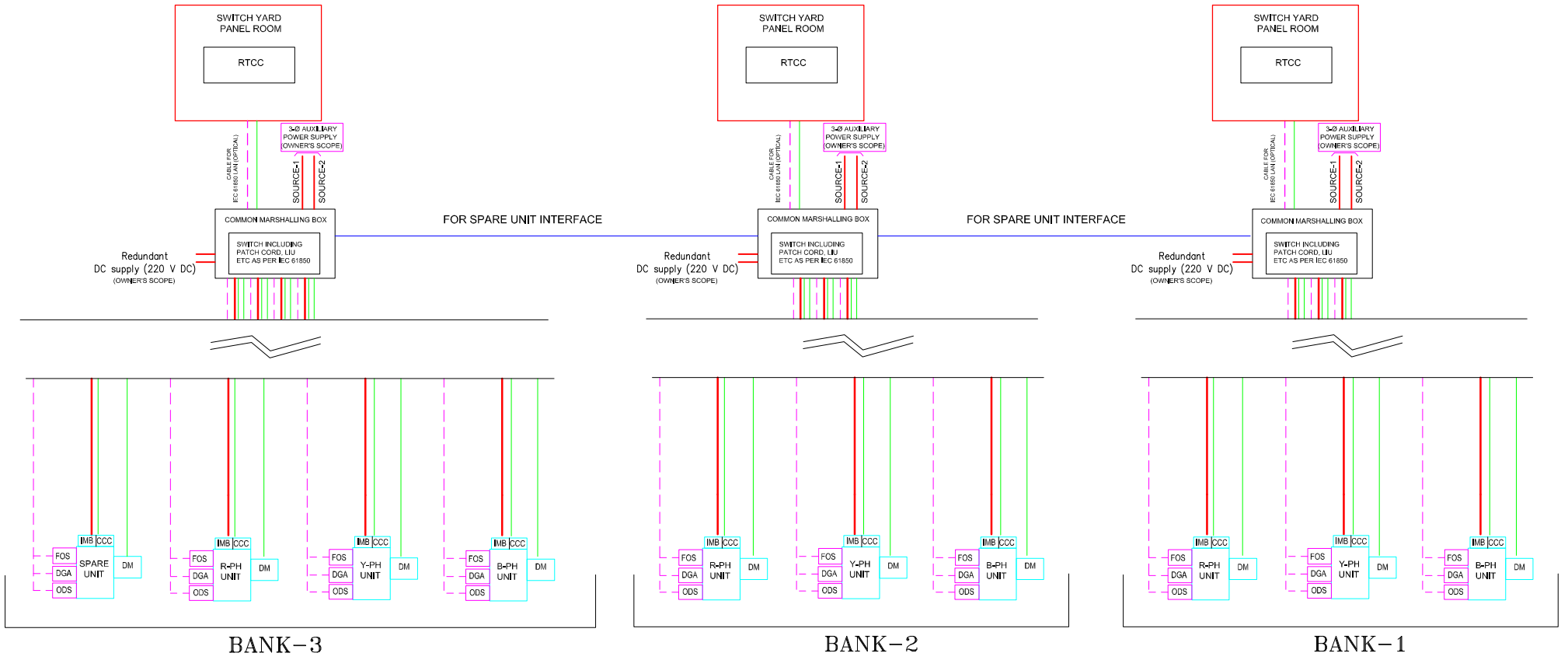
STANDARD FOUNDATION OF
500MVA, 400/220/33KV AUTO TRANSFORMER

DRG NO

STD/FDN/500MVA/400KV

1401648/2023/TBG-TB_HVDC

679/811



NOTE:

1. All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyzer, On-line insulating oil drying system (Cartridge type) provided for individual transformer unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in Common MB by the contractor. The switch shall be powered by redundant DC supply (220V DC). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) upto CMB shall be in the scope of contractor.
2. However, fiber optic cable, power cable, control cables, as applicable, between CMB to switchyard panel room/control room and power supply (AC & DC) to CMB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.
3. Control, Power, FO and any special cable from online monitoring equipment, DM, Cooler control cubicle and IMB to CMB shall be supplied by contractor
4. Ethernet switch, LIU, Patch cord etc. shall be provided at CMB by contractor
5. In CMB, R , Y & B phase of respective bank and terminal of common spare unit shall be available
6. All cable from RTCC to CMB and any special cable between CMB to switchyard panel room/control room hall be supplied by contractor

FO CABLE	
POWER CABLE	
CONTROL CABLE	
IMB	Individual Marshalling Box
CCC	Cooler Control Cubicle
FOS	Fiber Optic Sensor Box
DGA	Online DGA Box
ODS	On line drying system
DM	Drive Mechanism Box
CMB	Common Marshalling Box

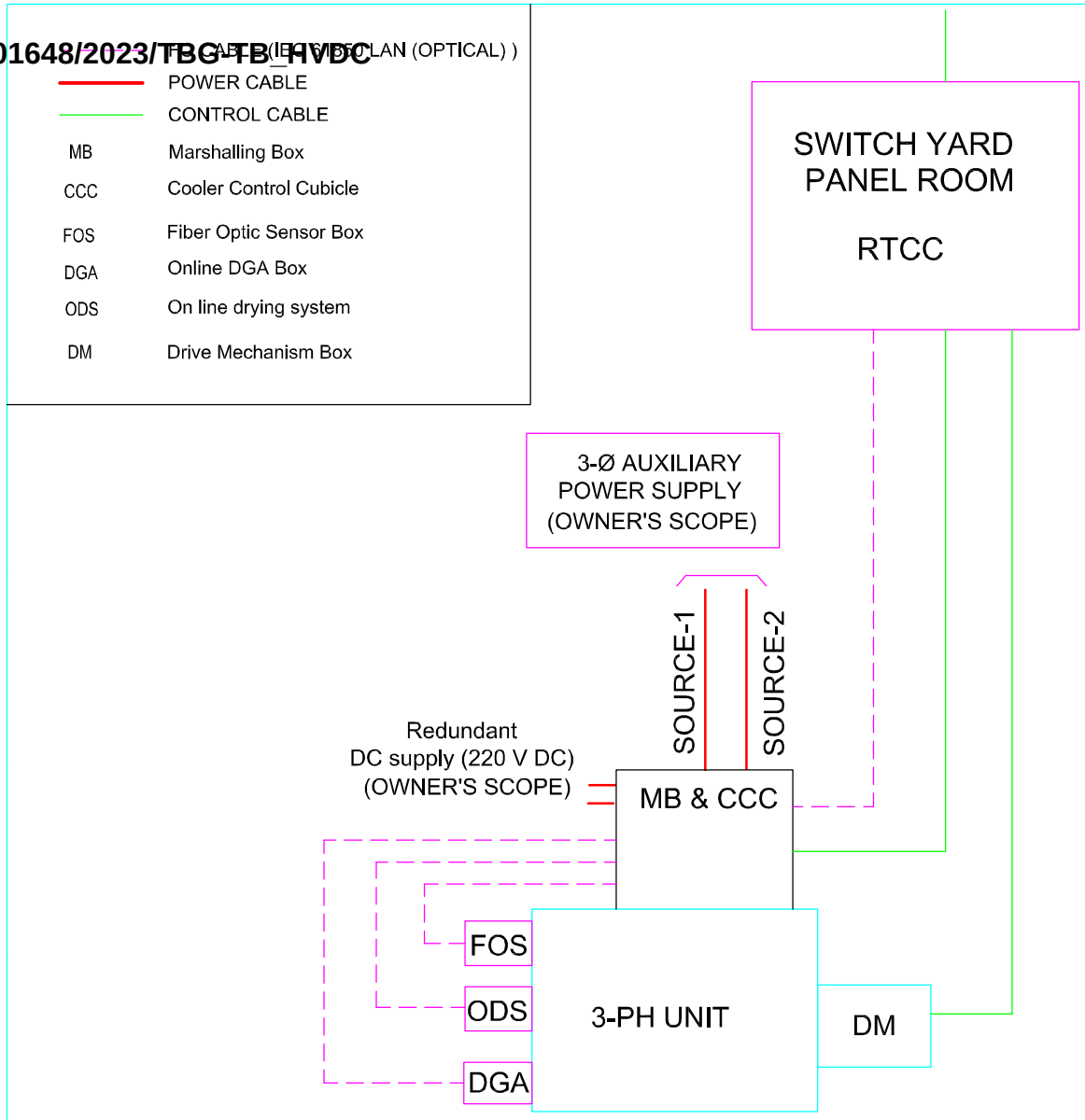
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

PROJECT : 765KV & 400KV 1-PH TRANSFORMER

TITLE : CONCEPTUAL DRG. FOR SHOWING POWER AND CONTROL CABLE CONNECTION FOR OPERATION WITH SPARE UNIT

DRAWN	CHKD.	REVIEWED	APPROVED BY	DRAWING NO.	REV.
ACDE	CDE	DGM	GM (ENGG-S/S)	C/ENGG/TR/SPARE/CABLE/STD	02

1401648/2023/TBG-TB HVDC



NOTE:

1. All the online monitoring equipment i.e. Optical Temperature Sensors & Measuring Unit, Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) provided for individual transformer unit including spare (if any), are IEC 61850 compliant (either directly or through a Gateway). These monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in MB by the contractor. The switch shall be powered by redundant DC supply (220V DC). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C. All required power & control cables including optical cable, patch chord (if any) upto MB shall be in the scope of contractor.

2. However, fiber optic cable, power cable, control cables, as applicable, between MB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of sub-station contractor.

3. Control, Power, FO and any special cable from online monitoring equipment, DM, Cooler control cubicle to MB shall be supplied by contractor

4. Ethernet switch, LIU, Patch cord etc. shall be provided at MB by contractor

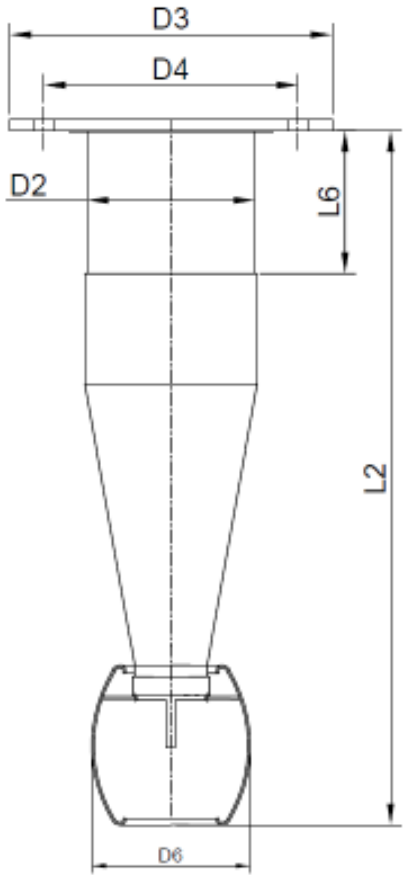
5. All cable from RTCC to MB & DM and any special cable between MB to switchyard panel room/control room shall be supplied by contractor

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG. FOR SHOWING POWER & CONTROL CABLE FOR OPERATION OF 3–PH TRANSFORMER	C/ENGG/STD/CABLE/TR	01

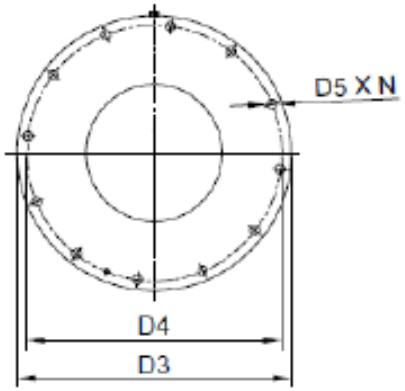
Annexure-R

STANDARD DIMENSION FOR LOWER PORTION OF CONDENSER BUSHINGS

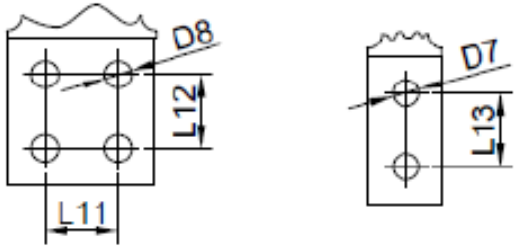
(For 420 kV and below voltage class Bushings)



Bushing Mounting Flange Details



Bottom Connection Details



Symbol	Description
L2	Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest
L6	Length for accommodating Bushing Current Transformer (BCT)
D2	Maximum diameter of oil immersed end
D3	Outside diameter of fixing flange
D4	Pitch Circle Diameter of fixing holes of flange
D5	Diameter of fixing hole
N	Number of fixing holes
D6	Maximum diameter of oil end shield/stress relieving electrode
L11	Horizontal Distance between holes for bushing bottom connection for 4 hole connection
L12	Vertical Distance between holes for bushing bottom connection for 4 hole connection
L13	Vertical Distance between holes for bushing bottom connection for 2 hole connection
D7	Diameter of hole for bushing bottom connection for 2 hole connection
D8	Diameter of hole for bushing bottom connection for 4 hole connection

Annexure-R

Voltage Rating (kV)	420	245		145		72.5		52
BIL kVp	1425 1550(for GT)	1050		650		325		250
Creepage Distance (mm)	13020	7595		4495		2248		1612
Current Rating (A)	1250	1250	2000	1250	2000	800	2000	1250
Type of lead	Solid Stem (SS)	SS	SS	SS	SS	SS		SS
L2 ±5	1640	1130	1230	800/ 1250[a]	1030	695		450
L6 (min.)	400	300		300/500 [a]	300	300		100
D2 (max.)	350	270		165	180	115	165	115
D3±2	720	450		335	335	225	335	225
D4±1 (PCD)	660	400		290	290	185	290	185
D5xN	24x12	20x12		15x12	15 x12	15x6	15x12	15x6
D6 (max.)	350	270		180		115		115
L11	-	-	45	-	45	-	55	-
L12	-	-	40	-	40	-	40	-
L13	40	40	-	40	-	40	-	40
D7	Φ14	Φ14		Φ14	Φ14	Φ14	Φ14	Φ14
D8	-	-	Φ 14	-	-	-	-	-
Length & Diameter of Air End Terminal	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60

[a] for 765 kV class shunt reactor

Notes:

1. All dimensions are in mm.
2. No positive tolerance where maximum dimension specified and no negative tolerance where minimum dimension is specified.
3. For other details of oil end terminal for 2000 A (145 kV/245 kV) solid stem type bushing, refer Fig 4 of IS 12676.
4. For other details of oil end terminal for 2000 A, 72.5 kV solid stem type bushing, refer Fig 3B of IS 12676.
5. For other details of oil end terminal for 800 A and 1250 A (52kV/72.5 kV/145 kV/245 kV/420 kV) solid stem type bushing, refer Fig 3A of IS 12676.

ANNEXURE-S

Standard Test Procedure of Transformer & Reactor

1401648/2023/TBG-TB_HVDC

STANDARD TEST PROCEDURE FOR TRANSFORMER & REACTOR

DOC. No.: POWERGRID/STD/TEST PROCEDURE/TR-RT

Revision-02

June 2021

INDEX

Sr. No.	Test	Page No
1.	General	4
2.	Low Voltage tests	5-11
2.1.	Voltage ratio measurement & Polarity check (Vector Group)	5
2.2	Measurement of insulation power factor and capacitance between winding and earth and Bushings	6-7
2.3	Measurement of insulation resistance & Polarization Index	8
2.4	Core assembly dielectric and earthing continuity test	9
2.5	Measurement of winding resistance	10
2.6	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	11
3.	Measurement of no-load loss and current & harmonic level in no load current	12
4.	Magnetic balance test (for three phase Transformer only)	13
5.	On-load tap changer test	14
6.	Measurement of short-circuit impedance and load loss	15
7.	Dielectric tests	16-34
7.1	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	17-24
7.2	Switching impulse test for the line terminal (SI)	25-26
7.3	Applied voltage test (AV)	27
7.4	Line terminal AC withstand voltage test (LTAC)	28
7.5	Induced voltage withstand test (IVW)	29
7.6	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	30-31
7.7	Induced voltage test with PD measurement (IVPD)	32-34
8.	Temperature rise test	35-41
9.	Overload testing in short-circuit method	42-43
10.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	44
11.	Over excitation test	45
12.	Measurement of Zero seq. reactance (for three phase Transformer only)	46-47
13.	Measurement of acoustic noise level	48
14.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	49
15.	High voltage with stand test on auxiliary equipment and wiring after assembly	50
16.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	51
17.1	Oil leakage test on transformer tank	52
17.2	Tank vacuum test	52
17.3	Tank pressure test	52
18.	Appearance, construction and dimension check	53
19.	Dynamic Short circuit withstand test (If specified in BPS)	54-57
20	Check Lists for Transformer & Reactor Tests	68-69

Test procedure for transformer & Reactor are similar. Hence, same method as mentioned for transformer shall be applicable for reactor also. However, few tests which only to be performed in Reactor are given below:

Sr. No.	Test (Only for Reactor)	Page No
20.	Short time over voltage Test (830kVrms) (765kV Reactor)	58
21.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	59-61
22.	2-Hour excitation test except type tested unit	62
23.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Um for reference only on one unit of each type)	63
24.	Measurement of harmonic content of current (Measured in Cold state)	64
25.	Knee point voltage measurement of reactor (Measured in Cold state)	65
26.	List of reference standards	66

1. General

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer/reactor unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) (excluding ODS, DGA, Fire protection system) assembled.

RTCC and Common Marshalling Box testing may be carried during routine testing of any one unit (Transformer/Reactor). In case of only one unit is being manufactured, RTCC and Common Marshalling Box testing may be carried out along with that unit.

All measuring systems used for the tests shall have certified traceable accuracy and be subjected to periodic calibration, according to the rules given in ISO 9001. Specific requirements on the accuracy and verification of the measuring systems are described in IEC 60060 series and IEC 60076-8.

Latest IEC standards (as applicable) shall be followed for all the tests.

1.1. Before start of FAT following tests shall be carried out on insulating oil:

Break Down voltage (BDV), Moisture content, Tan-delta, Interfacial tension and Particle count

Acceptance Criteria: POWERGRID Specification of Insulating Oil

2. Low Voltage Tests

2.1. Voltage ratio measurement & Polarity check (Vector Group)

Refer IEC 60076-1for procedure and acceptance criteria. Manufacturer's standard practice may be followed.

2.2. Measurement of insulation power factor and capacitance between winding and earth and Bushings

Standards: IEC 60076-1 & POWERGRID Technical Specification for Transformers & Reactors.

Capacitance & tan delta of HV bushings, IV bushings, LV bushings and neutral shall be measured at 5kV & 10kV. It is applicable only for condenser type bushing (having test tap)

Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz, at multiple of 17 Hz and applied voltage shall be 2 – 5kV) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before dispatch for reference and the result shall be compared at site during commissioning to verify the healthiness of the bushing. No temperature correction factor shall be applicable for tan delta.

Further winding capacitances & tan delta shall also be measured in the following modes as per the table given below:-

Transformer

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV-IV)/LV (C_{HL})	(UST)	5		
			10		
2	(HV-IV)-E (LV GUARD) (C_H)	(GSTg)	5		
			10		
3	(HV-IV)/(LV+E) (GST) ($C_{HL} + C_H$)	(GST)	5		
			10		
4	LV/(HV-IV) (C_{HL})	(UST)	5		
			10		
5	LV-E (HV+IV GUARD) (C_L)	(GSTg)	5		
			10		
6	LV/(HV + IV+GROUND) ($C_{HL} + C_L$)	(GST)	5		
			10		

Test Criteria

The test is successful if tan delta measured is less than 0.5% or as mentioned in specification. The capacitances measured for above combinations (C_H, C_L, $C_{HL} + C_H$, $C_{HL} + C_L$, C_{HL}) may be compared.

Reactor

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV+N) - E (C_H)	(GST)	5		
			10		

For bushings and neutral the following table shall be filled:-

Configuration		Voltage (in kV)	Capacitance in pF	% tan delta
HV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
IV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
LV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
Neutral		5		
		10		

2.3. Measurement of insulation resistance & Polarization Index

Measurement of insulation resistance between winding & earth by 5 kV megger.

Insulation resistance tests are made to determine the insulation resistance from individual winding to ground or between individual windings. The insulation resistance in such tests is commonly measured in mega-ohms, or may be calculated from measurements of applied voltage and leakage current. The dc voltage applied for measuring insulation resistance to ground shall not exceed a value equal to the half of the rated voltage of the winding or 5 kV whichever is lower.

Note

1. The insulation resistance of electrical apparatus is subjected to wide variation in design, temperature, dryness, and cleanliness of the parts. When the insulation resistance falls below prescribed values, it can, in most cases of good design and where no defect exists, be brought up to that required standard by cleaning and drying the apparatus. The insulation resistance, therefore, may offer a useful indication as to whether the apparatus is in suitable condition for application of dielectric tests.

2. Under no conditions, test should be made while the transformer is under vacuum.

Polarisation Index (PI)

The purpose of polarisation index test is to determine if equipment is suitable for operation or even for an overvoltage test. The polarisation index is a ratio of insulation resistance value at the end of 10 min test to that at the end of 1 min test at a constant voltage. The total current that is developed when applying a steady state dc voltage is composed of three components:

(1) Charging current due to the capacitance of the insulation being measured. This current falls off from maximum to zero very rapidly.

(2) Absorption current due to molecular charge shifting in the insulation. The transient current decays to zero more slowly.

(3) Leakage current which is the true conduction current of the insulation. It has a component due to the surface leakage because of the surface contamination.

The advantage of PI is that all of the variables that can affect a single IR reading, such as temperature and humidity, are essentially the same for both the 1 min and 10 min readings. Since leakage current increases at a faster rate with moisture present than does absorption current, the IR readings will not increase as fast with insulation in poor condition as with insulation in good condition. After 10 min the leakage current becomes constant and effects of charging current and absorption current die down.

Acceptable PI value for power transformer shall be better than 1.3.

2.4. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 AC Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 0.5 GΩ for all cases mentioned above.

2.5. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 h, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps shall be done.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

If fibre optic sensors are installed, temperature of winding and oil by FO sensors are also to be recorded in the test report. Further ensure that the FO reading should approx. match with RTD temperature reading.

Type tested unit:

Test engineer (manufacturers) add terminal cables/tube for taking immediate reading of hot resistance of winding. In that case the reference value of cold resistance of the same circuit to be measured and witnessed. Average oil temperature is also to be measured. The above is required for calculation of temperature at shut down condition.

2.6. Measurement of no load current & short circuit Impedance with 415 V, 50 Hz AC.

Measurement of no load current

415V, 50HZ 3-Ph supply (controlled) shall be supplied LV side (Tertiary side for Auto) and magnetising current shall be measured.

Voltage			Current		
U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ

Short circuit Impedance with 415 V, 50 Hz AC

Impedances shall be measured for all combinations and at Maximum, Minimum & Normal Voltage Tap – HV/IV, HV/LV & IV/LV

HV/IV – Connection

Applied Voltage at HV, IV Short circuited, Tertiary Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

HV/LV – Connection

Applied Voltage at HV, LV Short circuited, IV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

IV/LV – Connection

Applied Voltage at IV, LV Short circuited, HV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Normal							

Measured impedance shall be approximately matched with the impedances measured at rated current. The current at all the phases shall be approximately same.

3. No-load loss and current & harmonic measurement

As per IEC 60076-1:2011 clause 11.5. The transformer shall be approximately at factory ambient temperature. Measurement should be carried out at rated specified voltage of the transformer. Harmonics in no load current shall be measured during No Load Loss measurement.

Check points:

- The value of CT measurement range should be kept sufficiently high (3 to 5 times of measuring value) for better measurement and take care of distortions.
- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.

Note: After No load loss measurement Load loss measurement shall be commenced immediately and shall be carried out as per procedure mentioned at Sr. No. 6 below.

4. Magnetic Balance Test on 3-phase Transformers

This test is conducted only in three phase transformers to check the imbalance in the magnetic circuit. In this test, no winding terminal should be grounded; otherwise results would be erratic and confusing. Applied Test voltage shall be 415V.

Evaluation criteria

The voltage induced in the centre phase shall be 40% to 90% (approx.) of the applied voltage on the outer phases. However, when the centre phase is excited then the voltage induced in the outer phases shall be 30 to 70% (approx.) of the applied voltage. Zero voltage or very negligible voltage induced in the other two windings should be investigated. The purpose of this test basically is to ensure that there is no inter turn fault in the winding which is generally reflected in high excitation current in faulty winding.

5. Tests on On-load Tap-Changers

Operation Test

With the tap-changer fully assembled on the transformer the following sequence of operations shall be performed without failure:

a) With the transformer un-energised, eight complete cycles of operations (a cycle of operation goes from one end of the tapping range to the other, and back again).

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

d) With one winding short circuited and, as far as practicable, two rated current according to IEC 60076-1 in the winding, 10 tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping(the tap changer will pass 20 times through the changeover position). Total tap change operations shall be 80.

6. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

If fibre optic sensors are installed, hotspot temperature of winding and oil may be recorded for reference.

Following parameters shall be recorded:
Current, voltage (RMS & Average), power factor, apparent power, active power, reactive power etc.

Current measured at all the phases shall be approximately same. If more variation is observed between current values of all phases measured, test circuit shall be reviewed and test shall be repeated.

Check points:

- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.
- Current can also be verified from one of the measuring type bushing CTs.

7. Dielectric Tests

Dielectric tests shall be carried in the following sequence as per IEC 60076-3:2013 clause 7.2.3:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable). This test may be carried out followed by LI & SI test.
f) Short time over voltage Test (830kVrms) for 765kV Reactor
g) Induced voltage test with partial discharge measurement (IVPD)

Oil Sample shall be taken before starting and after completion of dielectric tests for DGA. In case any abnormality during testing, oil samples may also be taken for DGA.

7.1 **Full wave lightning impulse test (LI) & chopped wave lightning impulse test (LIC)**

Reference Standard:

IEC 60076-3:2013, IEC 60060-1(General definitions of terms related to impulse tests and requirements for test circuits), IEC 60060-2 (measuring devices) & IEC 60076-4 & IEEE Std C57.98-1993

General

For liquid-immersed transformers, the test voltage is normally of negative polarity, because this reduces the risk of erratic external flashovers in the test circuit.

Tap positions

If the tapping range is ± 5 % or less and the rated power of the transformer is ≤ 2 500 kVA then, the lightning impulse tests shall be made with the transformer connected on the **principal tapping**.

If the tapping range is larger than ± 5 % or the rated power of the transformer is > 2 500 kVA then, the two extreme tappings and the principal tapping shall be used, one tapping for each of the three individual phases of a three-phase transformer or the three single-phase transformers designed to form a three-phase bank.

Records of tests

1. Applied Voltage; the records obtained shall clearly show the applied voltage impulse shape (front time, time-to-half value and amplitude).

   The recorded curve and the extreme value of the recorded curve (as defined in IEC 60060-1) shall be presented in the test record.

   The value of the test voltage (after the application of any filtering or correction for overshoot, U_t see IEC 60060-1) shall be reported in the test record.

2. At least one more measurement channel shall be used. In most cases an oscillogram of the current flowing to earth from the tested winding (neutral current). Further recommendations about failure detection, suitable time-base durations, etc. are given in IEC 60076-4.

Test connections

Test connections for lightning impulse on the Line Terminals

The impulse test sequence is applied to each of the line terminals of the tested winding in succession. The other line terminals of the transformer shall be earthed directly or, if needed to achieve the required wave shape, through an impedance. The impedance shall not exceed the surge impedance of the connected line (if a value is supplied by the purchaser) or 400 Ω whichever is lower. In all circumstances, the voltage appearing during the impulse test at the other line terminals shall not be more than 75 % of their rated lightning impulse withstand voltage for star-connected

windings, or 50 % for delta-connected windings. The lowest value of impedance at each terminal needed to achieve the required wave shape shall be used.

If the winding has a neutral terminal, the neutral shall be earthed directly or through low impedance such as a current measuring shunt. The tank shall be earthed. If the required wave shape cannot be obtained without the use of a resistor between neutral and earth, then an additional complete impulse test sequence shall be applied. In this case the first impulse test sequence tests the winding at the full voltage without the resistor but the required wave shape may not be achieved and the second sequence with the resistor achieves the wave shape. Chopped waves, if required, would not be repeated in the second sequence.

When a transformer is fitted with internal non-linear elements such as surge arresters which will limit the voltage on internal parts during the impulse test then the provisions of Clause 13.2.3 of IEC 60076-3 apply. Any such internal non-linear elements which are present in the service condition shall be present during the tests. External non-linear elements and other external voltage control elements such as capacitors shall be disconnected for test.

The impulse circuit and measuring connections shall remain unchanged during reference and full voltage tests

Test connections for lightning impulse on Line terminals

Lightning impulses are applied directly to the neutral with all other terminals earthed.

Full wave lightning impulse test (LI)

Wave shape, determination of test voltage value and tolerances

The test impulse shall be a full standard lightning impulse: 1.2 ± 30 % / 50 μs ± 20 %.

The test voltage value shall be the test voltage value as defined specification If the maximum relative overshoot magnitude is 5 % or less, the test voltage value may be taken as the extreme value as defined in specification.

The tolerance on the test voltage value is ± 3 %.

If the standard impulse shape cannot reasonably be obtained because of low winding inductance or high capacitance to earth and the resulting impulse shape is oscillatory so that the relative overshoot magnitude exceeds 5 % then for windings that will receive a chopped wave lightning impulse test, the front time may be increased to reduce the overshoot. In all cases with Um ≤ 800 kV the front time shall not exceed 2.5 μs. If the relative overshoot magnitude exceeds 5 % at the full wave voltage level, then a test voltage function shall be applied in accordance with IEC 60060-1 to determine the test voltage value. It is permissible to apply the requirements of IEC 60060-1 Annex B to the evaluation of the parameters of the lightning impulse irrespective of the overshoot value.

NOTE
Case of overshoot of more than 5 % the peak voltage of the impulse (maximum value of the recorded curve) shall be increased and the frequency of oscillation is higher than about 100 kHz by the application of the test voltage function in accordance with IEC 60060-1.

Tests on transformers without non-linear elements

Test sequence

The test sequence shall consist of:

a) one reference impulse of a voltage between 50 % and 70 % of the full test voltage
b) Three subsequent impulses at full voltage.

If, during any of these applications, an external flashover in the circuit or across a bushing spark gap occurs, or if the recording fails on any of the specified measuring channels, that application shall be disregarded and a further application made.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report.

Test acceptance criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference impulse and those recorded at the full test voltage.

NOTE

The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure shall be clearly stated in the report. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

If non-linear elements or surge arresters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold. The test sequence shall consist of:

a) one reference impulse at between 50 % and 60 % of the full test voltage;
b) one reference impulse at between 60 % and 75 % of the full test voltage;
c) one reference impulse at between 75 % and 90 % of the full test voltage;
d) three consecutive 100 % full wave impulses;
e) a comparison impulse at as nearly as possible the same voltage as c) above;

f) a comparison impulse at as nearly as possible the same voltage as b) above;
g) A comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage record of the reference impulse records, then impulses e), f) and g) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full
test voltage. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and g)
– b) and f)
– c) and e)
– all the 100 % level impulse records.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records are progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE
Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Chopped wave lightning impulse test (LIC)

Wave shape

The chopped wave lightning impulse shall have a time to chopping between 3 μs and 6 μs. The time to first voltage zero after the instant of chopping shall be as short as possible. The test shall be made without the deliberate addition of impedance in the chopping circuit, but if the overswing observed during a reduced voltage application is more than 30 % then the minimum impedance required to bring the over swing below 30 % may be added to the chopping circuit.

NOTE

Transformers are normally designed to withstand an over swing to the opposite polarity of 30 % of the amplitude of the chopped wave lightning impulse. Usually, the same settings of the impulse generator and measuring equipment are used, and only the chopping gap equipment is added.

Different time bases may be used to record the chopped wave lightning impulses. It is recommended to use a triggered-type chopping gap with adjustable timing, although a plain rod-rod gap is allowed. The peak value of the chopped wave lightning impulse shall be 110 & of rated impulse voltage.

Tests on transformers without non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence. The order of the different impulse applications shall be:

a) one full wave reference impulse at between 50 % and 70 % of the full wave lightning
b) impulse test voltage;
c) one full wave impulse at the full wave lightning impulse test voltage;
d) two chopped impulses at the chopped wave lightning impulse test voltage;
e) Two full wave impulses at the full wave lightning impulse test voltage.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. As far as possible the same time to chop shall be used for all chopped wave lightning impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference reduced level full impulse and those recorded at the full test voltage including the chopped impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap.

NOTE
The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure requires a great deal of skill and experience. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence.
If non-linear elements or surge diverters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold.

The test sequence shall consist of:
a) one full wave reference impulse at between 50 % and 60 % of the full wave lightning impulse test voltage;
b) one full wave reference impulse at between 60 % and 75 % of the full wave lightning impulse test voltage;
c) one full wave reference impulse at between 75 % and 90 % of the full wave lightning impulse test voltage;
d) one full wave impulse at the full wave lightning impulse test voltage;
e) two chopped impulses at the chopped wave lightning impulse test voltage;
f) two full wave impulses at the full wave lightning impulse test voltage;
g) a comparison impulse at as nearly as possible the same voltage as c) above;
h) a comparison impulse at as nearly as possible the same voltage as b) above;
i) a comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage of the reference impulse record then impulses g), h) and i) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than 75 % of the full level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. The same types of measuring channels and oscillographic records are specified as for the full wave impulse test. As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full test voltage including the chopped wave impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and i);
– b) and h);
– c) and g);
– all the 100 % level impulse records;
– both the chopped wave records up to the time of chop.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records should be progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE

Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

NOTE

The information given in IEC 60076-4 with reference to waveshape evaluation is based on the visual observation of oscillographic records. Under certain circumstances it might be appropriate to evaluate the waveshape parameters of non-standard waveshapes and perform the interpretation of deviations manually rather than relying completely on software tools.

Lightning impulse test on a neutral terminal (LIN)

General
Full wave lightning impulses at the impulse voltage level specified for the neutral are applied directly to the neutral with all other terminals earthed.

Waveshape
The wave shape of the full wave impulses shall be as given in 13.2.1 of IEC-60076-3 except that the duration of the front may be up to a maximum of 13 μs.

Test sequence
The test sequence shall be as given in clause 13.2.2.1 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.1 of IEC-60076-3for transformers with a non-linear element.

Test criteria

The test criteria shall be as given in clause 13.2.2.2 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.2 of IEC-60076-3 for transformers with a non-linear element.

7.2 **Switching impulse test**

Standards:

IEC 60076-3, 60076-4, IEC 60060-1 (for Reactor IEC 60076-6) & IEEE Std C57.98-1993

General

During switching impulse tests, the voltages developed across different windings are approximately proportional to the ratio of numbers of turns. The switching impulse test voltage shall be as specified for the winding with the highest *U*m value. If the ratio between the windings is variable by tappings, the tappings shall be used to bring the test voltage for the winding with lower *U*m as close as possible to the corresponding test value given in Table 2 of IEC-60076-3.

The windings with lower *U*m values may not receive their full test voltage; this shall be accepted. In a three-phase transformer, the voltage developed between line terminals during the test shall be approximately 1.5 times the voltage between line and neutral terminals.

Test Connection

The impulses are applied either directly from the impulse voltage source to a line terminal of the highest voltage winding, or to a lower voltage winding so that the test voltage is inductively transferred to the highest voltage winding. The specified test voltage shall appear between the line terminal of the highest voltage winding and earth. The voltage shall be measured at the line terminal of the highest voltage winding. A three-phase transformer shall be tested phase by phase.

Star connected windings with the neutral brought out shall be earthed at the neutral terminal either directly or through a low impedance such as a current measuring shunt. A voltage of opposite polarity and about half amplitude appears on the two remaining line terminals which may be connected together but not connected to earth. To limit the voltage of opposite polarity to approximately 50 % of the applied level, it is permissible to connect high resistance damping resistors (5 kΩ to 20 kΩ) to earth at the non-tested phase terminals.

For delta connected windings the terminal corresponding to the end of the phase under test shall be earthed either directly or through a small measuring impedance, the other terminals shall be open circuit. Tests on a three-phase transformer shall be arranged so that a different terminal of the delta is earthed for each phase test. Delta connected windings with more than three terminals brought out shall have the delta closed for the test.

For a single phase transformer with one or more windings which will have both ends connected to a line in service and with a switching impulse test specified, then the switching impulse test shall be applied to both ends of the winding.

Bushing spark gaps may be removed or their spacing increased to prevent spark over during the test.

Reactor shall also be tested by the method mentioned above. However, additionally for reactor, clause 8.3 of IEC 60076-4 may also be referred. Since there is only one winding per phase, the application point for the test voltage is the line terminal of the phase winding which is to be tested. The other terminal of this phase winding should be earthed.

For three-phase reactors, the normal impulse test procedures as used for lightning impulse tests are required.

Wave shape

The test voltage is normally of negative polarity to reduce the risk of erratic external flashover in the test circuit.
The voltage impulse shall have a time to peak (*T*p as defined in IEC 60060-1) of at least 100 μs, a time above 90 % (*T*d as defined in IEC 60060-1) of the specified amplitude of at least 200 μs, and a time to zero (*T*z as defined in IEC 60060-1) of a minimum of 1000 μs.

Normally the transformer characteristic of Td ≥ 200 μs is not a problem for small reactors (<100 Mvar for three-phase reactors with relatively high impedances). For large reactors, Td and Tz as specified for transformers would require excessive impulse generator extension. For such cases, a minimum value for Td and Tz should be 120 μs and 500 μs respectively to assure adequate volt-time stress.

Test Sequence

The test sequence shall consist of one reference impulse of a voltage between 50 % and 70 % of the full test voltage and three impulses at full voltage. Sufficient reverse polarity applications shall be made before each full impulse to ensure the magnetization of the core is similar before each full wave impulse in order to make the time to first zero as uniform as possible.

Oscillographic records shall be made of the impulse wave-shape on the line terminal under test and the current between the tested winding and earth. If during any of these applications an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

Acceptance Criteria

The test is successful if there is no sudden collapse of voltage or discontinuity in the voltage or current indicated on the oscillographic records.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the oscillographic records, but they do not constitute evidence in themselves.

7.3 Applied voltage test (AV)

The test shall be carried out on each separate winding of the transformer in turn.

The full test voltage shall be applied for 60 s between all accessible terminals of the winding under test connected together and all accessible terminals of the remaining windings, core, frame and tank or casing of the transformer, connected to earth.

The test shall be made with an approximately sinusoidal single-phase alternating voltage at rated frequency. The peak value of voltage shall be measured. The peak value divided by √2 shall be equal to the test value.

NOTE
Approximately sinusoidal can be taken to mean that the peak value divided by √2 does not differ from the r.m.s value of the waveform by more than about 5 % (see IEC 60060-1), but wider deviations may be accepted.

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

For windings with non-uniform insulation, the test is carried out with the test voltage specified for the neutral terminal. In transformers where windings having different U_m values are connected together within the transformer (usually auto-transformers), the test voltages shall be determined by the insulation of the common neutral and it's assigned U_m.

7.4 Line terminal AC withstand test (LTAC)

The test shall be arranged so that the test voltage appears between the tested terminal and earth. Each phase terminal of the tested winding shall be tested in turn. The test time, frequency and voltage application shall be same as Induced voltage withstand test (IVW).

$$\text{Test time in Seconds} = 120 \times \frac{\text{rated frequency}}{\text{test frequency}}, \text{ but not less than 15 s}$$

For transformers with taps and a non-uniformly insulated lower voltage winding, the tap position for test shall be selected so that when the required test voltage appears on the highest voltage winding terminals, the voltage appearing on the lower voltage winding terminals shall be as close as possible to the required test value. For transformers with a uniformly insulated lower voltage winding subject to an applied voltage test, the tap position may be chosen by the manufacturer.

The test is successful if no collapse of the test voltage occurs.

NOTE
This test is intended only as a withstand test for each line terminal of a non-uniformly insulated transformer to earth, it is not intended to test the phase to phase or turn to turn insulation so the test arrangement can be made in any convenient way, for example with voltage at the neutral to reduce the turn to turn voltage and the test will normally be carried out as three single phase tests. Partial discharge measurements can be made during this test.

7.5 Induced voltage withstand test (IVW)

The test time at full test voltage shall be 60 s for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

$$120 \times \frac{\text{rated frequency}}{\text{test frequency}}, \text{ but not less than 15 s}$$

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

7.6 Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse

The voltage shall be applied on the phase for which transferred surge shall be measured in the same phase of tertiary (i.e. if voltage is applied on 1W, the transferred surge shall be measured at 3W terminal). The above process shall be repeated for the remaining HV & IV terminals.

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap (if applicable). However, applied voltage shall be selected such a way that induced voltage at other winding should not go more than the SI limit of that winding.

Following tests shall be carried out with applying 50% to 80% of rated Impulse & Switching impulse (upto 60% for IV to limit the max. limit of HV SI level) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

For each tap position, atleast 2 nos. shots (for LI - one at approx. 50% and other at approx. 80% and for SI – one at approx. 40% & at approx. 60%*) shall be applied and measured values shall be extrapolated to 100%. Measured and extrapolated values shall be recorded.

Transformer with non-linear element in the winding

If Lightning Arrestor (or **non-linear element)** is connected with tertiary or LV to limit the surges, transfer surge shall be carried out with LA (as to be connected in service) during Test at factory for HV and IV lightning & switching impulse Test. In that case applied voltage shall be raised gradually to the level where the LA shall operate/actuate. It shall be below the impulse / SI level of LV or tertiary winding.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

1-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1.1	2.1, N & 3.2	-	3.1
2	FW	1.1	2.1, N & 3.1	-	3.2
3	FW	2.1	1.1, N & 3.2	-	3.1
4	FW	2.1	1.1, N & 3.1	-	3.2

Where,

1.1 : HV Terminal
2.1 : IV Terminal
3.1 & 3.2 : LV or Tertiary Terminal

(*): Should not reach beyond the SI limit of HV winding

3-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
5	FW	1U	1V, 1W, 2U, 2V, 2W, N, 3V & 3W	-	3U
6	FW	1V	1U, 1W, 2U, 2V, 2W, N, 3U & 3W	-	3V
7	FW	1W	1U, 1V, 2U, 2V, 2W, N, 3V & 3U	-	3W
8	FW	2U	1U, 1V, 1W, 2V, 2W, N, 3V & 3W	-	3U
8	FW	2V	1U, 1V, 1W, 2U, 2W, N, 3U & 3W	-	3V
9	FW	2W	1U, 1V, 1W, 2U, 2V, N, 3V & 3U	-	3W

Acceptance criteria

Transfer surge at Tertiary should not exceed the rated impulse level of that winding. The extrapolated values measured at 50% and 80% (for LI) or 40% and 60% (for SI) as stated above shall be approximately matched.

When non-linear element is connected in the winding, the non-linear element should limit the transferred voltage below the rated impulse level of that winding. LA / nonlinear element shall operate/actuate below the impulse level of Tertiary or LV winding.

7.7 Induced voltage test with partial discharge measurement (IVPD)

Standards

IEC 60076-3, IEC 60270 & POWERGRID Technical Specification for Transformers & Reactors.

General

This test is intended to verify that the transformer will be free of harmful partial discharges under normal operating conditions. The test voltage is applied in the same way as the voltage that the transformer will experience in service. During the test, symmetrical voltages appear at all the line terminals and between turns, **with no voltage at the neutral**. The test is performed with a three phase voltage on three phase transformers

Each PD measurement channel including the associated bushing or coupling capacitor shall be calibrated in terms of apparent charge (pC) according to the method given in IEC 60270.

Voltage calibration to be done to check the test voltages to be applied as per test sequence given below before start of PD Test as there is no option of keeping the voltage divider connected to the transformer for voltage measurement continuously during PD test.

The PD measurement shall be given in pC and shall refer to the highest steady-state repetitive impulses indicated by the measuring instrument**. Occasional bursts of high partial discharge level may be disregarded.**

If high partial discharge is coming repeatedly, and may be due to external reason, manufacturer should improve the system and bring the value to ambient level before starting the PD cycle.

For each required PD measurement step in the test sequence, PD measurements shall be made and recorded on all the line terminals equipped with bushings with a Um ≥ 72.5 kV, during the test, however if there are more than six such terminals then only six measurements need to be made (one on each of the highest voltage terminals) unless otherwise specified.

Test sequence

The test sequence shall be as follows:

a) The voltage shall be switched on at a voltage not higher than $(0.4 \times Ur)/\sqrt{3}$.
b) The voltage shall be raised to $(0.4 \times Ur)/\sqrt{3}$ and a background PD measurement shall be made and recorded.
c) The voltage shall be raised to $(1.2 \times Ur)/\sqrt{3}$ and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
d) The PD level shall be measured and recorded.
e) The voltage shall be raised to the one hour PD measurement voltage and held there for a minimum duration of 5 min and only long enough to make a stable PD measurement.
f) The PD level shall be measured and recorded.
g) The voltage shall be raised to the enhancement voltage and held there for the test time mentioned below.

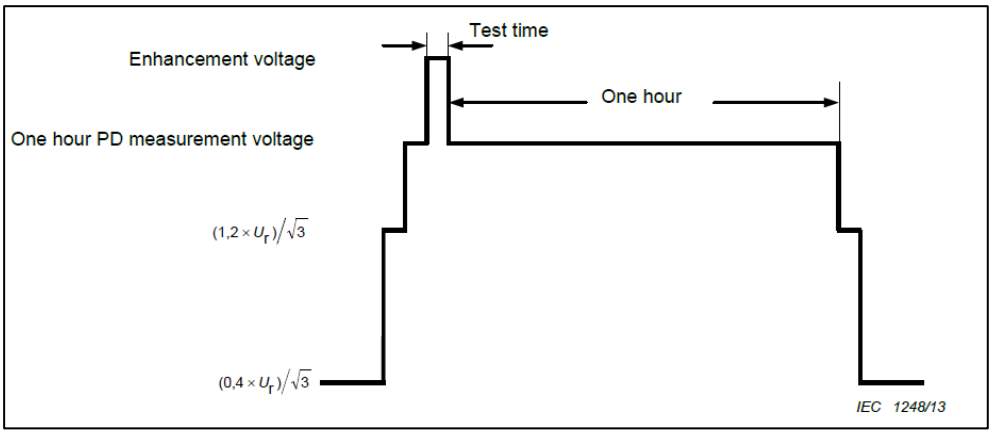
h) Immediately after the test time, the voltage shall be reduced without interruption to the one hour PD measurement voltage.
i) The PD level shall be measured and recorded.
j) The voltage shall be held at the one-hour PD measurement voltage for a duration of at least one hour following the PD measurement.
k) The PD level shall be measured and recorded every 5 min during the one hour period.
l) After the last PD measurement in the one hour period the voltage shall be reduced to (1.2 × Ur) /√3 and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
m)The PD level shall be measured and recorded.
n) The voltage shall be reduced to (0.4 × Ur) /√3 and the background PD level shall be measured and recorded.
o) The voltage shall be reduced to a value below (0.4 × Ur) /√3.
p) The voltage shall be switched off.

An enhancement (phase to earth) voltage level of (1.8 × Ur) /√3 and a one hour PD measurement voltage of (1.58 × Ur) /√3. Alternative higher voltage levels may be used if specified by the purchaser. In particular an enhancement voltage of Um and a one hour PD measurement voltage of (1.5 × Um) /√3 may be used if higher.

The partial discharge level shall be continuously observed on at least one measuring channel for the entire duration of the test.

During the test sequence the inception and extinction voltages of any significant PD activity should be noted to aid the evaluation of the test result if the test criteria are not met.

Test sequences are illustrated in below figure.



Test Duration & Frequency

The test time at the enhancement voltage shall be 60 s in case *U*m ≤ 800 kV and 300 s in case U_m > 800 kV for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

120 × rated frequency / test frequency, but not less than 15 s for *U*m ≤ 800 kV

The duration of the test, except for the enhancement level, shall be independent of the test Frequency.

Test acceptance criteria

The test can only be considered valid if the measured background PD level does not exceed 50 pC at both the beginning and the end of the test. For tests on shunt reactors a background PD level higher than 50pC may be accepted.

The test is successful if all the following criteria are fulfilled:

a) No collapse of the test voltage occurs;
b) None of the PD levels recorded during the one hour period exceed 100 pC;
c) The PD levels measured during the one hour period do not exhibit any rising trend and no sudden sustained increase in the levels occur during the last 20 min of the test;
d) The measured PD levels during the one hour period do not increase by more than 50 pC;
e) The PD level measured at a voltage level of $(1.2 \times U\text{r})/\sqrt{3}$ after the one hour period does not exceed 100 pC.
f) If the criteria c) or d) are not met, the one hour period may be extended and these criteria will be considered to have been met if they are fulfilled for a continuous period of one hour.

Check points:

1. For 3-Ph Transformer/Reactor, IVPD test shall be carried out by 3-Phase supply

2. Before start of the test, all parameters / data used for PD testing and mentioned in the computer software to be checked with calibrated result of the instrument.

3. In case of doubt, change of PD measuring channel, creating PD temporarily, and check the healthiness of the measuring channel.

4. Before and after the PD test, calibration of the channel and measuring circuit to be repeated.

5. Continuous PD recording (if facility available) to be carried out for reference.

8. Temperature Rise Test on Transformer

Reference Standard:

IEC 60076-1 Edition 3.0 2011-04 Clause 11.4 Measurement of short-circuit impedance and load loss & IEC 60076-2 Edition 3.0 2011

For each cooling combination with cooler bank, tests shall be done for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.

The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181. The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

Temperature of the cooling media

Ambient temperature

For the temperature rise test, the cooling air temperature should be in the range between 10 °C and the maximum ambient temperature 50 °C for which the transformer is designed.

At least four sensors shall be provided and the average of their readings shall be used to determine the ambient temperature for the evaluation of the test results.

Around an ONAN transformer, the ambient sensors shall be placed at a level about half-way up the cooling surfaces. The sensors shall be distributed around the tank, about 2 m away from the perimeter of tank and cooling surfaces, and protected from direct heat radiation.

For a forced-air-cooled (ONAF, OFAF, ODAF) transformer the sensors shall be placed in the air at about 0.5 m from the intake of the coolers.

Readings should be taken at regular intervals (30 minutes). Automatic continuous recording may be used.

In the case of separate cooling equipment placed at a distance of at least 3 m from the transformer tank, the ambient temperature shall be measured around the cooling equipment applying the same

rules given above. For separate cooler bank arrangement (distance of at least 3 m from the transformer tank) 4 numbers sensors shall be used to measure the ambient temperature.

Attention shall be paid to possible recirculation of hot air. The transformer should be placed so as to minimize obstructions to the air flow and to provide stable ambient conditions.

Total loss injection

The Contractor before carrying out this test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that result in highest temperature rise for the test. The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

2-Winding Transformer

Load Loss measurement for HV-LV connection and at Normal & extreme taps) shall be carried out. For 2-winding transformer, total losses to be fed during temperature rise test shall be **2-Winding Loss at tap corresponding to maximum measured loss and No load loss.**

2-Winding Loss = [HV-LV] (Max MVA)

The total losses to be injected during the first part of the test shall be equal to the highest value of total loss appearing at any tapping (corresponding to the particular tapping). This tapping is also often, but not always, the maximum current tapping. This part of the test determines the maximum top-liquid temperature rise. For the determination of winding temperature rise at the maximum current tapping, the value of liquid temperature rise to be used in the evaluation shall correspond to the total losses of that tapping.

3-Winding Transformer

Load Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps) shall be carried out. The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer. Total losses to be fed during temperature rise test shall be **3-Winding Loss and No load loss.**

3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (Max MVA)

The injection of total loss for the determination of liquid temperature rise may be made in an approximate manner by not short-circuiting or closing certain windings. The total losses shall be fed to HV or IV while LV winding is left open and raise the current until the correct total loss is obtained.

The top-liquid temperature and cooling medium temperature are monitored, and the test is continued until steady-state liquid temperature rises are established. The first part of the test may be terminated when the rate of change of top-liquid temperature rise has fallen below 1 K/h and has remained there for a period of 4 h. If discrete readings have been taken at regular intervals, the mean value of the readings during the last hour is taken as the result of the test. If continuous automatic recording is applied, the average value during the last hour is taken.

After the top-liquid temperature rise has been established, the test shall be continued without a break with the test current reduced to rated current for the winding combination connected. This condition is maintained for 1 h, during which time continuous temperature records of top-liquid, winding hot-spot (if measured) and external cooling medium should be taken at least every 15 min.

At the end of the hour, the resistances of the windings are measured, either after a rapid disconnection of the supply and short circuits (IEC 60076-2 clause 7.8 and Annex C) or, without switching off the supply, by means of the superposition method which consists of injecting into the windings and measuring direct current of low value superimposed on the load current. In the similar way winding hotspot, average winding rise etc. shall be measured for tertiary winding for various cooling.

Determination of liquid temperatures

Top-liquid temperature

The top-liquid temperature (θo) is conventionally determined by one or more sensors immersed in the insulating liquid at the top of the tank or, in pockets in the cover. The recommended number of pockets is the following:

− rated power ≥ 100 MVA: 3 pockets;
− rated power from 20 MVA to <100 MVA: 2 pockets;
− rated power < 20 MVA: 1 pocket.

The position of the sensors should be chosen to present the top-liquid temperature possibly in correspondence to the wound columns.

If more than one pocket is used, the readings of the sensors shall be averaged in order to obtain a representative temperature value.

Bottom and average liquid temperatures

The bottom liquid temperature (θb) shall be determined by sensors placed at the return headers from coolers or radiators. If several banks of cooling equipment are fitted, more than one sensor should be used and the reading average assumed as bottom liquid temperature.

Average liquid temperature (θom) is used for the calculation of the average winding gradient and correction of certain temperature rise test results. The average liquid temperature is:

$\theta om = (\theta o + \theta b)/ 2$

Determination of top, average and bottom liquid temperature rises

The top-liquid temperature rise ($\Delta\theta o$) shall be determined by difference between the top-liquid temperature measured at the end of the test period with total losses (θo) and the external cooling medium temperature at the end of the test period with total losses (θa), that is:

$\Delta\theta o = \theta o - \theta a$

The average liquid temperature rise (Δθom) shall be determined by difference between the average liquid temperature (θ om) calculated according to 4.2 and the external cooling medium temperature (θa), that is:

Δθom =θom –θa

The bottom liquid temperature rise (Δθb) shall be determined by difference between the bottom liquid temperature (θb) defined according to clause 7.4.2 of IEC 60076-2 and the external cooling medium temperature (θa), that is:

Δθb =θb –θa

Determination of average winding temperature

The average winding temperature is determined by measurement of winding resistance. On three-phase transformers, the measurement should be normally performed including the middle phase of the windings.

For star connected, low voltage and high current windings, the measurement should be made between line terminals in order to exclude the neutral connection from the test circuit. A reference measurement (R1,θ1) of all winding resistances is made with the transformer at ambient temperature, in a steady-state condition (see IEC 60076-1).

When the resistance (R2) is measured after disconnection of the power supply, extrapolated to the instant of shutdown, this yields the temperature value:

$$\theta_2 = \frac{R_2}{R_1}(235 + \theta_1) - 235 \qquad \text{for copper}$$

Where θ2 is the average temperature of the winding at the instant of shutdown. In the formula, the temperatures are expressed in Celsius degrees.

Determination of winding resistance at the instant of shutdown

The winding resistance (R2) before shutdown shall be determined using the rules indicated below.

Immediately after disconnection of the test power supply and removal of the short-circuiting connection, a direct current measuring circuit shall be connected across the winding terminals corresponding to the resistance to be measured.

As the resistance of the winding varies with time as the winding cools down, it shall be measured for a sufficient time to permit extrapolation back to the instant of shutdown.

As the windings have a large electrical time constant (L/R), accurate readings are therefore obtained only after a certain delay.

The delay can be reduced by minimizing as much as possible the time between the shutdown and the switching on the resistance circuit, as well as reducing the electrical time constant by an adequate choice of the parameters of the circuit.

The cooling conditions should preferably not be disturbed during the time the resistance measurements are made. If pumps are operating during the temperature rise test, they should be maintained during the measurements.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. Resistance shall be measured for atleast 30 minutes.

Determination of average winding temperature rise at the instant of shutdown

The average winding temperature rise shall be determined using the value of resistance at the instant of shutdown. The corrected winding average temperature rise of the winding ($\Delta\theta w$) is:

$\Delta\theta\ w = \theta 2 + \Delta\theta\ ofm - \theta\ a$

where $\theta 2$ is the average winding temperature at the instant of shutdown, θa is the external cooling medium temperature at the end of the test period with total losses, $\Delta\theta ofm$ the fall of the temperature of the average liquid during the 1 h test at rated current.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. The calculation details, Graph with Annexure C (duly filled) shall be submitted with temperature rise test result.

After hot resistance measurement of HV and IV winding, Tertiary winding shall be loaded at rated MVA (of LV) for 1 hour. After it, hot resistance measurement shall be carried for LV winding. The above sequence shall be followed for all cooling combinations (ONAN/ONAF/OFAF as applicable).

Determination of the average winding to liquid temperature gradient

The average winding to average liquid temperature gradient (g) shall be determined as the difference between the uncorrected average winding temperature ($\theta 2$) and the average liquid temperature θom at shutdown:

$g = \theta 2 - \theta om.$

Determination of the hot-spot winding temperature rise

Direct measurement during the temperature rise test

A number of thermal sensors (e.g., optical fibre sensors) shall be mounted inside the windings in positions where it is supposed the hot-spots are located.

When more than one sensor is used on the same winding, the maximum reading shall be taken as the hot-spot winding temperature.

The hot-spot winding temperature rise ($\Delta\theta h$) is then obtained by:

$\Delta\theta h = \theta h + \Delta\theta of - \theta a$

where θh is the temperature reading at shutdown, Δθ of the fall of the top-liquid temperature during the 1 h test at rated current, and θa the ambient temperature at the end of the total loss test period.

Determination by calculation

The hot-spot winding temperature rise can be determined using the following equation:

$\Delta\theta h = \Delta\theta o + Hg$

The average thermal gradient between each winding and liquid along the limb (g) is taken as the difference between the average winding temperature rise (Δθw) and average liquid temperature rise (Δθom).

(g)= (Δθw) - (Δθom).

H = Hotspot factor = 1.3 (As per existing practice) and also furnish the design calculate of this factor in line with IEC. Derive winding hotspot rise based on above factors and values should not exceed the guaranteed parameters for both the cases.

Hotspot temperature rise shall be measured by direct FO sensors and shall be recorded for reference only.

Calculation of Hotspot factor as per IEC 60076-2 shall also be furnished during design review.

The format of measuring parameters is attached at Annexure-I.

ANNEXURE-I

TRANSFORMER SR. NO.			
TRANSFORMER RATING :			WNDING
COOLING :			
The top-liquid temperature (θo)	(θo)	^{o}C	
The bottom liquid temperature (θb)	(θb)	^{o}C	
External cooling medium temperature at the end of the test period with total losses (θa)	(θa)	^{o}C	
The average liquid temperature θom	= (θo +θb)/ 2	^{o}C	
The top-liquid temperature rise (Δθo)	Δθo =θo −θa	^{o}C	
The average liquid temperature rise (Δθom)	=θom −θa	^{o}C	
Winding			
Average winding temperature at the instant of shutdown, θ2	θ2	^{o}C	
Fall of the temperature of the average liquid during the 1 h test at rated current , Δθofm	Δθ ofm	^{o}C	
The corrected winding average temperature rise of the winding Δθw	=θ2 + Δθofm −θa	^{o}C	
The average winding to average liquid temperature gradient (g) (Uncorrected)	g =θ2 −θom	^{o}C	
Temperature reading at shutdown by fiber optic sensor (direct reading), θh	θh	^{o}C	
The top-liquid temperature during the 1 h test at rated current, Δθof	Δθof	^{o}C	
The average winding to average liquid temperature gradient (g) (corrected)	g =g (uncorrected)+Δθofm	^{o}C	
The hot-spot winding temperature rise (Δθh)	=θh + Δθof −θa	^{o}C	
The average thermal gradient of Winding, (g)	= (Δθw) - (Δθom)	^{o}C	
Calculated Hotspot rise (Δθh) [where Hotspot factor, H = 1.3]	=Δθo +H g	^{o}C	
Hotspot rise (Δθh) [where design Hotspot factor, H = to be furnished by manufacturer]	=Δθo +H g	^{o}C	
Top liquid temperature rise		**^{o}C**	
HV Winding average temperature rise		**^{o}C**	
The hot-spot winding temperature rise (Δθh) by fiber optic sensor (reference purpose)		**^{o}C**	
The hot-spot winding temperature rise (Δθh) by conventional method		**^{o}C**	
The hot-spot winding temperature rise (Δθh) considering design hotspot factor and measured top oil rise.		**^{o}C**	

9. Overload testing in short-circuit method

The test shall be carried out on the tapping position that will cause the highest current under normal conditions. Hot spot temperature measurement shall be done by using temperature probes or sensors in approved locations.

The transformer shall be fully erected as for service with all cooling equipment.

I. Testing option 1:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with cooling as for service conditions.

- Increase the loading to 120% overload rating. Forced cooling shall be activated as per service conditions.
- Scan and record infra-red images of all four sides and the top of the transformer at the interval of every one hour.
- Hold the overload current for a period of 4 hours.
- Measure and record the hotspot temperatures (by resistance method & fiber optic sensors).

II. Testing option 2:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with 100% cooling as per service conditions.

- Increase the loading to 130% overload rating.
- Scan and record infra-red images of all four sides and the top of the transformer every 30 minutes.
- Hold the current at 130% for a period of 2 hours.
- Measure and record the hotspot temperature (by resistance method & fiber optic sensors).

III. Acceptance criteria:

Winding hotspot temperatures shall not exceed 130°C for option 1 and 135 °C for option 2.
The temperature rise recorded by infra-red shall be not more than 10°K above top oil temperature or 15°K above the local oil temperature.
The rate of gas development as determined from oil samples shall be determined. Samples shall be taken before and after the test and acceptance criteria shall be in accordance with IEC/IEEE guidelines.

IV. Test records:

Full details of the test arrangements, procedures and conditions shall be supplied with the test certificates and shall include the following:

- Purchaser’s reference number and site designation
- Manufacturer’s name and transformer serial number
- MVA rating and voltage ratio
- Vector group

- Altitude of test bay
- Designation of terminals supplied and terminals strapped
- Colour photographs of the four sides and top of the transformer.

V. Overload test:

A log of the following quantities taken at a minimum of 30-minute intervals:

- time
- voltage between phases
- current in each phase
- power in each phase and total power
- ambient temperature
- top oil temperature
- FO sensors readings

10. Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

The cooling down trend shall be observed by recording top and bottom oil temperature and winding resistance.

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow. FO sensors data shall be recorded during the test.

11. Over excitation test

A routine over excitation test at 1.05 p.u voltage for 12 hours shall be done on the tap position giving the highest flux. This test shall be carried out immediately after the routine short-term heat run test on the transformer. The rate of gas development during the test shall be evaluated using IEEE /IEC/CIGRE guidelines. FO sensors data shall be recorded during the test.

12. Measurement of zero-sequence impedance(s) on three-phase transformers/reactors

Standards: IEC 60076-1:2011, IEC 60076-8

General

In the case of transformers having more than one star-connected winding with neutral terminal, the zero-sequence impedance is dependent upon the connection.

The zero-sequence impedance may have several values because it depends on how the terminals of the other winding or windings are connected and loaded.

The zero-sequence impedance may be dependent on the value of the current and the temperature, particularly in transformers without any delta-connected winding.

The zero-sequence impedance may also be expressed as a relative value in the same way as the (positive sequence) short-circuit impedance

Test Procedure

The zero-sequence impedance is measured at rated frequency between the line terminals of a star-connected or zigzag-connected winding connected together, and its neutral terminal. It is expressed in ohms per phase and is given by $(3U/I)$, where U is the test voltage and I is the test current. The test current per phase $(I/3)$ shall be stated in the test report.

It shall be ensured that the current in the neutral connection is compatible with its current carrying capability.

In the case of a transformer with an additional delta-connected winding, the value of the test current shall be such that the current in the delta-connected winding is not excessive, taking into account the duration of application.

If winding balancing ampere-turns are missing in the zero-sequence system, for example, in a star-star-connected transformer without delta winding, the applied voltage shall not exceed the phase-to-neutral voltage at normal operation. The current in the neutral and the duration of application should be limited to avoid excessive temperatures of metallic constructional parts.

For autotransformers and YY transformers, there are several combinations of tests to perform:
– HV with LV open circuit;
– HV with LV short circuit;
– LV with HV open circuit;
– LV with HV short circuit.
– For YD transformers, the zero sequence impedance is measured from the Y side only.
– Auto-transformers with a neutral terminal intended to be permanently connected to earth shall be treated as normal transformers with two star-connected windings.

Thereby, the series winding and the common winding together form one measuring circuit, and the common winding alone forms the other. The measurements are carried out with a current not exceeding the difference between the rated currents on the low-voltage side and the high voltage side.

For Reactor, this measurement shall be carried out at a voltage corresponding to a neutral current equal to the rated phase current.

NOTE 1 In conditions where winding balancing ampere-turns are missing, the relation between voltage and current is generally not linear. In that case, several measurements at different values of current may give useful information.

NOTE 2 The zero-sequence impedance is dependent upon the physical disposition of the windings and the magnetic parts, measurements on different windings may therefore not agree. In particular, for a transformer with a zigzag winding the zero sequence impedance measured between line terminals connected together and the neutral may result in a different value to that obtained when a three phase symmetrical voltage is applied and one line terminal is connected to the neutral.

NOTE 3 An additional zero-sequence impedance test may be required for transformers with delta windings with two connections to one corner brought out so that it can be either open or closed.

NOTE 4 Further guidance is given in IEC 60076-8.

315MVA, 500MVA 400/220/33kV Transformer Connections

Tap No.	**Current Applied**	**Open Terminals**	**3xU/I**	**%ZO**
1	Between HV (1U, 1V & 1W Shorted) and Neutral	2U, 2V, 2W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		
1	Between IV (2U, 2V & 2W Shorted) and Neutral	1U, 1V, 1W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		

The above measurements shall be repeated with Tertiary terminals shorted. Voltage and current shall be measured and recorded.

13. Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)

Test shall be performed as per IEC 60076-10 and clause 7.8.12 of IEC 60076-6 (for reactor). The measured value shall not be exceeded the limit as specified at Annexure-A of this specification. Sound pressure levels shall be established in line with specification. Sound power level shall be calculated from sound pressure level using the method described in IEC 60076-10. Location of microphones shall be in line with IEC 60076-10.

Important check points

The available frequency response of the measuring instrument shall range from below the rated power frequency to above the upper limit of the human ear capability of 20 kHz.

The upper limit for the actual measurement shall be chosen in accordance with the highest emitted significant frequency, usually below 10 kHz. The selected frequency range for background noise measurements and the test measurement shall be the same.

Sound pressure measurements shall be made using a type 1 sound level meter complying with IEC 61672-1 and IEC 61672-2 and calibrated in accordance with 5.2 of ISO 3746:2010.

The sound pressure method of measurements described in this standard is based on ISO 3746. Measurements made in conformity with this standard tend to result in standard deviations of reproducibility between determinations made in different laboratories which are less than or equal to 3 dB.

The measuring equipment shall be calibrated in accordance with manufacturer's instructions immediately before and after the measurement sequence. If the calibration changes by more than 0.3 dB, the measurements shall be declared invalid and the test repeated.

All measurements shall be made using the energetic average over the measurement duration of the sound quantity (pressure). Statistically derived sound quantities such as percentiles shall not be applied.

The fast response indication of the meter shall be used to identify and avoid measurement errors due to transient background noise.

The sound level measurement is usually of manual operation but the errors introduced by varying distances will tend to average out. Their impact on the final measurement is of less significance than other acoustical factors. Nevertheless, all effort shall be made to keep the measurement distance as constant as possible.

Test Report shall be in line with Annexure-B of IEC 60076-10.

14. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps including spare shall be measured at rated voltage (415V) and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, Applied voltage, measured current, frequency and make shall be furnished in the test report.

15. High voltage with stand test on auxiliary equipment and wiring after assembly

The wiring for auxiliary power, and control circuitry shall be subjected to a 1 min AC separate source test of 2 kV to earth. The test is passed if no voltage collapse or other sign of breakdown occurs.

The wiring for current transformer secondary windings shall be tested at 2.5 kV AC to earth for 1 min. The test shall be carried out at the manufacturer's works. If the current transformer knee-point voltage exceeds 2 kV AC the test shall be performed at 4 kV AC. The test is passed if no voltage collapse or other sign of breakdown occurs.

16. Frequency Response analysis (SFRA)

Frequency Response Analysis (FRA) is conducted to assess the mechanical integrity of the transformer. FRA signatures will be taken at works in oil filled condition after completion of all tests.

It is recommended to follow the standard procedure for the SFRA measurement as per the below Table. It should be done on maximum, normal and minimum tap of the transformer.

Combination of test for Autotransformer

Test Type	Test	3- Phase	1-Phase
Series Winding (Open circuit) All other terminals floating	Test 1	H1-X1	H1-X1
	Test 2	H2-X2	
	Test 3	H3-X3	
Common Winding (Open circuit) All other terminals floating	Test 4	X1-H0X0	X1-H0X0
	Test 5	X2-H0X0	
	Test 6	X3-H0X0	
Tertiary Winding (Open circuit) 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-Y0)
	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	

H1: HV Terminal; X1: IV Terminal; H0X0: Neutral

In case of Shunt Reactor, FRA to be done in following combinations:

- H1-H0
- H2-H0
- H3-H0

17. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil during which no leakage shall occur. Pressure may slightly vary with ambient temperature change during 12 hours.

ii. Vacuum Test

All transformer tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

18. Appearance, construction and dimension check

At Complete assembled transformer, Dimensions, fittings/accessories, clearances shall be verified in line with approved General Arrangement drawing, Bill of material, drawings of other accessories (OLTC, Bushing, Online DGA, Drying system, Buchhoolz relay, PRD, SPR, OTI, WTI, etc. as applicable).

19. Dynamic Short circuit withstand Test

19.1 Reference Standard: IEC 60076-5 (Latest Standard)

19.2 The tests shall be carried out on a new transformer ready for service. Protection accessories, such as gas-and-oil-actuated relay and pressure-relief device, shall be mounted on the transformer during the test. However, Detachable type cooler bank may not be required to install during short circuit test.

19.3 Prior to the short-circuit tests, the transformer shall be subjected to the routine tests and type tests as per POWERGRID specification (including routine tests which are specified in IEC 60076-1). If the windings are provided with tappings, the reactance and, if required, also the resistance shall be measured for the tapping positions at which short-circuit tests will be carried out. All the reactance measurements shall be to a repeatability of better than ±0.2 %. A report containing the result of the routine tests shall be available at the beginning of short-circuits tests.

Manufacturers shall compare the reactance measured at short circuit test lab with the value measured at their manufacturing works before proceeding to short circuit test.

19.4 At the beginning of short-circuit tests, the average temperature of the oil/winding shall preferably be between 10 °C and 40 °C (see 4.2.2.3 of IEC 60076-5).

19.5 During the tests, winding temperature may increase owing to the circulation of the short-circuit current. This aspect shall be taken into consideration when arranging the test circuit for transformers of category I.

19.6 **Test current peak value *î* for two-winding transformers**

The test shall be performed with current holding maximum asymmetry as regards the phase under test. The amplitude $\hat{\imath}$ of the first peak of the asymmetrical test current is calculated as follows:
$\hat{\imath} = I \cdot k \cdot \sqrt{2}$, where I the is symmetrical short-circuit current (see 4.1.2 of IEC 60076-5).
The factor k accounts for the initial offset of the test current and $\sqrt{2}$ accounts for the peak to-r.m.s. value of a sinusoidal wave. The factor $k\sqrt{2}$, or peak factor, depends on the ratio X/R

Where, X is the sum of the reactances of the transformer and the system (Xt + Xs), in ohms (Ω);
R is the sum of resistances of the transformer and the system (Rt + Rs), in ohms (Ω), where Rt is at reference temperature (see 10.1 of IEC 60076-1).

In the case X/R >14 the factor $k \cdot \sqrt{2}$ is assumed to be equal to

1.8 $\sqrt{2}$ = 2.55 for transformers of category II;

1.9 $\sqrt{2}$ = 2.69 for transformers of category III.

19.7 **Tolerance on the asymmetrical peak and symmetrical r.m.s. value of the short-circuit test current**

If the duration of the short-circuit test is sufficiently long, the asymmetrical current having first peak amplitude î will change into the symmetrical current having r.m.s. value I (see 4.1.2 of IEC 60076-5). The peak value of the current obtained in testing shall not deviate by more than 5 % and the symmetrical current by more than 10 % from the respective specified value. However any positive tolerance may be acceptable subject to meeting the other requirements as per IEC.

The short-circuiting of the winding may either follow (post-set short circuit) or precede (pre-set short circuit) the application of the voltage to the other winding of the transformer.

If the post-set short circuit is used, the voltage shall not exceed 1.15 times the rated voltage of the winding

19.8 In order to avoid injurious overheating, an appropriate time interval (minimum 15 minutes between two consecutive shots) shall occur between successive overcurrent applications.

19.9 In order to check the values î and I of the test currents, oscillographic records shall always be taken.

19.10 The frequency of the test supply shall be, in principle, the rated frequency of the transformer.

19.11 Test connection shall be followed as per Clause 4.2.5.4 of IEC 60076-5.

19.12 The number of tests on three-phase and single-phase transformers is determined as follows, not including preliminary adjustment tests carried out at less than 70 % of the specified current to check the proper functioning of the test set-up with regard to the moment of switching on, the current setting, the damping and the duration.

19.13 For categories I, II & III single-phase transformers, the number of tests shall be three. The three tests on a single-phase transformer with tappings are made in a different position of the tap-changer, i.e. one test in the position corresponding to the highest voltage ratio, one test on the principal tapping and one test in the position corresponding to the lowest voltage ratio.\

19.14 For categories I, II & III three-phase transformers, the total number of tests shall be nine, i.e. three tests on each phase. Unless otherwise specified, the nine tests on a three-phase transformer with tappings are made in different positions of the tap changer, i.e. three tests in the position corresponding to the highest voltage ratio on one of the outer phases, three tests on the principal tapping on the middle phase and three tests in the position corresponding to the lowest voltage ratio on the other outer phase (manufacturer may change sequence).

19.15 For particular winding combination (HV-IV, HV-LV or HV-LV) number of shots shall be as per the following:

– for single-phase transformers: three;

– for three-phase transformers: nine.

19.16 For Tertiary winding dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation.

19.17 The duration of each test shall be 0.5 s for transformers of category I & 0.25 s for transformers of categories II and III, with a tolerance of ±10 %.

19.18 Detection of faults and evaluation of test results including acceptance criteria shall be followed as Clause 4.2.7 of IEC 60076-5. However, variations of short-circuit reactance (Acceptable limit) values shall be as per the following :

19.18.1 Transformers of categories I and II

2% for transformers with circular concentric coils and sandwich non-circular coils. However, for transformers having metal foil as a conductor in the low-voltage winding and with rated power up to 10 000 kVA, higher values, not exceeding 4 %,are acceptable for transformers with a short-circuit impedance of 3 % or more.

7,5 % for transformers with non-circular concentric coils having a short-circuit impedance of 3 % or more.

19.18.2 Transformers of categories III

The short-circuit reactance values, in ohms, evaluated for each phase at the end of the tests do not differ from the original values by more than 1 %.

Detail information pertaining to sort circuit test shall be furnished as per the format attached in Annexure-A.

STANDARD TEST PROCEDURE-TRANSFORMER & REACTOR

ANNEXURE-A

Sr. No.	Parameters	Data
1	MVA Rating	
2	Phase	
3	Voltage Rating	
4	Tapping Range & Variation	
5	Fault MVA	
6	Fault Current	
7	Short circuit current feed to HV/LV	*Ex. From HV side for HV-IV Combination* *From LV side for HV-LV combination*

Tap Position	Maximum Voltage Tap	Normal Voltage Tap	Minimum Voltage Tap
Combination	HV-IV		
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
k .√2 Value			
Asymmetrical short circuit current			
No of Shots			
Combination	IV-LV		
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
k .√2 Value			
Asymmetrical short circuit current			
No of Shots			

20. Short time over voltage Test (830kVrms)

The test duration is 5 minutes at rated frequency. When the test frequency exceeds the rated frequency, the test time in seconds of the test shall be:

300 × rated frequency / test frequency

21. Shunt reactor loss measurement & temperature rise test

Reference Standard:

IEC 60076-6:2007 Clause 7.8.6 & Annex D (Temperature correction of losses for liquid-immersed gapped-core and magnetically-shielded air-core reactors)

Losses are based on reactor operation with rated current at rated frequency and at reference temperature. Measured losses shall be corrected to rated current and reference temperature.

For three-phase reactors, the measurement of loss shall be performed under three-phase excitation and loss shall be measured phase wise.

Method

Reactor shall be assembled with all accessories, cooling system as per approved GA drawing (Unit being offered for Type test). No deviation shall be accepted. The tests shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours. DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC61181. Please also refer temperature rise test procedure of transformer.

Full details of the test arrangements, procedures and conditions shall be provided with the test certificates and the following shall at least be included.

All the parameters as per specification shall be measured and recorded.

After completion of temperature rise test (24 hours) hot resistance shall be measured. During this period of hot winding resistance measurement, preparation for loss measurement at hot state shall be made. After completion of resistance measurement (atleast for 20 minutes) connection shall be made for loss measurement at hot state. During this complete process oil temperature shall be recorded.

Calculation methodology:

Average oil temperature at cold state: θ_c

Top oil temperature after 24 hours: θ_1

Average winding temperature at shut-down
(measured by resistance): θ_2

Difference between Average winding & Top oil temperature: $\theta_2 - \theta_1$

Rated voltage shall be supplied during hot loss measurement. The supply shall continue for at least 30 minutes and subsequently loss shall be measured.

Top oil temperature during loss measurement: $\theta_{3\,(U, V,W)}$

Average winding temperature during loss measurement: $\theta_4 = \theta_3 + (\theta_2 - \theta_1)$

Calculation of Temperature co-efficient phase wise
Following parameters shall be measured during Loss measurement;

Rated Voltage KV	Current $I_{measured}$ A		Loss (Measured or calculated)		Top Oil Temperature $\theta_{3\,(U, V,W)}$		Tan Delta	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
90%								
100%								
110%								

Loss measured at cold state: W_c

Cold Loss at rated current: $W_{cr} = W_c \times (I_{rated}/I_{measured})^2$

Loss measured at hot state: W_h

Hot Loss at rated current: $W_{hr} = W_h \times (I_{rated}/I_{measured})^2$

Establishing the temperature coefficient of loss for individual phase:
$\Delta Ptot / \Delta\theta = (W_{hr} - W_{cr})$ kW / $(\theta_4 - \theta_c)$ °C = α kW / °C

Recalculation to reference temperature 75 °C with temperature coefficient:
$Ptot\ (75\ °C) = Ptot\ (\theta_4) + \alpha\ (75 - \theta_4)$ °C

The same process shall be followed for other 2 phases for calculation of temperature coefficient of individual phase.

Measurement of loss on a second identical unit at ambient temperature (routine test):

Measured mean oil temperature at cold state: θt
Loss measured at cold state: W_c
Cold Loss at rated current Ptot (θt °C): $W_c \times (I_{rated}/I_{measured})^2$

Total losses, Ptot (Measured)	I^2R loss (at rated current)	Additional losses
Ptot (θt °C) = W_1+W_2	W_1 (Calculated)	W_2 (Calculated)

Re-calculation to reference temperature 75 °C with temperature coefficient derived after temperature rise test:

Ptot (75 °C) = Ptot (θt °C) + α × (75 – θt) °C

The loss shall be calculated for each phase at reference temperature (75 Deg C) and shall be added for total losses of all three phases. This value is the measured loss value against the guaranteed loss value for the second identical unit.

Check Points:

Inputs like – Value of Standard Capacitor, constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.

22. Two hours excitation test

a) Each reactor to be excited at Um for 2 hours except type tested unit.
b) Measure Vibration at Um and 1.05Um
c) DGA rate interpretation shall be as per IEC/ CIGRE/ IEEE guidelines
d) Test shall be performed before partial discharge test
e) Reactance & Loss measurement shall be carried out after completion of the above test to check the healthiness of the reactor

23. Stress measurement

After all dielectric test reactor shall be energized and Stress will be measured at one point (please refer specification for no. of points) of each wall where vibration reordered is maximum. Measurement shall be carried out at Um and 1.05Um voltage.

24. Measurement of harmonic content of current (Measured in Cold state) - Reactor

The harmonics of the current in all three phases are measured at rated voltage, by means of a harmonic analyser. The magnitude of the relevant harmonics is expressed as a percentage of the fundamental component. For more information on the magnetic characteristic, see Annex B of IEC 60076-6. The harmonics of the applied voltage shall be adequately measured at the same time.

25. Knee point voltage measurement of reactor (Measured in Cold state)

The test shall be carried out as per IEC 60076-6 clause B.7.1 "DC current charging – discharging method (theory)" or applying AC voltage from 0.7p.u, 0.8p.u, 0.9p.u and so on upto the level as per specification and measure the current at various voltages and calculate the tolerance of reactance as per annexure-A of this specification.

26. Standards:

IEC Standards	Latest IEC
Power transformers - Part 1: General	Edition 3.0 2011 -04
Power transformers - Part 2: Temperature rise for liquid-immersed transformers	Edition 3.0 2011-02
Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	Edition 3.1 2018-03
Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors	First edition 2002-06
Power transformers - Part 5: Ability to withstand short circuit	Third edition 2006-02
Power transformers - Part 6: Reactors	Edition 1.0 2007-12
Power transformers - Part 7: Loading guide for mineral-oil-immersed power transformers	Edition 2.0 2018-01
Power transformers - Part 8: Application guide	First edition 1997-10
Power transformers - Part 10: Determination of sound levels	Edition 2. 0 201 6 -03
Power transformers - Part 14: Liquid-immersed power transformers using high-temperature insulation materials	Edition 1.0 2013-09
Power transformers - Part 18: Measurement of frequency response	Edition 1.0 2012 -07
Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors	Edition 1.0 2013-03

Check Lists for Transformer & Reactor Tests

Sr. No.	Test	Acceptance Criteria*	Check list (✓ if conducted)
1.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Insulation power factor for windings < 0.5% Insulation power factor for Bushing as per GTP/TS	
2.	Measurement of insulation resistance & Polarization Index	PI > 1.3	
3.	Core assembly dielectric and earthing continuity test	IR >1 GΩ	
4.	Measurement of winding resistance	As per GTP	
5.	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	Refer procedure	
6.	Switching impulse test for the line terminal (SI)		
7.	Applied voltage test (AV)	No collapse of voltage or other sign of breakdown	
8.	Induced voltage withstand test (IVW)		
9.	Induced voltage test with PD measurement (IVPD)	Refer procedure	
10.	Temperature rise test	As per GTP/ TS	
11.	Measurement of acoustic noise level	As per GTP/ TS	
12.	High voltage with stand test on auxiliary equipment and wiring after assembly	No voltage collapse or other sign of breakdown	
13.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	For record	
14.	Oil leakage test on transformer/ Reactor tank	No oil leakage	
15.	Tank vacuum test	Refer procedure	
16.	Tank pressure test	Refer procedure	
17.	Appearance, construction and dimension check	Dimensions measured shall match with approved GA drawing	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

Check lists for additional tests applicable only for Transformer

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Voltage ratio measurement & Polarity check (Vector Group)	≤0.5% as per IEC 60076-1 for Voltage ratio. Vector group as per specification.	
2.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC	For record	
3.	No-load loss and current measurement	As per GTP / TS	
4.	Measurement of harmonic level in no load current	For record	
5.	Magnetic balance test (for three phase Transformer only)	Refer procedure	
6.	On-load tap changer test	Refer procedure	
7.	Measurement of short-circuit impedance and load loss	As per GTP/ TS	
8.	Line terminal AC withstand voltage test (LTAC)	No collapse of voltage or other sign of breakdown	
9.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Refer procedure	
10.	Overload testing in short-circuit method	Refer procedure	
11.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Refer procedure	
12.	Over excitation test	Refer procedure	
13.	Measurement of Zero seq. reactance (for three phase Transformer only)	As per GTP/ TS	
14.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	As per GTP/ TS	
15.	Dynamic Short circuit withstand test (If specified in BPS)	Refer procedure	

Check lists for additional tests applicable only for Reactor

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Short time over voltage Test (830kVrms) (765kV Reactor)	No voltage collapse or other sign of breakdown	
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	As per GTP/ TS	
3.	2-Hour excitation test except type tested unit	Refer procedure	
4.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Ur for reference only on one unit of each type)	As per GTP/ TS	
5.	Measurement of harmonic content of current (Measured in Cold state)	As per TS	
6.	Knee point voltage measurement of reactor (Measured in Cold state)	As per GTP/ TS	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

APRIL 2013

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Pre-Commissioning Procedures and Formats for **Switchyard Equipments**

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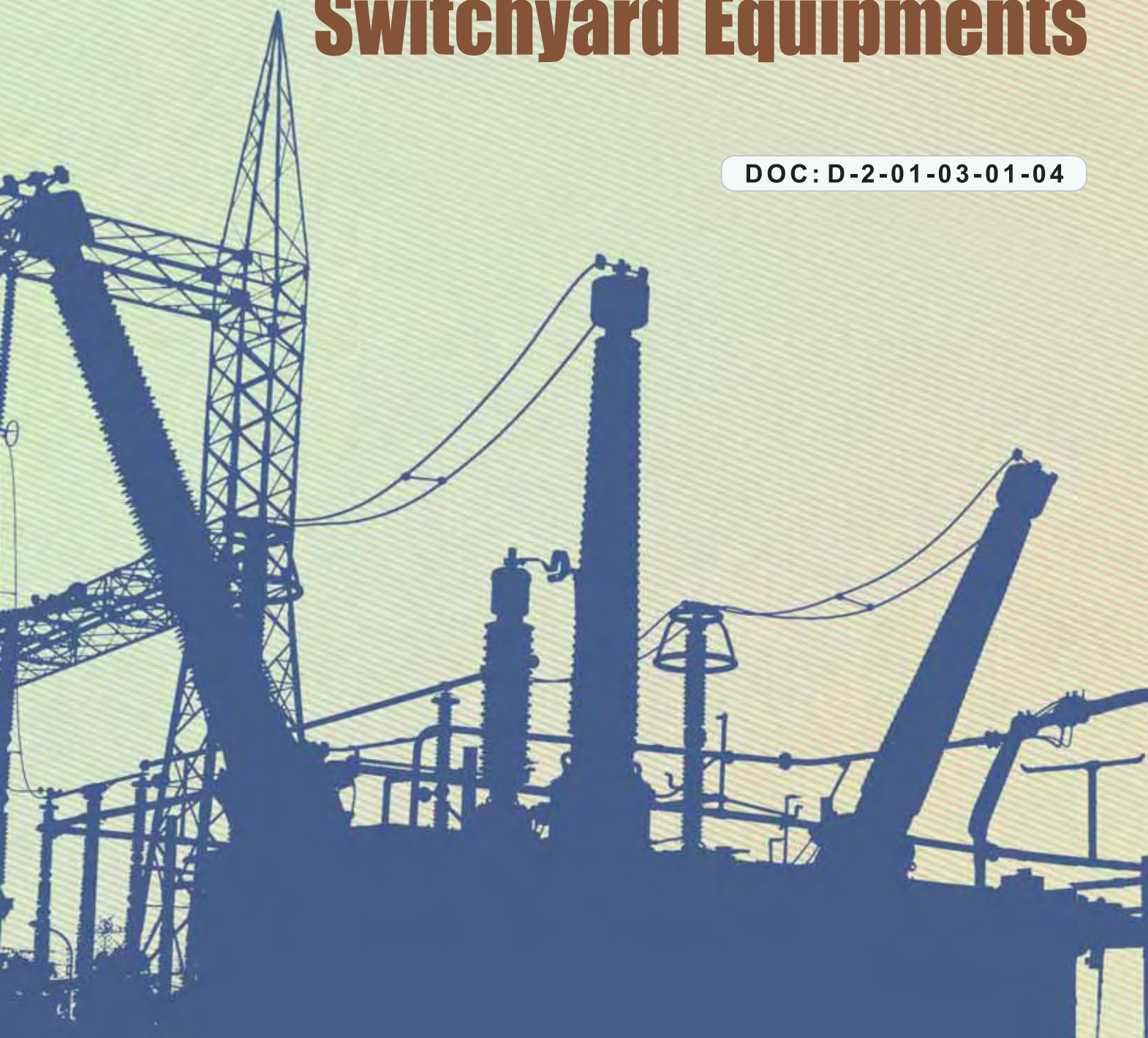


CONTENTS

SL.NO.	PARTICULARS	PAGE NOS
	PRE-COMMISSIONING PROCEDURES FOR SWITCHYARD EQUIPMENTS	1
	TRANSFORMER AND REACTOR	1
2.1	Checks after receipt of Transformer/Reactor at site	4
2.2	Insulating oil	5
2.3	Internal Inspection	6
2.4	Precautions during erection	7
2.5	Final tightness test with vacuum (i.e. leakage test or Vacuum Drop Test)	9
2.6	Oil filling	10
2.7	Hot oil Circulation using High Vacuum Filter Machine	13
2.8	Procedure for Dry Out of Wet Winding of Transformer/Reactor by Vacuum Pulling,N2 filling and Heating	14
2.9	Relation between different units (conversion of units)	16
	PRE-COMMISIONING CHECKS/ TESTS FOR TRANSFORMER & REACTOR	17
3.1	Core Insulations Check	18
3.2	Earth Pit Resistance Measurement	19
3.3	Insulation Resistance (IR) Measurement	20
3.4	Capacitance & Tand Measurement of Bushing	21
3.5	Capacitance and Tand measurement of windings	24
3.6	Turns ratio (Voltage ratio) measurement	25
3.7	Vector Group & Polarity	25
3.8	Magnetic Balance test	26
3.9	Floating Neutral point measurement	27
3.10	Measurement of Short Circuit Impedance	27
3.11	Exciting/Magnetising current measurement	28
3.12	Operational checks on OLTCs	28
3.13	Tests/Checks on Bushing Current Transformer (BCT)s	29
3.14	Operational checks on Protection System	29
3.15	Stability Test of Differential, REF of Transformers/Reactor	30
3.16	Frequency Response Analysis (FRA) measurement	32
3.17	Winding resistance measurement	33
3.18	Dissolved Gas Analysis (DGA) of oil sample	34
	CHECK LIST FOR ENERGISATION OF TRANSFORMER/ REACTOR	35
4.1	Preliminary checks	35
4.2	Checking of auxiliary and protective ciruits	36

SL.NO	PARTICULARS	PAGE NOS
	POST COMMISSIONING CHECKS/ TESTS FOR TRANSFORMERS AND REACTORS	38
5.1	Thermovision scanning (IR thermography)	38
5.2	Online Moisture Measurement	38
5.3	Vibration measurement of Oil- immersed reactor	38
	PRE-COMMISSIONING CHECKS/ TESTS FOR OTHER SWITCHYARD EQUIPMENTS	39
6.1	Capacitance & Tand Measurement of CT, CVT, CB voltage grading capacitor & Surge Arresters	42
6.2	Checks/ tests applicable for Cts	43
6.3	Checks/ tests application for Circuit Breakers	47
6.4	Checks / Test applicable for CVTs	54
6.5	Checks/ tests applicable for Isolator	55
6.6	Checks/ tests applicable for Surge Arrester	55
6.7	Checks/ tests applicable for other areas/equipments	56
	BUS BAR PROTECTION	59
7.1	High Impedance Protection	59
7.2	Low Impedance Protection	60
7.3	Primary injection and bus bar differential stability test (New Substation)	61
7.4	Primary injection and bus bar differential stability test (Bay Extension in the old substation)	62
7.5	Scheme Checking of bus bar protection & DC trip logic. (New substation & Bay extension)	64
7.6	AMP Testing of bus bar protection and scheme	65
7.7	Double main transfer scheme (400kV/220kV)	66
7.8	Scheme checking of bus bar protection & DC trip logic. (New substation & Bay extension)	73
7.9	AMP testing of bus bar protection and scheme	74
	PRE-COMMISSIONING FORMATS FOR SWITCHYARD EQUIPMENT	
1	No. CF/ICT/01/ R-4 DATED 01/04/2013 ICT	75
2	No. CF/SR/02/ R-4 DATED 01/04/2013 SHUNT REACTOR	106
3	No. CF/CB/03/ R-4 DATED 01/04/2013 CIRCUIT BREAKER	126
4	No. CF/CT/04/ R-4 DATED 01/04/2013 CURRENT TRANSFORMER	140
5	No. CF/CVT/05/ R-4 DATED 01/04/2013 CVT	151
6	No. CF/BAY/06/ R-4 DATED 01/04/2013 BAY/FEEDER	156
7	No. CF/ISO/07/ R-4 DATED 01/04/2013 ISOLATOR/GROUND SWITCH	166
8	No. CF/SA/08/ R-4 DATED 01/04/2013 SURGE ARRESTER	171
9	No. CF/WT/09/ R-4 DATED 01/04/2013 WAVE TRAP	174
10	No. CF/C&P/10/ R-4 DATED 01/04/2013 CONTROL & PROTECTION	176

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.

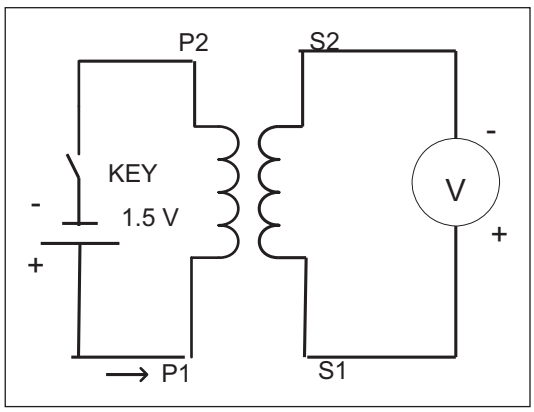


Figure - 9

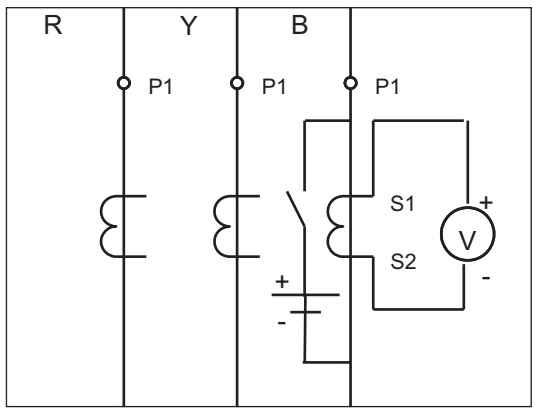


Figure - 10

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

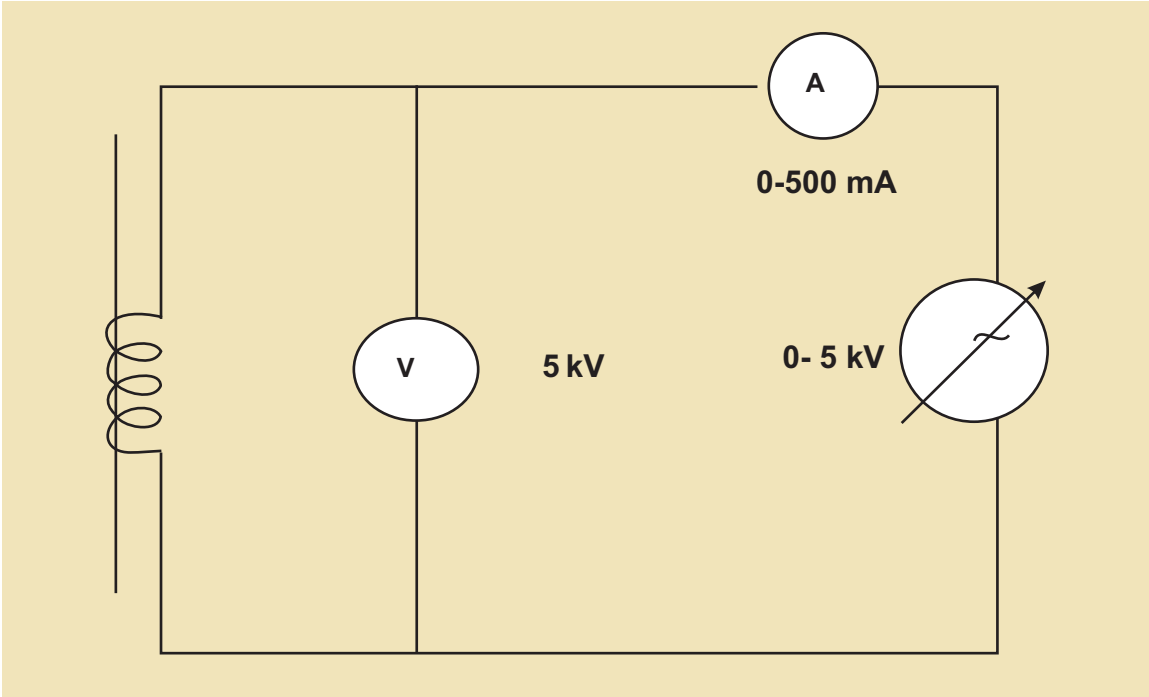


Figure - 11

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.

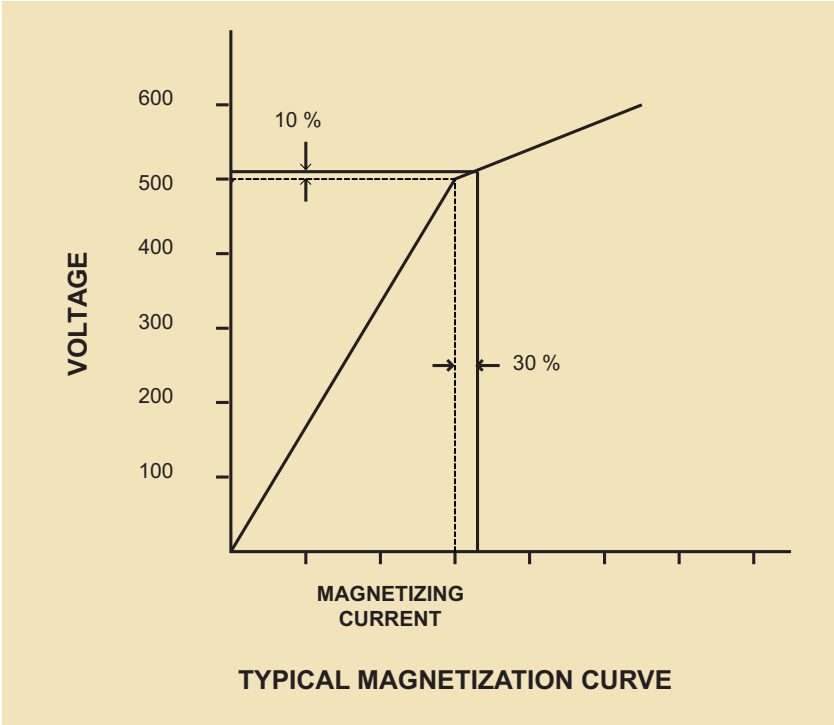


Figure - 12

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.

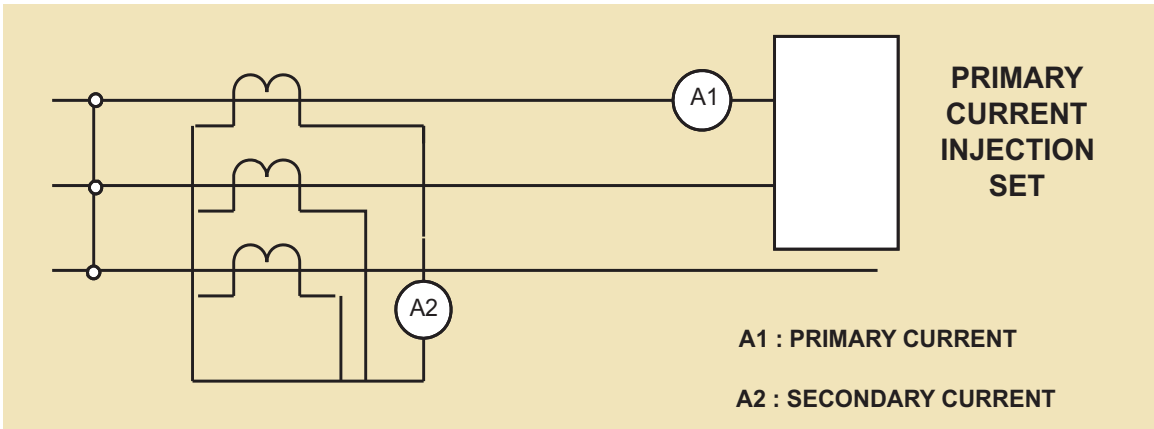


Figure - 13

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).

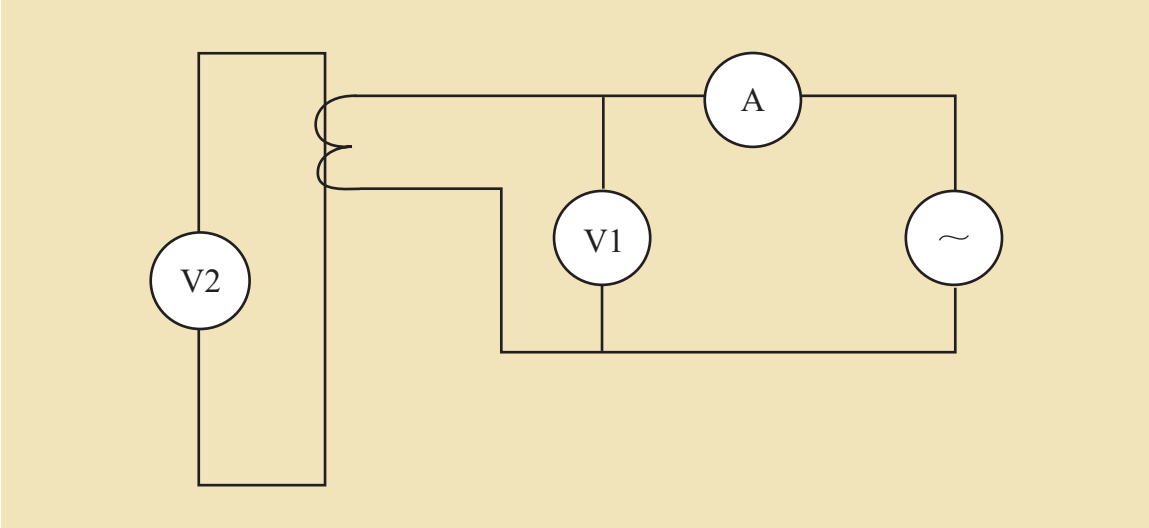


Figure - 14

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

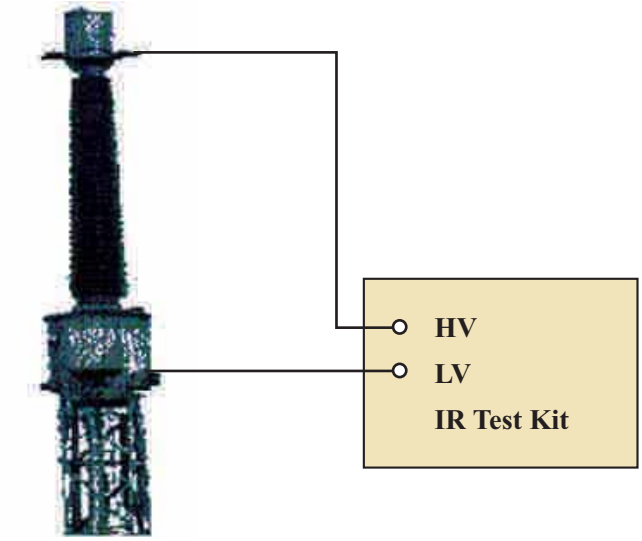


Figure-15 Typical Arrangement for IR measurement

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.

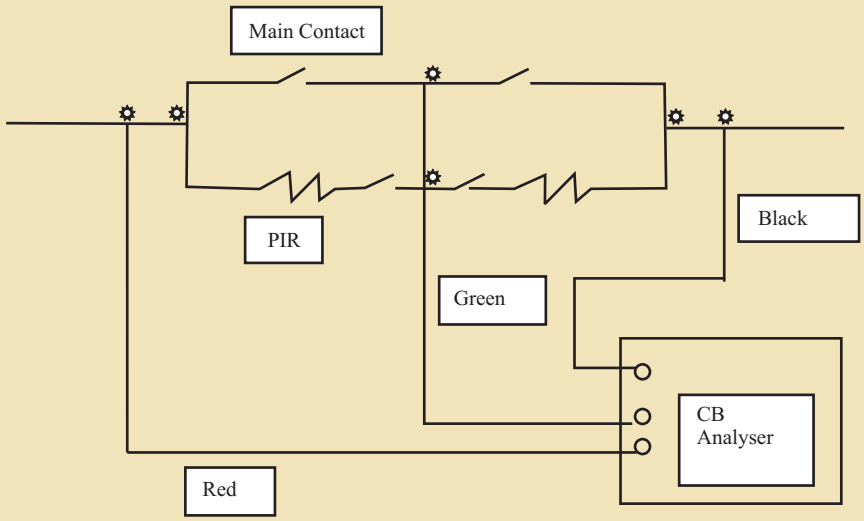
g) Note down the timings for `CO', and `OCO' by giving respective commands. CO command to be given without time delay but 300ms time delay to be given between O and CO operation in testing for OCO.

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.

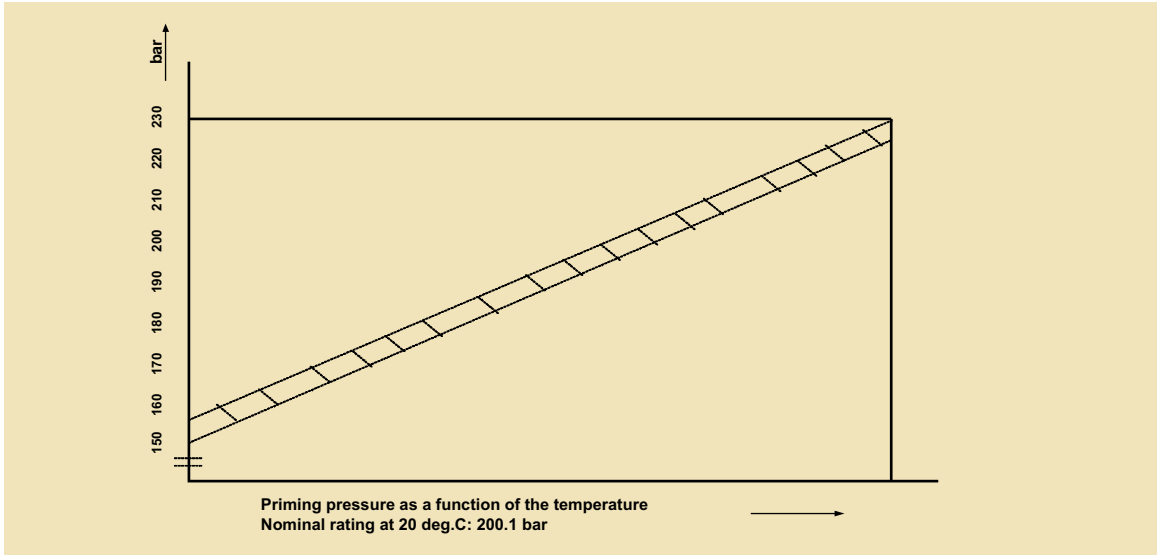


Figure - 17

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.

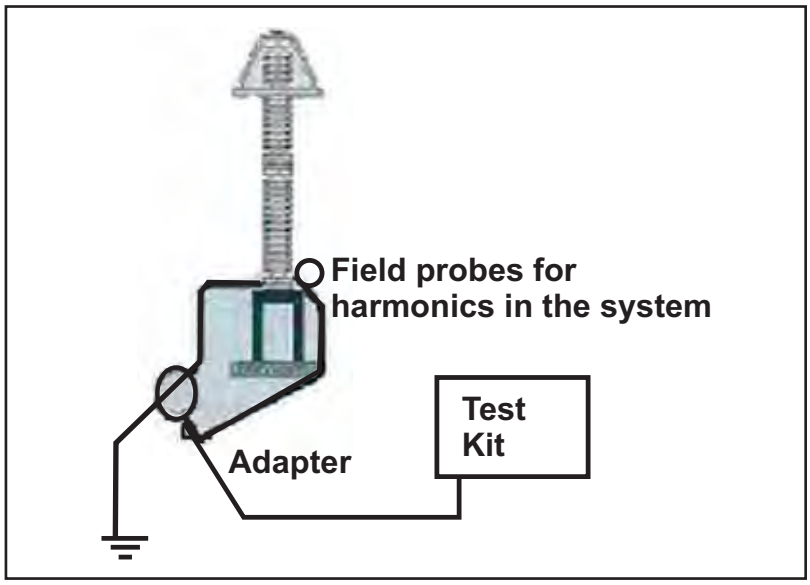


Figure- 18 Typical arrangement for THRCM Test

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

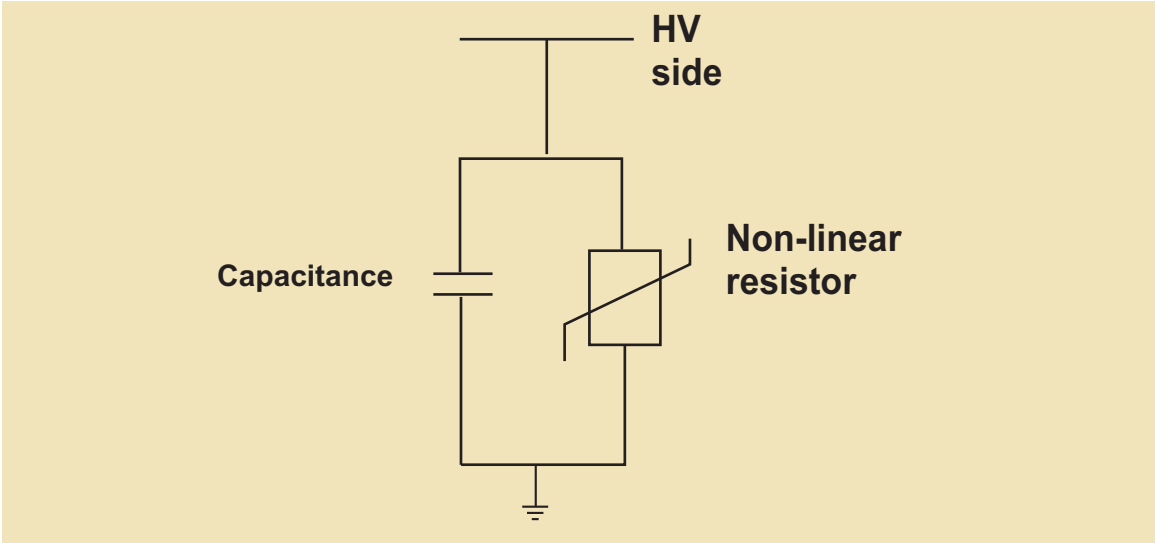


Figure-19 Arrester equivalent circuit

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.

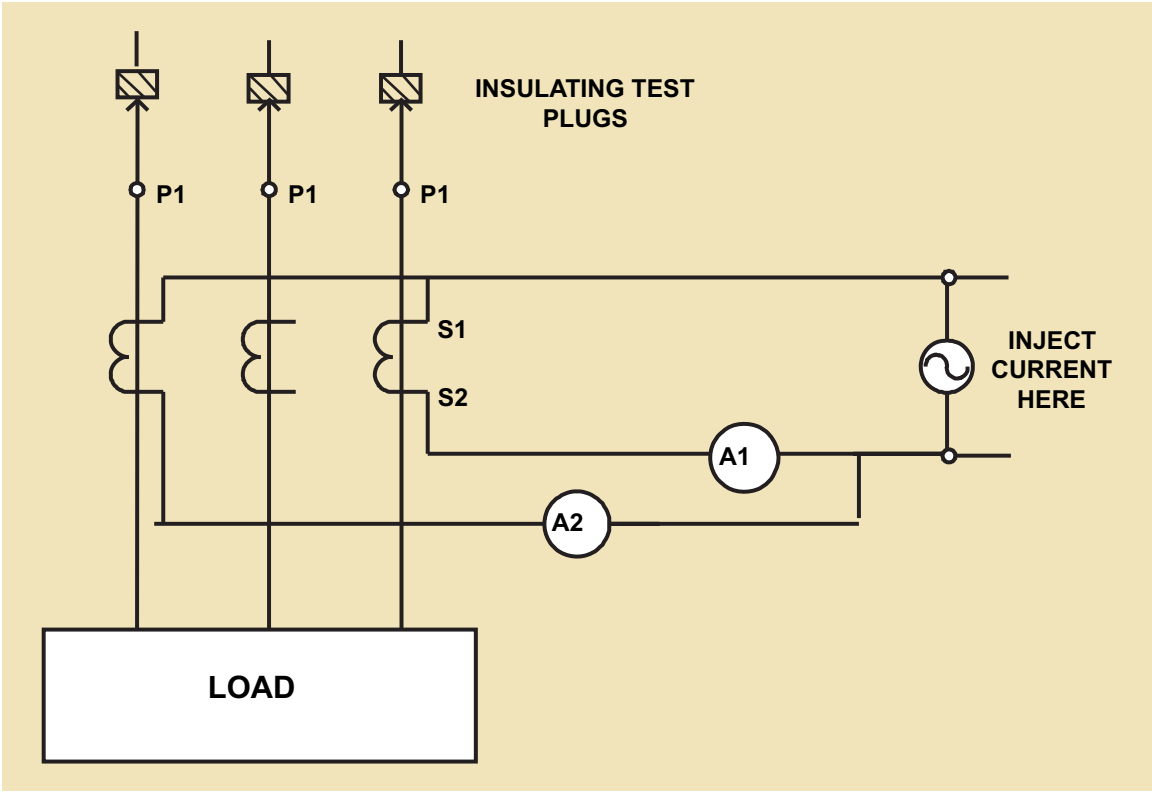


Figure - 20

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.

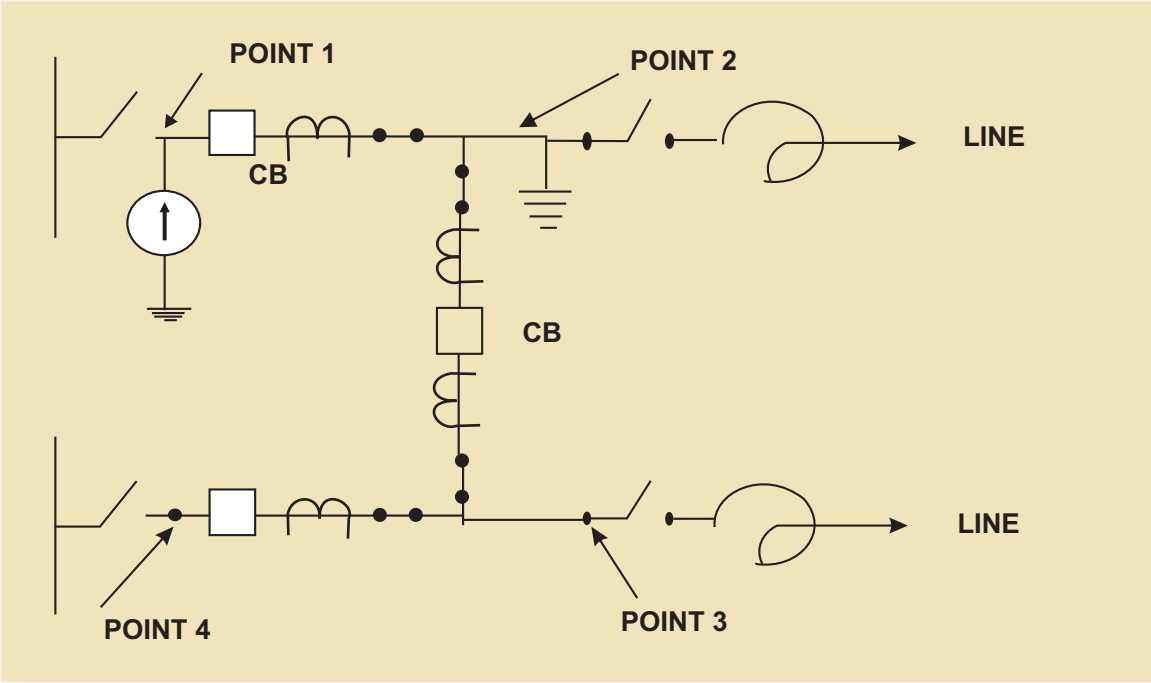


Figure-21 : Primary injection test to check contact tightness of Bay/ feeders

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	: $10000 \times 10^6 / 1.732 * 400000 = 14434$ 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.

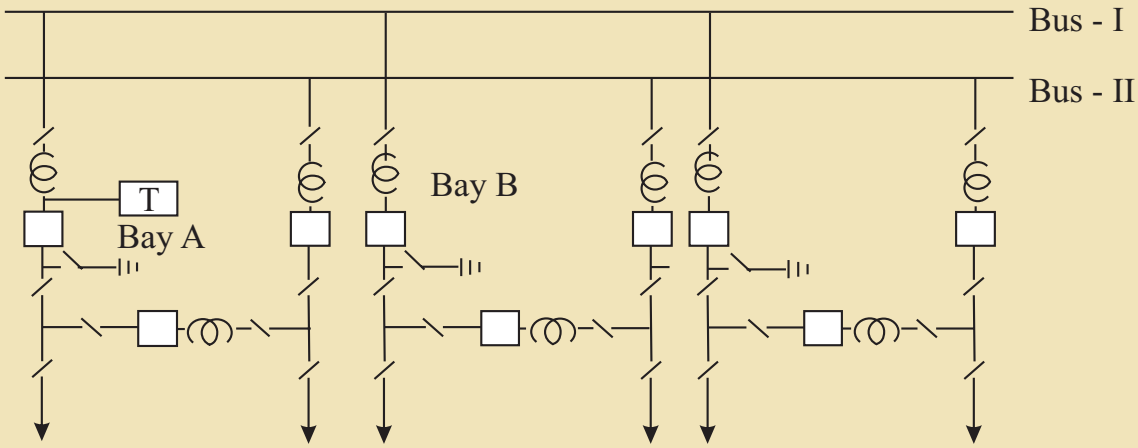
Free of any need for matched CT characteristic or ratios, low leakage reactance or resistance.

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**

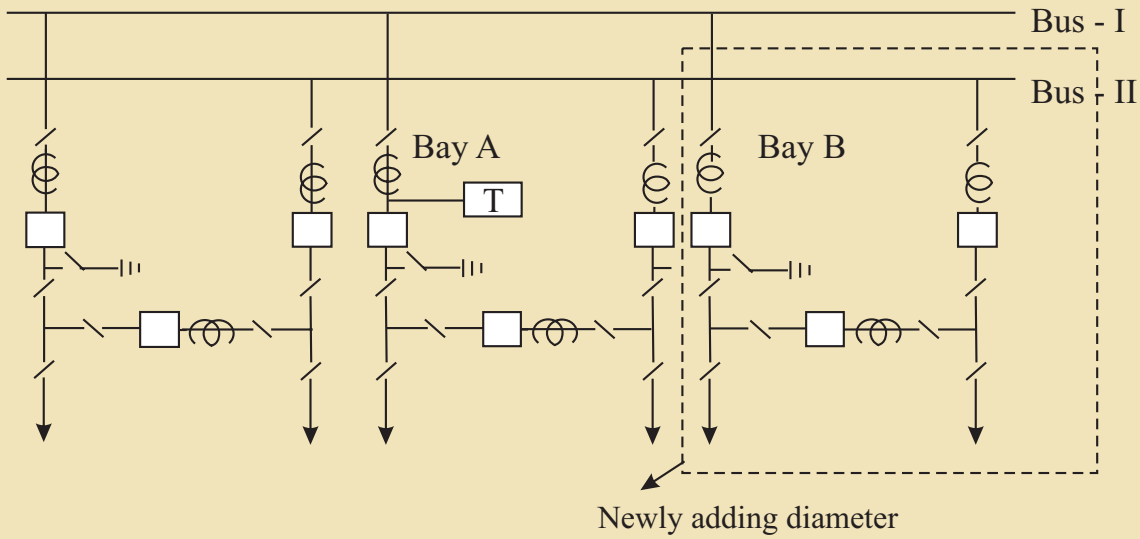
5. Inject primary current using primary current injection test kit across one phase (e.g.R Phase) and ground; don't use other phase as return path for the current.

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):



T- Primary current injection test kit

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

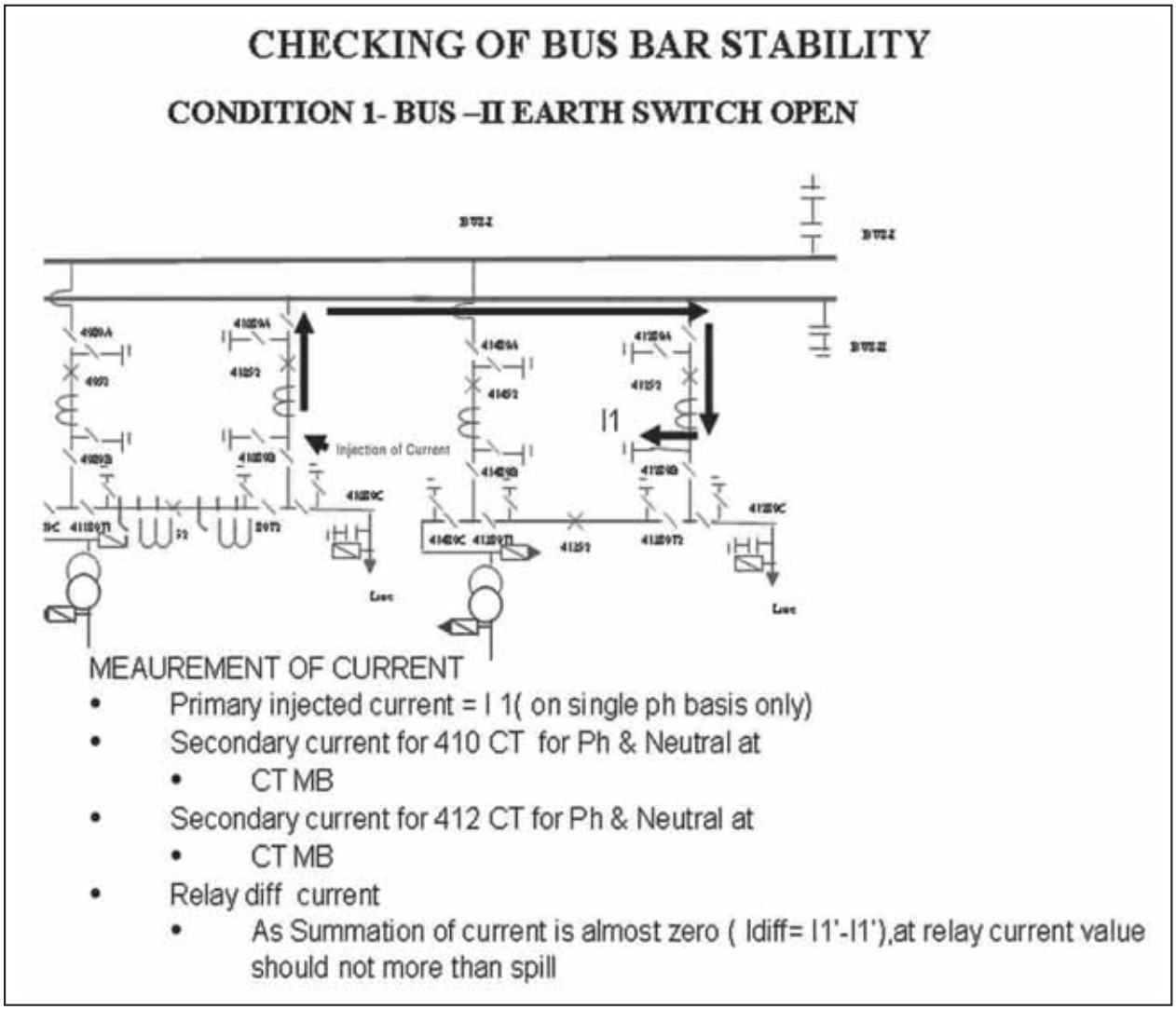
1. Test the relay by secondary injection.
2. Check the tripping of the corresponding breakers and non tripping of other bus breakers and tie breakers.
3. Check initiation of LBB relays of the breakers corresponding to particular bus.
4. Check blocking of the bus bar protection on operation of CT supervision 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

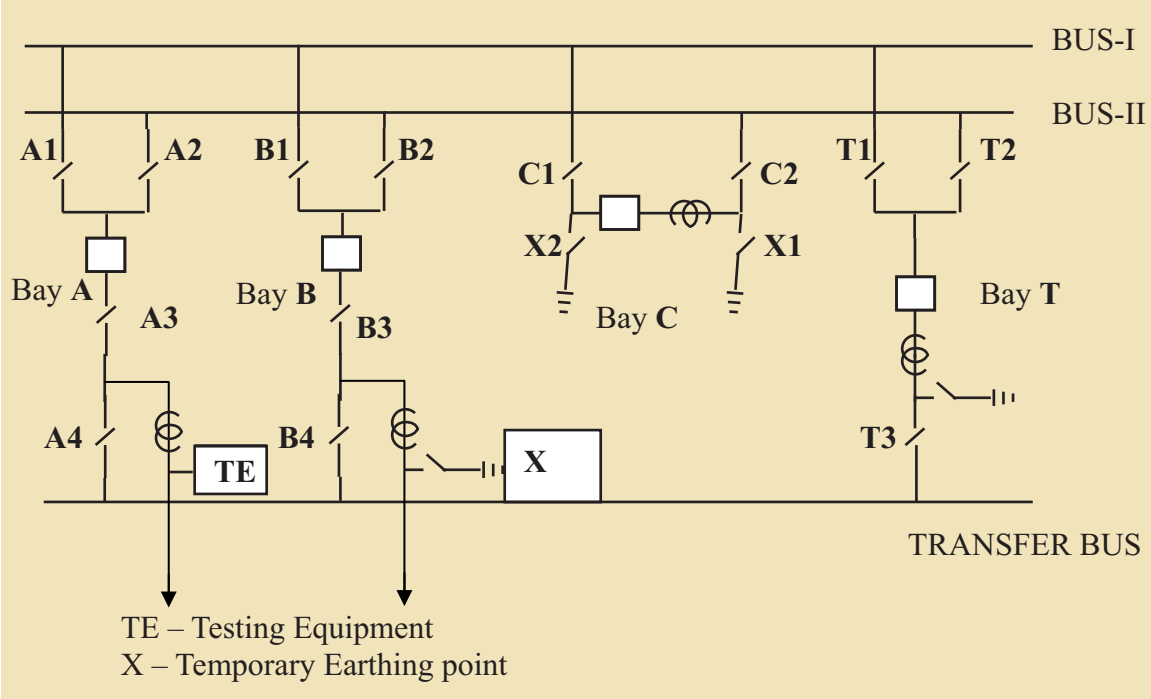
1. Arrange bus bar shutdown for off line testing. Preferably the bus bar isolation should done through bus bar protection trip relay.
2. Insert the test block after shorting the incoming current terminals for on line testing.
3. Test the relays.
4. For off line testing:
   - i. Check tripping scheme 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.



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):



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.

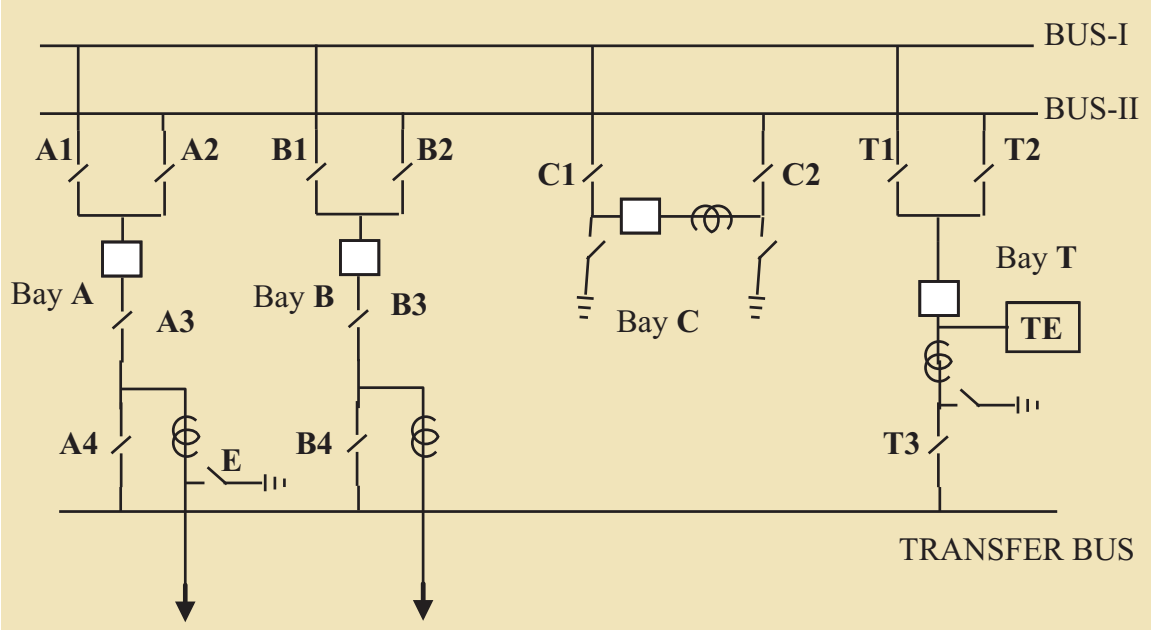
21. Above said procedure shall be carried out between Phase-Phase (R-Y &Y-B) by injecting in one phase and joining with other phase for using it as return path instead of earth return for one set of CTs (Two bays).

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.

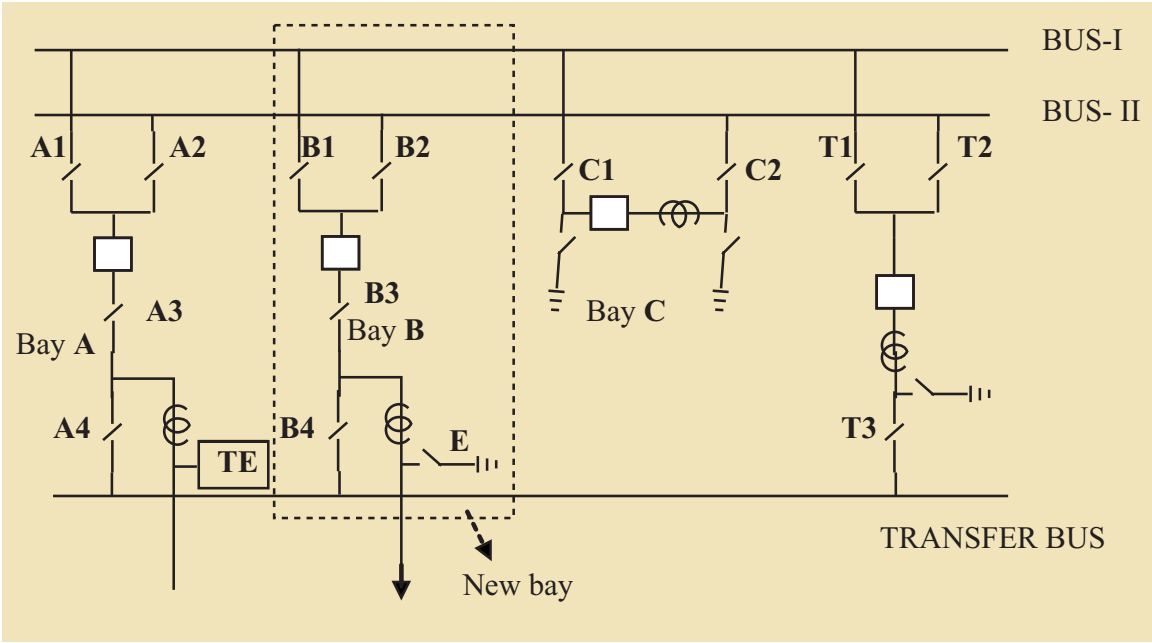
13. After ensuring the above stop injecting the current and normalize the system.

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.

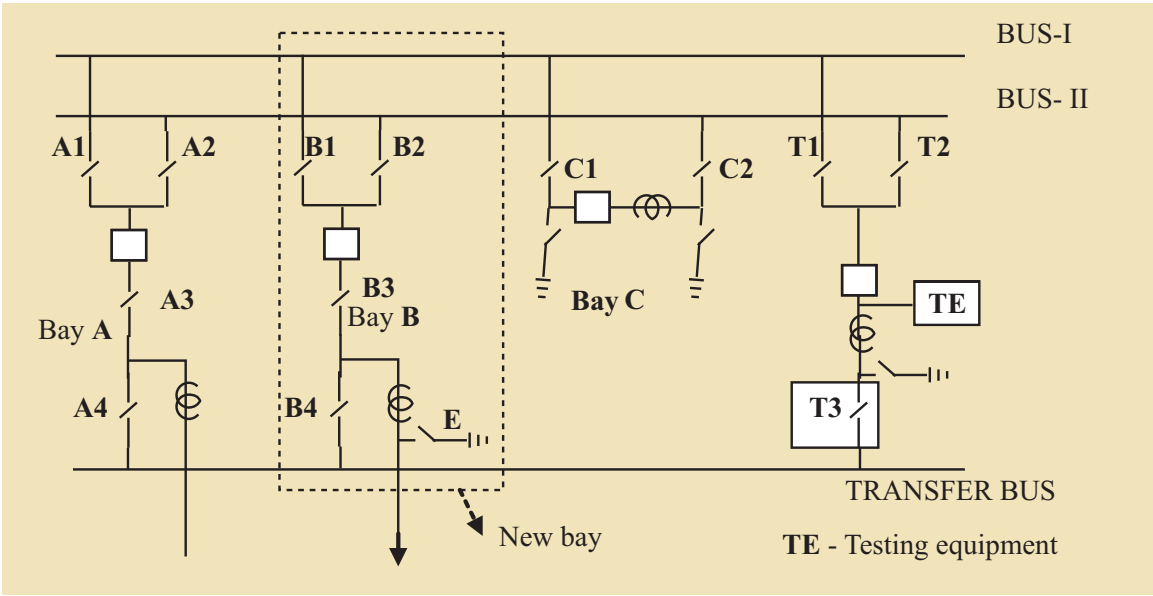
13. Open the breaker and isolator A1 in bay A and breaker and isolator B1 in bay B.

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.

TECHNICAL SPECIFICATION
FOR INSULATING MAT

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 and rear side 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.

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BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DOCUMENT No.	TB xxx 618 002a	Rev 04	Prepared	Checked	Appd
TYPE OF DOC.	TECHNICAL SPECFICATION	NAME	BVG	PLK	RMS
TITLE		SIGN	-SD-	-SD-	-SD-
	G I HARDWARES	DATE			
		GROUP	TBEM		
		W.O. No			
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PROJECT					

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Contents:

Section No.	Description	No of Pages
SECTION-1	SCOPE, SPECIFIC TECHNICAL REQUIREMENTS and QUANTITIES	01
SECTION-2	STANDARD SPECIFICATION	03
SECTION-3	PROJECT DETAILS AND GENERAL SPECIFICATION	01
SECTION-4	GUARANTEED TECHNICAL PARTICULARS (Not Applicable)	....
SECTION-5	MANUFACTURING QUALITY PLAN (Not Applicable)	....
SECTION-6	CHECK LIST	01

Rev	Date	Altered	Checked	Approved	
04	18.11.10	BVG	PLK	RMS	Unit wt of hardware added
02	13.4.06.	BVG	PLK	RMS	Eqpt mounting hardwares added.
Distribution				To	
				Copies	

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SECTION - 1

SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & QUANTITIES

1.1 SCOPE

The scope of this specification is to specify all details required by a supplier for supply of galvanized hardwares for projects being executed by BHEL on turnkey basis for NTPC, PGCIL, SEBs and other Customers.

1.2 SPECIFIC TECHNICAL REQUIREMENTS

The specific technical requirements shall be as per Standard Technical Specification (Refer Section 2).

1.3 QUANTITIES

The quantities shall be as per attached BOQ.

SECTION - 2

2.0 GENERAL

This section covers the standard technical specification for GI Hardwares.

2.1 BOLTS:

M16 bolts shall be used in all types of structures except equipment mounting/ earthing bolts which shall be as per equipment requirement.

All bolts for member connections in towers, beams & equipment support structures shall conform to IS: 12427 - 2001 and for step bolts shall conform to IS: 10238 – 1982.

The mechanical properties shall conform to property class 5.6 of IS:1367 (part 3) - 1991.

All bolt heads shall have hexagonal shape, the heads being forged out of the solid material truly concentric and square with the shank, which must be perfectly straight.

Fully threaded bolts should not be used.

All bolts shall be threaded with metric standard thread to take the full depth of the nut and permit firm grip of the member.

All bolts shall be hot dip galvanized as per IS: 1367 (Part 13) – 1983.

2.2 NUTS:

All nuts shall conform to IS: 1363 (Part 3) –1992.

The mechanical properties shall conform to property class 5 of IS:1367 (part 6) – 1980.

The nuts shall be capable of being worked with fingers along the entire threaded portion of the bolt with a neat fit capable of developing the full strength of the bolt.

All nuts shall be hot dip galvanized as per IS: 1367 (Part 13) – 1983.

2.3 PLAIN WASHERS:

All plain washers shall be punched washers, A type conforming to IS: 2016-1967.

These shall be hot dip galvanized as per IS: 4759 – 1984.

2.4 SPRING WASHER:

All spring washers shall be of spring steel, positive lock type and conforming to type B of IS: 3063-1972. The thickness of spring washer shall be as specified under:

Bolt Diameter	Thickness of Spring washers
16 mm	3.5 mm
12 mm	2.5 mm

These shall be electro-galvanized as per IS: 1573 – 1986.

2.5 UNIT WEIGHT OF BOLTS I/C NUT, PLAIN AND SPRING WASHERS:

For purpose of payment, following unit weights as indicated below shall be considered.

A.) STANDARD BOLTS I/C ONE NUT UNIT WEIGHTS

S. NO.	TYPE	SIZE OF BOLTS	TOTAL WT (KG)
1	M16	16 ϕ X 35 LG	**0.117**
2	M16	16 ϕ X 40 LG	**0.125**
3	M16	16 ϕ X 45 LG	**0.133**
4	M16	16 ϕ X 50 LG	**0.141**
5	M16	16 ϕ X 55 LG	**0.149**
6	M16	16 ϕ X 60 LG	**0.157**
7	M16	16 ϕ X 65 LG	**0.164**
8	M16	16 ϕ X 70 LG	**0.172**
9	M16	16 ϕ X 75 LG	**0.180**
10	M16	16 ϕ X 80 LG	**0.188**
11	M16	16 ϕ X 85 LG	**0.196**
12	M16	16 ϕ X 90 LG	**0.204**
13	M16	16 ϕ X 95 LG	**0.212**
14	M16	16 ϕ X 100 LG	**0.220**
15	M12	12 ϕ X 35 LG	**0.0620**
16	M12	12 ϕ X 40 LG	**0.0664**
17	M12	12 ϕ X 45 LG	**0.0708**
18	M12	12 ϕ X 50 LG	**0.0753**
19	M12	12 ϕ X 55 LG	**0.0797**
20	M12	12 ϕ X 60 LG	**0.0842**

B.) SPRING WASHER

S. NO.	TYPE	TOTAL WT (KG)
1	3.5mm thk (M16 bolt)	**0.00891**
2	2.5mm thk (M12 bolt)	**0.00382**

C.) For supplies of bolts i/c nuts, plain washers and spring washer other than those listed above, payment shall be made based on unit weights worked out considering theoretical dimensions & density of steel as 7850kg/cum.

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BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS - ENGINEERING DEPARTMENT, NOIDA

			Prepared	Checked	Approved
DOCUMENT No.	TBEM/ ETC/ NEEMUCH	Rev-01			
TYPE OF DOC.	ESTIMATION	NAME	Vikram Singh Meena	Muneet Surinder Mehta	-
TITLE	ETC WORKS ESTIMATES	SIGN			-
ESTIMATED COST OF		DATE	07.04.2023	07.04.2023	-
Erection, Testing & Commissioning (ETC) work includes Material handling, safe keeping, Pre-erection assembly, erection, testing, pre-commissioning and commissioning including trial run of 400/220kV AIS and associated systems / equipment at 400/220kV new substation, Neemuch and reconciliation & handing over surplus material to BHEL.		GROUP	TBEM	TBEM	-

CUSTOMER	Power Grid Corporation of India Limited (POWERGRID)
PROJECT	Substation Package SS-01: For (I) Establishment of 400/220kV new substation at Neemuch under Transmission system for evacuation of power from Neemuch REZ through TBCB

TOTAL ESTIMATED COST: **INR 2,20,05,077**
(Excluding Taxes and Other Duties)
Rupees Two Crore Twenty Lacs Five Thousand Seventy Seven Only

Finance Query & TBEM reply attached & forwarded for Concurrence. 07/04/23.

Sl no 7 ("A") the additional cost to be taken up with customer for reimbursement. It is understood this additional expenditure is due to compression of execution Schedule at the instance of customer.

07/04/2023

▶ **TBG (Finance)**
- For Concurrence, please.

▶ **TBG (Engineering) - GM**
- For Approval, please.

7/4/23.

Rev. No.	Date	Altered	Checked	Approved
01	7/4/23			

Note: Estimate revised due to addition of Item 7 vide email dt 07.04.2023. "A"

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1406451/2023/TBG-TBG_SC

PQR FOR ETC WORKS – 400/220 kV Neemuch Substation

The contractor must have either of the following experience of having successfully completed similar works during last 7 years as on original date technical bid opening of this tender:

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

OR

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

OR

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

1. Minimum Average Annual Turnover #(MAAT) for best three years i.e. 36 months out of last five financial years of the contractor should be Rs. 3,30,07,615/-(Completion Period Considered as 1 year)

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

Notes:

a) Similar work shall mean the erection works of 132kV or above switchyard.
b) The aforesaid qualifying requirement shall however, not be applicable for engaging labour as per extant policy.
c) The cost of the work shall be the estimated value for work.
d) The above criteria is in addition to extant policy on selection of contractor as per WPPP, Vol-II as available on POWERGRID website: https://apps.powergrid.in/pgcil_new/doc.aspx.
e) The MAAT requirement shall be worked out basis the following formula:
Minimum Average Annual Turnover (MAAT) = (Cost of the work to be contracted x 1.5) / Completion period in years**

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

Shobhna Singh
Sr. Manager, TBEM

Sr. DGM/TBEM

GM/TBEM – on Tour will sign on return

1406451/2023/TBG-TBG_SC

BHARAT HEAVY ELECTRICALS LIMITED
Transmission Business Group, NOIDA
Sub-Contracting Management
Tower-A,5th Floor
Advant Navis IT Business Park
Plot No-7,Sector-142,Expressway Noida
Noida-201305
Distt. Gautam Budhnagar, UP.

Work Indent (EN2300273)

Work Indent Number : EN2300273
Project :PGCIL Neemuch (New)
Work Indent Date : 06 Apr, 2023
TBG Sector : TBNS
Revision Number: 1
Type of Package : ETC
Revision Date : 07 Apr, 2023
Name of Package : ETC WORKS OF NEEMUCH SUBSTATION
Currency : INR
Remarks: ETC PACKAGE

Sr. No.	Description Of Item	SAC Code	Quantity	Unit	Unit Rate	AMOUNT
1	400/220/33kV, 500 MVA, 3-Ph, ICT complete in all respect alongwith its MB Box, Radiator Bank and its cooling arrangement, Conservator, Cooler Control Cabinet/Marshalling Kiosk, Unloading along with safe storage of accessories and insulating oil till completion of commissioning of Equipment. Work includes arrangement of all required T&P for E&C works including storage Tank and its placement for filtration (of required capacity of ICT) , Dry air Generator / Cylinder of Dew Point -60 or better , Filter Machine of 10-12 KL capcity with 0.3 µ filters and arrangement of Pre-erection testing of Turrets and Bushing, carrying out erection of all auxiliaries viz turrets, Bushings, terminal connectors, associated earthing works (excluding riser connections to main earthmat), laying of cable from ICT auxiliaries to IMB -CMB -RTCC, Oil filtration, filling of oil, hot oil circulation, Oil testing including fine filtration and particle count etc as required to complete the erection & commissioning of ICT. All required electrical and oil testing during different stage of E&C works of ICT are deemed to be covered in this line item. (1 Set means complete activity for 1 ICT)		2.00	Set	1628607.44	3257214.87
2	400/220/33kV, 500 MVA, 3-Ph, ICT-Dragging and turning of any required degree including placement of plinth and removal of wheels (if needed)		100.00	meter	3072.67	307267.03
3	400/220/33kV, 500 MVA, 3-Ph, ICT : Complete dryout of 400kV ICT as per standard BHEL procedure to achieve Rh of 0.5% and Dew point of -36 or better. All required arrangement for vacuum filling of Tank by Dry N2 /Air cylinder of Dew point -60 or better, to achieve the required acceptable values from calibrated Dew point meter of vaisala make, are deemed to be covered in this line item. (1 Set means complete activity for 1 ICT)		2.00	Set	162860.74	325721.49
4	420kV 125 MVAr, 3-Ph, Reactor complete in all respect alongwith its MB Box, Radiator Bank and its cooling arrangement, Conservator, Cooler Control Cabinet/Marshalling Kiosk, Unloading along with safe storage of accessories and insulating oil till completion of commissioning of Equipment . Work includes arrangement of all required T&P for E&C works including storage Tank and its placement for filtration (of required capacity of Reactor), Dry air Generator / Cylinder of Dew oint -60 or better , Filter Machine of 10-12 KL capcity with 0.3 µ filters and arrangement of Pre-erection testing of Turrets and Bushing carrying out erection of all auxiliaries viz turrets, Bushings, terminal connectors, associated earthing works (excluding riser connections to main earthmat), laying of cable from Reactor auxiliaries to IMB , Oil filtration, filling of oil, hot oil circulation, Oil testing including fine filtration and particle count etc as required to complete the erection & commissioning of ICT. All required electrical and oil testing during different stage of E&C works of Reactor along with post charging vibration masurement are deemed to be covered in this line item. (1 Set means complete activity for 1Reactor)		1.00	Set	708030.32	708030.32
5	420kV 125 MVAr, 3-Ph, Bus Reactor- Dragging and turning of any required degree including placement of plinth and removal of wheels		100.00	meter	1698.77	169877.15

6	420kV 125 MVAr, 3-Ph, Bus Reactor : Complete dryout of 400kV Rector as per standard BHEL procedure to achieve Rh of 0.5% and Dew point of -36 or better. All required arrangement for vacuum filling of Tank by Dry N2 /Air cylinder of Dew point -60 or better, to achieve the required acceptable values from calibrated Dew point meter of vaisala make, are deemed to be covered in this line item. (1 Set means complete activity for 1Rector)		1.00	Set	70803.03	70803.03
7	DG SET suitable for operating load of 2 oil filteration machine simultaneously for complete testing & commissioning		1.00	Set	815600.00	815600.00
8	420kV, 3150A, 63kA Circuit Breaker (3-Phase) without closing resistor complete in all respect along with lattice type GI supporting structure, platform with ladder, terminal connectors, Breaker Control Cabinets and interpole cabling, SF6 Gas cylinders. (Supervision of Erection, Testing and commissioning will be done by supplier. Supplier will bring Breaker timing kit and Gas leak detector only. Necessary manpower support, tools, tackles and testing kits is in the scope of ETC contractor).		11.00	No.	60172.45	661896.98
9	420 kV, 3-ph Circuit Breaker: Special cabling between CB/CSD and Relay Panel in SPR		300.00	meter	26.39	7916.04
10	420 kV, 3000A, 63KA, 1-Phase Current Transformer complete with terminal connectors without support structure.		33.00	No.	10530.18	347495.81
11	DGA Test for 420kV CT Oil – Scope includes sampling of oil from CT (sample bottle, syringe etc for DGA test is NOT in the scope of bidder) under supervision of OEM / BHEL. Bidder's scope covers all supports for sampling, safely delivery and submission of test sample to Powergrid laboratory, getting it tested and submission of test report to BHEL. Powergrid laboratory charges shall in the scope of bidder.		33.00	No.	2682.49	88522.17
12	420kV, 3150A, 63KA Isolator (3-phase)(Double Break) with two E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		2.00	No.	36761.44	73522.88
13	420kV, 3150A, 63KA, Isolator (3-phase)(Double Break) with one E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		27.00	No.	36761.44	992558.82
14	420 kV, 4400 pF Capacitive Voltage Transformer (1-Phase) complete with terminal connectors without support structure.		18.00	No.	10530.18	189543.17
15	336kV Surge Arrester (1-phase) complete with surge counter, leakage current meter, insulating base, connecting cable and terminal connector, without support structure.		21.00	No.	3758.98	78938.48
16	420 kV, 1 phase Bus Post Insulator complete with corona ring & terminal connectors without support structure		35.00	No.	1931.85	67614.75
17	245kV, 3150A, 50KA Circuit Breaker (3-Phase) without closing resistor complete in all respect along with lattice type GI supporting structure, platform with ladder, terminal connectors, Breaker Control Cabinets and interpole cabling, SF6 Gas cylinders. (Supervision of Erection, Testing and commissioning will be done by supplier. Supplier will bring Breaker timing kit and Gas leak detector only. Necessary manpower support, tools, tackles and testing kits is in the scope of ETC contractor).		1.00	No.	35595.65	35595.65
18	245kV, 1600A, 50KA Circuit Breaker (3-Phase) without closing resistor complete in all respect along with lattice type GI supporting structure, platform with ladder, terminal connectors, Breaker Control Cabinets and interpole cabling, SF6 Gas cylinders. (Supervision of Erection, Testing and commissioning will be done by supplier. Supplier will bring Breaker timing kit and Gas leak detector only. Necessary manpower support, tools, tackles and testing kits is in the scope of ETC contractor).		5.00	No.	35595.65	177978.27
19	245 kV, 2500A, 50KA, 1-Phase Current Transformer complete with terminal connectors without support structure.		3.00	No.	7119.71	21359.13
20	245 kV, 1600A, 50KA, 1-Phase Current Transformer complete with terminal connectors without support structure.		15.00	No.	7119.71	106795.67
21	245 kV, 4400 pF Capacitive Voltage Transformer (1-Phase) complete with terminal connectors without support structure.		12.00	No.	7083.45	85001.40
22	216kV Surge Arrester (1-phase) complete with surge counter, leakage current meter, insulating base, connecting cable and terminal connector, without support structure.		12.00	No.	2575.80	30909.60
23	245KV, 3150A, 50KA, Isolator (3-phase)(Double Break) with two E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector &		2.00	No.	24099.01	48198.02

	accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).					
24	245KV, 1600A, 50KA, Isolator (3-phase)(Double Break) with two E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		5.00	No.	24099.01	120495.05
25	245KV, 1600A, 50KA, Isolator (3-phase)(Double Break) with one E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		5.00	No.	22592.82	112964.11
26	245KV, 1600A, 50KA, Isolator (3-phase)(Double Break tandem) without E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		9.00	No.	22592.82	203335.40
27	245 kV, 1 phase Bus Post Insulator complete with corona ring & terminal connectors without support structure		60.00	No.	1545.48	92728.80
28	72.5 kV, 1250A, 25 kA, Circuit Breaker (3-Phase) without closing resistor complete in all respect along with lattice type GI supporting structure, platform, terminal connectors, Breaker Control Cabinets and interpole cabling, SF6 Gas cylinders. (Supervision of Erection, Testing and commissioning will be done by supplier. Supplier will bring Breaker timing kit and Gas leak detector only. Necessary manpower support, tools, tackles and testing kits is in the scope of ETC contractor).		1.00	No.	5916.10	5916.10
29	72.5 kV, 50A, 25KA, 1-Phase Current Transformer complete with terminal connectors without support structure.		3.00	No.	3006.64	9019.91
30	72.5 kV Voltage Transformer (1-Phase) complete with terminal connectors without support structure.		3.00	No.	2710.66	8131.99
31	72.5 kV, 400A, 25 KA, Isolator (3-phase)(Double Break) without E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		1.00	No.	4929.90	4929.90
32	72.5 kV, 1 phase Bus Post Insulator complete with terminal connectors without support structure		6.00	No.	1172.72	7036.33
33	30kV Surge Arrester (1-phase) complete with surge counter, leakage current meter, insulating base, connecting cable and terminal connector, without support structure.		3.00	No.	878.98	2636.95
34	36 kV, 1 phase Bus Post Insulator complete with terminal connectors without support structure		3.00	No.	600.88	1802.64
35	36 kV, 3-Ph Horn Gap Fuse complete with terminal connectors without support structure		1.00	No.	3863.70	3863.70
36	36 kV, 400A, 25 KA, Isolator (3-phase)(Double Break) without E/S complete in all respect alongwith its operating mechanism with all cabling between equipment & operating mechanism and associated support insulator, terminal connector & accessories, without support structure.(Supervision of unloading, Erection, Testing and commissioning will be done by OEM).		1.00	No.	5489.46	5489.46
37	Bay Marshalling Kiosk: MK-SAS		13.00	No.	3237.39	42086.12
38	CT Junction Box : JB D-180		11.00	No.	2312.42	25436.67
39	CT Junction Box JB D-130		6.00	No.	2312.42	13874.55
40	CVT Junction Box JB D-75		10.00	No.	1849.94	18499.40
41	CT Junction Box JB D-30		1.00	No.	1849.94	1849.94
42	VT Junction Box JB D-50		1.00	No.	1849.94	1849.94
43	SA Junction box JB N-12		11.00	No.	1849.94	20349.34
44	400kV Circuit Breaker Relay Panel with Auto Reclose (with Automation) - (Including Mounting & Internal wiring of loose-supplied CSD As Applicable)		11.00	No.	6439.50	70834.50
45	400kV Line Protection Panel (with Automation)		4.00	No.	6439.50	25758.00
46	400kV Transformer Protection Panel (For both HV & MV side)-(withAutomation)		4.00	No.	6439.50	25758.00
47	400kV Bus Bar Protection Panel (Duplicate)-(with Automation)		1.00	No.	6439.50	6439.50
48	400kV Reactor Protection Panel (with Automation)- (Including Mounting & Internal wiring of loose-supplied CSD As Applicable)		2.00	No.	6439.50	12879.00
49	220kV Circuit Breaker Relay Panel with Auto Reclose (with Automation)		6.00	No.	6439.50	38637.00
50	220kV Line Protection Panel (with Automation)		2.00	No.	6439.50	12879.00
51	220kV Bus Bar Protection Panel (Single)-(with Automation)		1.00	No.	6439.50	6439.50

52	Substation automation System for controlling and monitoring of Auxilary System including BCUs		1.00	SET	26753.00	26753.00
53	PMU with GPS Clock (clock can be either internal or external)		4.00	No.	13250.30	53001.20
54	WAMS Hardware - Time System (GPS receiver)		4.00	No.	6126.95	24507.82
55	WAMS Hardware - Substation Grade Layer-3 LAN Switches with minimum 4 x10/100 Mbps Ethernet ports and 2 x 1 Gbps Ethernet ports		5.00	No.	659.44	3297.18
56	Installation of Armored Fibre Optic Cable in GI Pipe / HDPE Pipe along with connectors and associated termination (e.g. L2 Switch) for connecting PMU panels located in different control room of a station. Splicing and Termination shall be in cable supplier's scope. Installation of GI / HDPE Pipe is covered in separate BOQ line item		300.00	Meter	19.03	5709.07
57	Unloading, storage , material handling and Handing over of Relay Test kit		1.00	No.	338.07	338.07
58	400kV,3150A,0.5mH ,63kA Wave trap pedestal mounted including 3 Nos. Post Insulators and Terminal connectors without support structure.		8.00	No.	13918.53	111348.27
59	PLCC PANEL		4.00	No.	6183.11	24732.42
60	Coupling device on CVT for PLCC		4.00	No.	12366.21	49464.85
61	Digital Protection Coupler		4.00	No.	6183.11	24732.42
62	HF CABLE 75 OHMS FOR PLCC		0.50	KM	11961.20	5980.60
63	4 wire telephone equipment		1.00	No.	620.81	620.81
64	220kV,1600A,0.5mH ,50kA Wave trap pedestal mounted including 3 Nos. Post Insulators and Terminal connectors without support structure.		2.00	No.	9381.78	18763.55
65	EPAX (24/8) with 24 telephones, Cables etc.		1.00	SET	5395.66	5395.66
66	Equipment Cabinets For SDH: SDH EQUIPMENT (STM-16 MADM UPTO 5 MSP PROTECTED DIRECTIONS)-BASE EQUIPMENT (COMMON CARDS, CROSS CONNECT/CONTROL CARDS, OPTICAL BASECARDS, POWER SUPPLY CARDS, POWER CABLING, OTHER HARDWARE ANDACCESSORIES INCLUDING SUB RACKS, PATCH CORD, DDF ETC FULLY EQUIPEDEXCLUDING OPTICAL INTERFACE & TRIBUTARY CARDS		2.00	No.	7178.32	14356.63
67	NMS- CRAFT TERMINAL-HARDWARE-HANDLING & STORAGE & MOVEMENT TO WORK SITE		1.00	No.	5981.75	5981.75
68	VOIP TELEPHONE INSTRUMENT WITH ONE COMMON SWITCH (MIN. 8 PORT)		4.00	No.	620.81	2483.26
69	Installation of Armored Fibre Optic Cable in GI Pipe / HDPE Pipe along with connectors. Splicing and Termination shall be in cable supplier's scope. Installation of GI / HDPE Pipe is covered in separate BOQ line item		3.00	KM	16200.33	48600.98
70	OPGW Fibre Optic Distribution Panel (FODP): Indoor Type: 96F		2.00	No.	3972.17	7944.35
71	415V Main Switchboard		1.00	SET	64910.16	64910.16
72	415V AC Distribution Board (ACDB) as per Technical Specification		1.00	SET	64910.16	64910.16
73	415V MLDB(along with 2 nos. 100 kVA Lighting transformer)		1.00	SET	48682.62	48682.62
74	415V Emergency Lighting DB(along with 1no. 25kVA 415V/415V lightingtransformer)		1.00	SET	38946.10	38946.10
75	220V DCDB		2.00	SET	48682.62	97365.24
76	48V DCDB		2.00	SET	29209.57	58419.14
77	48V Battery set (750 AH VRLA) along with all accessories such as racks, interconnecting cables, connectors etc. complete with MCCB box. Supervision of ETC is in Battery supplier scope.		2.00	SET	30832.33	61664.65
78	220V Battery (700 AH VRLA) set along with all accessories such as racks, interconnecting cables, connectors etc. complete with MCCB box. Supervision of ETC is in Battery supplier scope.		2.00	SET	64910.16	129820.32
79	220V Float Cum Boost Battery Charger (Supervision of ETC will be done by OEM).		2.00	No.	10020.51	20041.01
80	48V Float Cum Boost Battery Charger (Supervision of ETC will be done by OEM).		2.00	No.	6166.47	12332.93
81	unloading, storage of DG set & its accessories and shifting from storage space to its foundation at site		1.00	SET	4056.88	4056.88
82	Supply & ETC of Temperature transducer in building: Temperature transducer shall have the following specification: Sensor : Air temperature sensor (indoor use) Output : 4 to 20 mA Temperature range : -5° C to 60° C Resolution : 0.1°C Accuracy : 0.5° C or better.		5.00	No.	7250.00	36250.00
83	unloading, storage, material handling of High wall type split AC unit of 2 TR capacity		15.00	No.	643.95	9659.25
84	unloading, storage, material handling of Air conditioning system for Switchyard Panel Room of 9m length		4.00	No.	1400.00	5600.00

85	unloading, storage, material handling of Air conditioning system for Switchyard Panel Room of 6m length		2.00	No.	1200.00	2400.00
86	Galvanised steel Lattice Structures including hardwares for Towers, beams & equipment support - In Switchyard Area		534.00	MT	4832.96	2580802.39
87	1.1KV GRADE 3CX2.5 SQMM CONTROL CABLE		5.50	KM	14350.83	78929.58
88	1.1KV GRADE 5CX2.5 SQMM CONTROL CABLE		32.00	KM	14350.83	459226.67
89	1.1KV GRADE 10CX2.5 SQMM CONTROL CABLE		22.00	KM	15369.20	338122.49
90	1.1KV GRADE 19CX1.5 SQMM CONTROL CABLE		14.00	KM	23709.72	331936.15
91	1.1KV GRADE 27CX1.5 SQMM CONTROL CABLE		4.50	KM	36231.69	163042.62
92	1.1KV GRADE 1CX630 SQ. MM (XLPE) POWER CABLE		0.80	KM	181126.62	144901.30
93	1.1KV GRADE 3.5CX300 SQMM (XLPE) POWER CABLE		1.10	KM	70436.48	77480.12
94	1.1KV GRADE 1CX150 SQMM (PVC) POWER CABLE		1.50	KM	51382.46	77073.69
95	1.1KV GRADE 3.5CX70 SQMM (PVC) POWER CABLE		1.50	KM	29720.04	44580.06
96	1.1KV GRADE 3.5CX35 SQMM (PVC) POWER CABLE		10.00	KM	20496.17	204961.74
97	1.1KV GRADE 4CX16 SQMM (PVC) POWER CABLE		5.50	KM	15825.72	87041.43
98	1.1KV GRADE 4CX6 SQMM (PVC) POWER CABLE		16.50	KM	15825.72	261124.30
99	1.1KV GRADE 2CX6 SQMM (PVC) POWER CABLE		4.50	KM	15825.72	71215.72
100	4PAIR, 0.5 SQ.MM SCREENED CABLE		3.00	KM	14350.83	43052.50
101	10PAIR, 1.5 SQ.MM SCREENED CABLE		0.50	KM	14350.83	7175.42
102	Supply of Cable gland for 1.1KV GRADE 3CX2.5 SQMM CONTROL CABLE		20.00	No.	204.99	4099.70
103	Supply of Cable gland for 1.1KV GRADE 5CX2.5 SQMM CONTROL CABLE		160.00	No.	204.99	32797.62
104	Supply of Cable gland for 1.1KV GRADE 10CX2.5 SQMM CONTROL CABLE		100.00	No.	245.99	24598.92
105	Supply of Cable gland for 1.1KV GRADE 19CX1.5 SQMM CONTROL CABLE		90.00	No.	350.29	31525.79
106	Supply of Cable gland for 1.1KV GRADE 27CX1.5 SQMM CONTROL CABLE		20.00	No.	720.86	14417.29
107	Supply of Cable gland for 1.1KV GRADE 1CX630 SQ. MM (XLPE) POWER CABLE		30.00	No.	2187.00	65610.00
108	Supply of Cable gland for 1.1KV GRADE 3.5CX300 SQMM (XLPE) POWER CABLE		30.00	No.	737.44	22123.23
109	Supply of Cable gland for 1.1KV GRADE 1CX150 SQMM (PVC) POWER CABLE		35.00	No.	564.00	19740.00
110	Supply of Cable gland for 1.1KV GRADE 3.5CX70 SQMM (PVC) POWER CABLE		20.00	No.	409.96	8199.17
111	Supply of Cable gland for 1.1KV GRADE 3.5CX35 SQMM (PVC) POWER CABLE		100.00	No.	358.72	35872.40
112	Supply of Cable gland for 1.1KV GRADE 4CX16 SQMM (PVC) POWER CABLE		60.00	No.	307.48	18448.66
113	Supply of Cable gland for 1.1KV GRADE 4CX6 SQMM (PVC) POWER CABLE		550.00	No.	307.48	169112.75
114	Supply of Cable gland for 1.1KV GRADE 2CX6 SQMM (PVC) POWER CABLE		80.00	No.	225.97	18077.84
115	Supply of Cable gland for 4PAIR, 0.5 SQ.MM SCREENED CABLE		10.00	No.	204.99	2049.85
116	Supply of Cable gland for 10PAIR, 1.5 SQ.MM SCREENED CABLE		10.00	No.	204.99	2049.85
117	38/66KV HV POWER CABLE: Work includes laying in buried cable trench (buried cable section as per CABLE TRENCH LAYOUT DRG), on cable racks including lugs, glands, ferrules, route markers etc to complete . Cable Max OD=65 mm.		500.00	Meter	211.31	105657.20
118	38/66KV HV POWER CABLE: installation of TERMINATION KIT		6.00	No.	2415.02	14490.13
119	11/11KV or 12.7/22KV HV POWER CABLE: Work includes laying in buried cable trench (buried cable section as per CABLE TRENCH LAYOUT DRG), on cable racks including lugs, glands, ferrules, route markers etc to complete . Cable Max OD=45 mm.		300.00	Meter	146.29	43888.37
120	11/11KV or 12.7/22KV HV POWER CABLE: installation of TERMINATION KIT		6.00	No.	1932.02	11592.10
121	400kV tension insulator string and associated hardware fittings without turn buckle suitable for quad conductor (conductor OD<40mm)		36.00	No.	3391.56	122096.01
122	400kV tension insulator string and associated hardware fittings with turn buckle suitable for quad conductor (conductor OD<40mm)		48.00	No.	3391.56	162794.68
123	400kv suspension insulator string and associated hardware fittings with drop clamp suitable for quad conductor (conductor OD<40mm)		21.00	No.	2774.91	58273.10
124	220kv tension insulator string and associated hardware fittings without turn buckle suitable for quad conductor (conductor OD<40mm)		15.00	No.	2575.80	38637.00
125	220kv tension insulator string and associated hardware fittings without turn buckle suitable for twin conductor (conductor OD<40mm)		24.00	No.	2575.80	61819.20
126	220kv tension insulator string and associated hardware fittings withturn buckle suitable for twin conductor (conductor OD<40mm)		27.00	No.	2575.80	69546.60

127	220kv tension insulator string and associated hardware fittings withturn buckle suitable for quad conductor (conductor OD<40mm)		15.00	No.	2575.80	38637.00
128	220kv suspension insulator string and associated hardware fittings with through clamp suitable for twin conductor (conductor OD<40mm)		15.00	No.	2318.22	34773.30
129	220kv suspension insulator string and associated hardware fittings with drop clamp suitable for twin conductor (conductor OD<40mm)		12.00	No.	2318.22	27818.64
130	220 kV Single Suspension insulator string and associated hardware fittings with Drop Clamp suitable for Quad ACSR Bersimis Conductor		6.00	No.	2318.22	13909.32
131	ACSR Bersimis Conductor complete with Tee connectors for droppers to equipment connections, PG clamps for Busbar jumpering, Twin/Quad bundle rigid/flexible spacers etc to complete		16.20	kM	69372.73	1123838.28
132	4.5" Al Tube (ETC of Al.Tube includes cutting, Aluminum welding, testing, bending & installation of Al. Tube). (Welding sleeve and Al. tube will be supplied by BHEL)		21.00	MT	38863.64	816136.36
133	Installation of 7/9 SWG GI Stranded Shield wire including tension clamp, PG clamp and clamping on structure for down conductor, fixing/bolting with earth strip etc to complete.		2200.00	Meter	53.96	118704.46
134	Earthing work with 75X12 GI Flat - Installation of GI Flat including cutting, bending, welding with GI Flat / MS Rod, supply and application of paint, clamping to structure/building wall etc. to complete in all respect. All arc welding shall be done with low hydrogen content electrodes. the welds should be treated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminum paint. The red oxide and zinc chromate shall conform to IS:2074.		54.00	MT	11429.04	617168.16
135	Earthing work with 50X6 GI Flat / MS Flat - Installation of Flat including cutting, bending, welding with Flat / MS Rod, supply and application of paint, clamping to structure/building wall etc. to complete in all respect. All arc welding shall be done with low hydrogen content electrodes. the welds should be treated with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminum paint. The red oxide and zinc chromate shall conform to IS:2074.		10.00	MT	11429.04	114290.40
136	Laying of 100 to 150 mm wide, 2.5 M long, 2mm thick (minimum) G.S. steel Perforated type cable trays with cover, coupler plates, hardware, fixing and clamping arrangement with lattice type support equipment's structure etc to complete including cutting & jointing to suitable length. Fixing and clamping hardware required for fixing of perforated tray with lattice / pipe structure shall be in ETC contractor scope.		133.00	No.	67.61	8992.76
137	Supply of 50x50x6 mm MS Angle - Powergrid approved make		1.00	MT	44742.71	44742.71
138	Supply of 50x6 mm MS Flat - Powergrid approved make		1.00	MT	61209.54	61209.54
139	Installation of Cable Rack - work includes cutting, welding and fabrication of cable racks with MS angles & MS Flat (for continues earthing run) on inserts of cable trench walls. Cable rack assembly shall be of 1/2/3/4 tier as applicable. 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 aluminum paint. (supply of paint is in scope of bidder)		10.00	MT	30832.33	308323.26
140	Supply and installation of Panel Supporting Angles / Channel etc on cable trench/cutouts in CRB , Vertical support for cables etc (Including Supply). 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 aluminum paint. (supply of paint is in scope of bidder)		1.00	MT	73954.20	73954.20
141	Supply of 32 mm (Nominal Dia) HDPE - High Density PE pipe including tee / elbow as per relevant IS code. Mode of measurement shall be running length of HDPE Pipe only. Tee & Bend as per requirements are deemed included.		100.00	Meter	139.55	13955.04
142	INSTALLATION OF 110 mm dia PVC Pipe. Which shall be buried in the ground at a depth of 300 mm below FGL. Work includes excavation, backfilling, making trench holes and repairing of cable trench walls, cutting, fixing of sockets/ bends where required etc. complete. Both ends of PVC conduits shall be closed by plastering. (Payment will be made for the as erected pipe length)		3714.00	Meter	113.74	422433.12
143	INSTALLATION OF 50 mm dia PVC Pipe. Which shall be buried in the ground at a depth of 300 mm below FGL. Work includes excavation, backfilling, making trench holes and repairing of cable trench walls, cutting, fixing of sockets/ bends where required etc. complete. Both ends of PVC conduits shall be closed by plastering. (Payment will be made for the as erected pipe length)		2700.00	Meter	95.20	257043.90
144	INSTALLATION OF 50 NB GI pipes conduits along with socket, bend and joint on trench rack support . Cutting, threading, fixing of clamps sockets/ bends/joints where required etc. complete. Mode of measurement shall be running length of pipe conduit. GI conduits shall be used for INSTALLATION OF fiber optic cables /sensor cables.		660.00	Meter	53.47	35287.62

145	INSTALLATION OF 32 MM DIA. HDPE PIPE in cable trench, trays, hanger, supports, STRUCTURE, through wall etc		100.00	Meter	28.56	2856.04
146	INSTALLATION OF 32 MM DIA. HDPE PIPE buried in the ground at a depth of 300 mm below FGL. Work includes excavation, backfilling, making trench holes and repairing of cable trench walls, cutting, fixing of sockets/ bends where required etc. complete. (Payment will be made for the as erected pipe length)		100.00	Meter	47.60	4760.07
147	INSTALLATION of ARMOURED FIBER OPTIC CABLE in GI Pipe / HDPE Pipe along with connectors for SAS & Busbar Protection/PLCC. Splicing and Termination shall be in supplier's scope.). Installation of GI / HDPE Pipe is covered in separate BOQ line item.		250.00	Meter	18.94	4735.97
148	Supply of Rubber mats (Class-A suitable for 1.1 kV as per IS: 15652) - Refer TS Section Erection Clause 9.11		100.00	Sq.m	1509.18	150918.33
149	Installation of Rubber mats (Class-A suitable for 1.1 kV as per IS: 15652) in front of Panels		100.00	Sq.m	167.69	16768.70
150	Supply & Mounting of Phase Color Discs, Danger Plate and Identification Plates for bays & Equipments as per IS:2551: 1982 & IS:5: 1978.		1.00	Lot	139317.35	139317.35
151	PHASE IDENTIFICATION - Painting the structures in Red, Yellow and Blue by reflecting Colour is to be provided around the top of the structure with Colour band of 100 mm width.		1.00	Lot	13818.89	13818.89
152	Supply & Installation of BAY IDENTIFICATION - Bay Name Plate as per drawing no. C/ENG/STD/BAY NAME PLATE		17.00	Nos.	1184.39	20134.65
153	Supply & Installation of Cable Tag - The tag shall be of aluminum 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.		1.00	Lot	13818.89	13818.89
154	Cutting and Modification - Structural Plates: Structure Modification - All tools and tackles required for GI structure, any other steel structure modification, Aluminium Items etc. shall be in the scope of bidder. Cutting , drilling, punching, minor civil works also included in the scope. Minor welding and application of protective / zinc rich paint on welded surface is also included in the scope.		50.00	kg	20.00	1000.00
155	Modification of Hole Sizes in Structures: Structure Modification - All tools and tackles required for GI structure, any other steel structure modification, Aluminium Items etc. shall be in the scope of bidder. Cutting , drilling, punching, minor civil works also included in the scope. Minor welding and application of protective / zinc rich paint on welded surface is also included in the scope.		50.00	Nos	100.00	5000.00
156	Drilling of Additional Holes in Structures : Structure Modification - All tools and tackles required for GI structure, any other steel structure modification, Aluminium Items etc. shall be in the scope of bidder. Cutting , drilling, punching, minor civil works also included in the scope. Minor welding and application of protective / zinc rich paint on welded surface is also included in the scope.		50.00	Nos	100.00	5000.00
157	Splicing of Armoured FO Cable (1 No. = Splicing of 1 No. Fibre) - Bidder to also arrange required tools and tackles		50.00	Nos	800.00	40000.00
158	Watch and ward of stored / erected material at project site and storage area or any other locations as per instruction of site in charge. (round the clock security by authorized service agency)		8.00	Per Post Per Month	60853.28	486826.20
159	Supply & ETC of CUSTOMER/BHEL approved make 2.0 HP Automatic Start/ Stop type Centrifugal pump and accessories for sump pit		1.00	No.	19318.50	19318.50
160	Supply & ETC of CUSTOMER/BHEL approved make 1.0 HP Automatic Start/ Stop type Centrifugal pump and accessories for sump pit		1.00	No.	15454.80	15454.80
161	Supply & ETC of CUSTOMER/BHEL approved make 0.5 HP Automatic Start/ Stop type Centrifugal pump and accessories for sump pit		1.00	No.	11591.10	11591.10
162	Supply & ETC of Equipment Fixing Hardware - Full Threaded bolts with nut and two Plane Washer and one Spring Washer as per technical specification		100.00	kg	108.52	10851.89
163	Supply of required size (M12/M16/M20 upto 150mm long) of Anchor Fastner /Bolts and fixing in Concrete/wall/ceiling wherever required.		30.00	kg	154.16	4624.85
164	Unloading, storage , material handling and Handing over of Mandatory spares a per Annexure-Mandatory spares		1.00	Lot	119527.25	119527.25

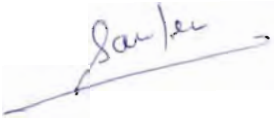
Estimated Value = 22005077.07

Prepared By : Shobhna Singh

Checked By : Sanjeev Kumar Shrivastava

1406451/2023/TBG-TBG_SC

Approved By : Sanjeev Kumar Shrivastava



1406475/2023/TBG-TBG_SC

राजू कुमार (प्रबंधक, उप संविदा)

From: विनीत गुप्ता (उप-प्रबंधक, संविदा प्रबंधन, टीबीजी) VINEET GUPTA <vineet.gupta@bhel.in>
Sent: Thursday, April 6, 2023 4:05 PM
To: 'राजू कुमार (प्रबंधक, उप संविदा)'
Cc: 'TBG Subcontracting'; anujkumar@bhel.in; joshimm@bhel.in; 'A K Chowdhary'; 'Amrish Kumar Tiwari'
Subject: RE: Regarding Completion schedule and Special conditions for " ETC Works of Neemuch 400kV AIS."

Sir,

Please find details as below:

Sl. No.	**TBSM query**	**TBCM/PPMG reply**
1	Completion Schedule	Replied by TBG-PPMG
2	Special Conditions (if any) to be incorporated in NIT	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. 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 subcontractedx1.5/Completion period in years****

		****The completion period shall be considered as 1 year even if the same is less than 1 year.**
3	List of documents required for Vendor Approval from end Customer	Work Credentials/Financial credentials

सादर/Thanks and Best Regards,
विनीत गुप्ता/ Vineet Gupta
उप-प्रबंधक-संविदा प्रबंधन/ Dy. Manager-TBG Contracts Management
बीएचईएल, पारेषण व्यापार समूह/ BHEL, Transmission Business Group
Plot No.25, Sector-16A,
Noida (U.P.) PIN:201301
Mob: 9873967276
Tel: +91-1206748568

From: Amrish Kumar Tiwari <amrish@bhel.in>
Sent: 06 April 2023 16:01
To: 'राजू कुमार (प्रबंधक, उप संविदा)' <rajoo.kumar@bhel.in>; vineet.gupta@bhel.in
Cc: 'TBG Subcontracting' <tbsm@bhel.in>; anujkumar@bhel.in; joshimm@bhel.in; 'A K Chowdhary' <akchowdhary@bhel.in>
Subject: RE: Regarding Completion schedule and Special conditions for " ETC Works of Neemuch 400kV AIS."

Dear Sir,

This has reference to the trailing email. The completion plan for site has been discussed with AGM & Head (PPMG & DTG) and AGM & Head (TBNS).

Please go ahead with tendering process for ETC works for NEEMUCH Site considering the completion schedule as Sep'23.

Point No-2 and 3 of the trailing email shall be replied to by TBCM.

Regards,
Amrish Tiwari
Manager (PPMG)
BHEL- TBG, Noida
Ph: 0120- 6748564
Mo: 9650094436
Follow us on:

From: राजू कुमार (प्रबंधक, उप संविदा) [mailto:rajoo.kumar@bhel.in]
Sent: 06 April 2023 15:49
To: amrish@bhel.in; vineet.gupta@bhel.in
Cc: 'TBG Subcontracting'
Subject: Regarding Completion schedule and Special conditions for " ETC Works of Neemuch 400kV AIS."

Dear Sir,

1406475/2023/TBG-TBG_SC

TBSM has in receipt of BOQ, Estimate, for "ETC Works at Neemuch 400/220 kV AIS.

Please inform the followings for floating open tender enquiry for subject work:

Sl. No.	TBSM query	TBCM/PPMG reply
1	Completion Schedule	
2	Special Conditions (if any) to be incorporated in NIT	
3	List of documents required for Vendor Approval from end Customer	

Thanks & Regards,

राजू कुमार/ Rajoo Kumar
प्रबंधक (उप संविदा) /Manager(TBSM)
बीएचईएल-पारेषण व्यापार समूह/ **BHEL-TBG**
Noida, UP-201301
Ph:+91 120 674-**8551**

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