NATIONAL COMPETITIVE BIDDING

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BIDDING DOCUMENT

for

"Supply of 220/132/33kV, 200MVA Auto Transformers and Related Services for Tinsukia Substations of AEGCL (Package-T-7)"

BID IDENTIFICATION NO:

AEGCL/MD/Tech-1145/Aug Trafo/200MVA/T-7/2026/BID, Date: 11.06.2026

VOLUME -II

(Technical Specification)

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Tender Fees: Rs. 2,000.00

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CHAPTER 1: TECHNICAL SPECIFICATION OF TRANSFORMER (UPTO 400kV CLASS)

1.1.0 SCOPE:

1.1.1 This specification provides for design, manufacture, inspection and testing before dispatch, packing and delivery at destination sub-stations of transformers complete with all fittings, accessories, spares, unloading, handling, proper storage at site, associated equipments specified herein. The scope of work shall also include, supervision of Erection, Testing and Commissioning of all the equipments supplied under this specification.

1.1.2 It is not the intent to specify completely herein all details of the design and construction of equipments. However, the equipment shall conform in all respects standards of engineering, design and workmanship listed in clause no. 1.2.0 and shall be capable of performing in continuous commercial operation up to the supplier's guarantee in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment, is not in accordance therewith. The equipments offered shall be complete with all components necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of supplier's supply, irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

1.1.3 The scope of supply includes the provision of training for Purchaser's personnel (Limiting to 10 Persons for minimum of 05 days duration) in regard to design, manufacture, assembly, testing, operation and maintenance of offered transformer at his works in the event of order, free of cost to AEGCL.

1.2.0 STANDARDS:

1.2.1.0 The Transformer and associated accessories shall conform to the latest issues of the standards as given below, except to the extent explicitly modified in this specification.

1	1.2.1.0	The Transformer and associated accessories shall conform to the latest issues of the standards as given below, except to the extent explicitly modified in this specification. (1) CBIP manual on Transformer. (2) 'Standard Specifications and technical Parameters for Transformers and Reactors (66 kV & above voltage class)' of CEA vide 'File No.CEA-PS-14- 169/2/2019-PSETD Division Dated: April, 2021' (3) Power Transformers (4) Fittings and accessories for power transformers (5) Insulating oils for transformers and switchgears (6) Bushings for alternating voltages above 1000 V (7) Gas operated relays (8) Code of practice for installation and maintenance (9) Colours for ready mix paints. (10) Industrial cooling fans. (11) Guide for loading of oil immersed transformers. (12) 'Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector' of CEA	

1.2.1.1 In case equipment conforms to other international standard which ensure equivalent or better performance than that specified under **Clause 1.3.0,** then relevant extracts of the same shall be forwarded with the bid and the salient features of comparison shall be brought out separately in additional information schedule.

1.2.1.2 For further reference regarding standards **Annexure-V (List of Codes/Standards/ Regulations/Publications)** shall be followed.

1.3.0. GENERAL REQUIREMENT:

1.3.1.0 The transformers shall conform in all respects to high standards of engineering, design, workmanship and latest revisions of relevant standards at the time of offer and the purchaser shall have the power to reject any work or material which, in his judgment, is not in full accordance therewith.

1.3.1.1 The Transformer offered by the contractor shall at least conform to the requirements specified under relevant IS/IEC 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.

1.3.1.2 The equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the tropical conditions mentioned in Annexure – 1: General Technical Requirement (GTR), of this bidding document.

1.3.1.3 The transformers shall in general have constant percentage impedance type as per CEA guideline between HV and IV on all taps. However, in case of transformer to be connected for parallel operation:

i) The percentage impedance, vector group, OLTC connection and range etc. of the transformers shall be matched.
ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the OLTC control scheme having provision of Master/Follower/Independent /Off operation etc.
iii) External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances.

Note –

1. Parallel operation with existing transformer is not required. Bidders shall follow technical specification as per Annexure A – 3.0 (Sr. no. 7.12).

1.3.1.4 The Transformer shall be multi-winding, oil immersed complying as per Specific technical parameters and suitable for outdoor installation.

1.3.1.5 The transformer of manufacturer having same or higher MVA rating and same or higher voltage class must be in successful operation in any STATE or CENTRAL utility for not less than five (5) years as on date of NIT.

	1.3.1.5	Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL: a) 500 MVA – 400/220/33 KV Auto Trasformer with loaded 33 kV tertiary winding b) 160 MVA - 220/132/33 KV Auto Transformer with loaded 33 KV tertiary winding. **c) 50 MVA - 132/33 KV Power Transformer.**	

1.3.1.6 Components having identical rating shall be interchangeable.

1.3.1.5 Rated Capacity and Voltage of the Transformers as per present requirement of AEGCL:

a) 500 MVA - 400/220/33 KV Auto Transformer with loaded 33 KV tertiary winding.
b) 160 MVA - 220/132 KV Auto Transformer

1.4.0. SPECIFIC REQUIREMENT:

(i) Type Test:

The transformers should be Type Tested as per IS 2026 or IEC 60076 in conjunction with their relevant Part. Necessary test documents of previously tested similar or higher rated (both in MVA and voltage class) transformer shall have to be submitted with the bid.
Materials, which have never been tested for critical performance, shall not be accepted.
Type test certificates shall be acceptable only if: -

(a) Tests are conducted in an independent and well known (**NABL**/**BIS** Accredited) testing laboratory, or
(b) Tests are conducted in manufacturer's own laboratory. In this case,

(i) The laboratory must have ISO 9000 (or its equivalent) series certificatio, and
(ii)Tests have been witnessed by technically qualified representatives of earlier clients or purchaser.

Test reports to be acceptable must be related directly to the materials offered. **Type Test Reports of Power/Auto transformer older than ten (10) years on the date of technical bid opening shall not be accepted**.
The Validity of Dynamic Short Circuit test report shall be as per CEA's notification no. CEA-TH-17/1/2021-TETD Division—dated 23rd December, 2022.
The Validity of type test report of Power/Auto Transformer and its accessories shall be as per CEA's "Guideline for Validity period of Type Tests conducted on Major Electrical Equipment in power transmission system", file No CEA-PS-14-80/1/2019-PSETD Division-Part (2).

Full Type Test Reports of at least the following equipment must be submitted: -

1. **500, 200, 160, 100, 80 and 50 MVA class Power/Auto Transformer**
2. **Tap Changer**
3. **Transformer Oil**
4. **Bushings**
5. **Buchholz Relay**
6. **Pressure Relief Device**
7. **Bushing Current Transformer**
8. **Oil Surge Relay**
9. **Cooling Gears**
10. **AVR Relay**
11. **On line drying system**

(ii) Dynamic Effect of Short Circuit:

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. **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 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.

For 220 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 160 MVA or above rating,220/132/33 kV 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 has not successfully tested 220/132/33 kV, 160 MVA or above rating Auto–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.

For 132 kV Class Transformer:

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on 50 MVA or above rating, 132/33 kV Power 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 132/33 kV, 50 MVA or above rating 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.

(iii) Sweep Frequency Response Analysis (SFRA/FRA) shall have to be carried out as special test for each transformer at manufacturer's premises in presence of representative of AEGCL free of cost. Test result shall have to be handed over to AEGCL. Before commissioning of the Transformer at site, the same SFRA/FRA test will have to be carried by the test engineers of the manufacturer in presence of customer's representative for comparing the results to take the decisions of the commissioning. The Testing Engineers & FRA kit for such pre-commissioning site testing shall have to be arranged by the manufacturer free of cost.

(iv) Tests at Manufacturer's works: The Transformers shall be subjected to type & routine test, special tests and no load & load loss measurement as per relevant IS.

(v) Guaranteed Technical Particulars: The Bidder shall furnish all guaranteed technical particulars as called for in this specification along with each copy of Bid submission. Bids lacking information in this respect may not be considered.

(vi) Core Materials: Core materials should be directly procured from either the manufacturer or their accredited reputed marketing organization and not through any agent.

1.5.0. Guaranteed Technical Particulars

1.5.1.0 The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in the prescribed Schedules with the Technical Bid. The Bidder shall also furnish any other information's as in their opinion is needed to give full description and details to judge the item(s) offered by them.
1.5.1.1 The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum/maximum value required as per the technical specification. No preference what so ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

1.6.0. Liquidated Damages and Rejection for Excessive Losses

1.6.1.0 The offered transformer shall not have any latent design defect within ten (10) years of commissioning.

1.6.1.1 The no-load losses, load losses and auxiliary losses shall not exceed the values specified in the **Maximum losses** Clause (i.e., Clause 1.6.1.3). No positive tolerance on no-load loss, load loss and auxiliary losses as well as total losses will be allowed. Any change in the figures assigned for transformer losses will not be permitted after opening of bids and evaluation will be carried out on the basis of information made available at the time of bid opening. Bid with higher losses as that of provided in the Technical Data Sheet, bid will be treated as non-responsive.

1.6.1.3 Maximum losses:
The maximum limit of losses shall be as per 'Standard Fixed Losses for Transformers and Shunt Reactors as per Central Electricity Authority (CEA) letter CEA/PSE&TD/218/3056-4028 dated 01.03.19'

Sr. No	Rating (MVA)	Voltage Rating (kV)	Phase	No Load Loss (kW)	Load Loss (kW)	I^2R (kW)	Stray + Eddy (kW)	Aux. Loss
1.	500	400/220/33	3- Phase	AT 90	500	375	125	15
2.	160	220/132	3- Phase	AT 30	200	145	55	6
3.	100	220/33	3- Phase	AT 43	245	200	45	5
4.	50	132/33	3- Phase	AT 25	125	105	20	3

1.7.0 Transportation

1.7.1 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.

1.7.2 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.

1.7.3 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/employer 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.

1.7.4 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.

1.7.5 The Contractor shall despatch the transformer filled with dry air/N2/oil at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air/N2 during transit and storage till completion of oil filling during erection. A dry air/N2 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/N2, 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/N2 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/N2 pressure shall be ensured.

1.7.6 The Transformer shall also be fitted with at least 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.

1.7.7 Vendor/EPC shall remove the electronic impact recorders after reaching the Transformer main foundation Location in front of AEGCL representative. Transformer manufacturer/EPC shall stop the electronic impact recorders and soft copy shall be handed over to AEGCL Site representative. EPC/Vendor shall return the electronic impact recorders to Manufacture factory, this hardcopies of report with the values (softcopy shall also be downloadable at site) to be submitted by Vendor at AEGCL Design cell/ Project Team.

1.8.0 Performance

1.8.1.0 The transformers shall be used for bi-directional flow of rated power. The major technical parameters of three phase transformer units are defined at **Annexure – A.**

1.8.1.1 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 up to specified load and then as OFAF (or ODAF 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 deg 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 deg C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

1.8.1.2 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.

1.8.1.3 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.

1.8.1.4 The transformers shall be capable of being over loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

1.8.1.5 Tank hotspot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

1.8.1.6 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/LV** System to which the transformers will be connected is as follows:

400kV system - 63 kA for 3 sec (sym, rms, 3 phase fault)
220kV system - 50 kA for 3 sec (sym, rms, 3 phase fault)
132kV system - 40 kA for 3 sec (sym, rms, 3 phase fault)
33kV system - 31.5 kA for 3 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., Zs = 0).

1.8.1.7 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 through fault** short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

1.8.1.8 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.

1.8.1.9 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.

1.8.1.10 The air core reactance of HV winding of transformer of 400 kV and above voltage class shall not be less than 20%. **External or internal reactors shall not be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.**

1.9.0 Tertiary Windings (if applicable as per Annexure - A)

1.9.1.0 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/**porcelain** 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.

1.10.0 Radio Interference and Noise Level

1.10.1.0 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.

1.10.1.1 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.

1.11.0 Measurable Defects

1.11.1.0 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.

1.12.0 Design review

1.12.1.0 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 – B**.

1.12.1.1 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.

1.12.1.2 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".

1.12.1.3 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 or Cigre SC 12 shall be applied for short circuit withstand evaluation.

1.12.1.4 **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 within **last 5 years** or as per latest CEA guideline as on the last date of submission of bid. 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. 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.

1.13.0 Construction Details

1.10.1.0 The construction details and features of transformer shall be in accordance with the requirement stated hereunder.

1.13.1.1 Tank

1.13.1.1.1 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 BS-4360 / IS 2062.

1.13.1.1.2 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 BS-5135/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 BS-5500 table 4.4.3.1/IS 10801.

1.13.1.1.3 Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

1.13.1.1.3 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.

1.13.1.1.4 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 for UHF sensors for PD Measurements (applicable for 400kV Transformer only) at various locations. Location of valves shall be finalized during design review.

e. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

1.13.1.1.5 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.

1.13.1.1.6 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

1.13.1.1.7 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.

1.13.1.1.8 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.

1.13.1.1.9 All pipes connected to Transformer shall follow IS 1239.

1.13.1.2 Tank Cover

1.13.1.2.1 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.

1.13.1.2.2 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.

1.13.1.2.3 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.

1.13.1.2.4 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.

1.13.1.2.5 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.

1.13.1.2.6 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.

1.13.1.3 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.

1.13.1.4 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.

1.13.1.6 Roller Assembly and Anti Earthquake Clamping Device

The roller mounted transformers 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. 3-Phase auto transformers of 400kV class shall have four (4) rails and other voltage class transformers shall have two (2) rails.

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

1.13.1.7 Conservator

1.13.1.7.1 Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts, prismatic oil level gauge and Conservator Protection Relay (CPR)/Air cell puncture detection relay.

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.

1.13.1.7.2 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.

1.13.1.7.3 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.

1.13.1.7.4 Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

1.13.1.7.5 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”.**

1.13.1.7.6 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 deg.C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

1.13.1.7.7 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.

1.13.1.7.8 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.

1.13.1.7.9 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. 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.

1.13.2.0 Piping works for conservator

1.13.2.1 Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

1.13.2.2 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be loaded 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 80 mm.

1.13.2.3 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.

1.13.2.4 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.

1.13.2.5 Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

1.13.3.0 Dehydrating Silica gel Filter Breather

1.13.3.1 Conservator of Main Tank and OLTC shall be fitted with a dehydrating **non-carcinogenic** silica gel 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 silica gel.
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 in series of identical size shall be connected to OLTC Conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.

1.13.3.2 **Thermosyphon Filter:**

To extract the harmful constituents like water, acids etc. from oil, Thermosyphon filter of cylindrical shape with perforated steel trays filled with absorbents such as active alumina should be provided.

The filter assembly shall be mounted on the transformer as well as ground supported and connected with pipes and shut off valves. Suitable instructions required to be followed for commissioning, dismantlement and maintenance of filter arrangement, re-generation and storage of the absorbent etc. must be included in the instrumentation manual. A detailed drawing showing internal arrangement shall be submitted.

The oil & absorbent capacity required in the thermo-syphon filter is as under.

i) Quantity of oil - 1.0% of total oil by weight
ii) Quantity of absorbent - 0.2% to 0.25% of total oil by weight

1.13.4.0 Pressure Relief Device

1.13.4.1 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.

Pressure Relief Device:
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 in **PRV and its terminal box**. One set of potential free contacts (1NO+1NC) (with plug & socket type
arrangement) per device shall be provided for tripping.

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

1.13.5.0 Sudden Pressure Relay

1.13.5.1 **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 in SPR and **its terminal box**. Pressurized water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

1.13.6.0 Buchholz Relay
1.13.6.1 Two numbers double float, reed type Buchholz relay shall be provided in series of 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.

1.13.6.2 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.

1.13.7.0 Oil Surge Relay
Reed type Oil Surge Relay shall be provided individually to each tap changer diverter switches and one common OSR at OLTC conservator tank. Valves of required size are to be put before and after of each OSR. For 3-phase OLTC, there shall be two numbers OSR. It is preferable that each oil surge relays have independent indicators. OSR shall have two trip contacts.

1.13.8.0 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 (As per ANNEXURE- J)
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 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 IEC 61850 compliant communications.

1.13.9.0 Winding Temperature Indicator (WTI)

1.13.9.1 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°C. 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 oil temperature:

Temperature transducer with Pt100 sensor for each winding (As per ANNEXURE- J)

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 IEC 61850 compliant communications.

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.

1.13.10.3 Optical sensors & temperature measuring unit

1.13.10.3.1 Optical temperature sensors shall be fitted on each Transformer unit. 16 number probes for 3-ph unit shall be provided. The optical sensors measuring system shall be of direct measurement non-calibrating type. All the sensors shall be brought out to separate optical sensor box or in Individual Marshalling Box mounted on transformer tank to facilitate measurement of temperature during service life on each unit.

1.13.10.3.2 In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 16 channels shall be mounted inside the separate optical sensor box or Transformer Marshalling Box for each transformer unit**.** The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

1.13.10.3.3 Temperature measuring unit/system shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system through FO port.

1.13.10.3.4 Location of optical temperature sensors inside the transformer shall be decided during design review.

1.13.10.3.5 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

1.13.10.4 Earthing Terminals

1.13.10.4.1 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.

1.13.10.4.2 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/ Optical Sensor Box 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.

1.13.10.4.3 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 link.

1.13.10.4.4 Earthing terminal: 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 through two (2) separate earthing pits. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

1.13.9.0 Core

1.13.9.1 The magnetic circuit shall be core type. Each limb shall be joined with top and bottom yokes. The laminations shall be made from high grade non-ageing cold rolled grain oriented (CRGO) silicon alloy of **HI -B** grade steel (as per **BIS / IEC**). Indian transformer manufacturers shall use core material as per above specification with BIS certification. Only those bidders who directly imported **CRGO** either from the manufacturer or through their accredited marketing organization of repute (and not through any agent) shall be considered. **In support of this requirement the bidder shall submit an undertaking in specified format (Annexure C) in the form of affidavit on Rs.100/- stamp paper, duly notarized.**

Laminations of one particular thickness i.e., 0.23mm or 0.27mm or better (quoted grade and type) shall be used. Laminations of different grade(s) and different thickness(s) are not allowed to be used in any manner or under any circumstance.

1.13.9.2 The CRGO shall be cut at Mill's authorized Processing unit only.

1.13.9.3 The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under 10% over voltage and maximum ambient air temperature conditions of 50 deg C. Adequate temperature margin shall be provided to maintain the long-life expectancy for this material.

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.

1.13.9.4 Core and winding shall be capable of withstanding the shock during transport, installation and service and adequate provision shall be made to prevent movement of core and winding with respect to tank during these conditions.

1.13.9.5 All steel sections used for supporting the core shall be thoroughly sand / shot blasted after cutting, drilling and welding.

1.13.9.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

1.13.9.7 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.

1.13.9.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.

1.13.9.9 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.

1.13.9.10 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.
1.13.9.11 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.
1.13.9.12 The maximum flux density in any part of the core and yoke at the rated MVA, voltage & frequency shall be such that less than 10% continuous over voltage condition does not exceed 1.9 Tesla.

1.13.9.13 For consideration of over fluxing, the transformer shall be suitable for continuous operation for values of over fluxing at (i) 110% (ii) one minute for 125% and (iii) 5 seconds for 140% of rated voltage.

1.13.9.14 The Transformer shall be of **BOLTLESS** core design. The Bidders will furnish documentary evidence with proof of their experience and performance in such type of design.

1.13.9.15 When bell type construction is offered, suitable projecting guides shall be provided on core assembly to facilitate removal of tank. The supporting framework of core shall be so designed so as to avoid presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

1.13.9.16 Successful Bidder shall furnish calculation towards maximum peak value of magnetizing in-rush current and shall justify that the transformer will not trip due to this during initial charging and subsequent charging.

1.13.9.17 Oil ducts shall be provided where necessary to ensure adequate cooling. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

1.13.9.18 The prime core materials are only to be used. Bidder's should furnish following document as applicable as a proof towards use of prime Core material to be submitted before the stage inspection:

(a) Invoice of supplier
(b) Mill's test certificate

(c) Packing List
(d) Bill of lading
(e) Bill of entry certificate by Custom.
(f) Description of material, electrical analysis, physical inspection, certificate for surface defects, thickness and width of the materials.
(g) Place of cutting of core materials

All parts of the cores shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and service.

1.13.9.19 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.

1.14.0 Windings

1.14.1.0 General

- The manufacturer shall ensure that windings of all transformers are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity-controlled environment with positive atmospheric pressure. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.
- Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.
- 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.

- 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.

- The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

- 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.

- 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.

- The barrier insulation including spacers shall be made from high density precompressed 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.

- 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.

- 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.

- 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. 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.
- Winding paper moisture shall be less than 0.5%.
- **In the case of ICTs with tertiary**, the insulation of LV (Tertiary) winding shall be adequate to withstand surge voltages appearing across them as a result of transfer due to impulse striking on HV or IV terminals. **The transformer shall be suitably designed so that the surges transferred to tertiary winding do not exceed the permissible limits** without the use of any external means such as surge capacitors etc. under any condition. The tenderer shall also state whether the transferred surges could be restricted to 170 KVP without the use of any external means. **The current density of the conductor used for tertiary winding shall not exceed the current density specified for the main winding**/conductor.

- The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices, if necessary, shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.

- **The conductors shall be transposed at suitable intervals in order to minimize eddy current** and to equalize the distribution of current and temperature along the windings.

- The transformer manufacturer should have in house availability of vapour phase Drying (VPD) plant for proper drying of the insulation. In case VPD facility is not available, the bidder will prove that the method of drying adopted by them is equivalent or better than VPD in terms of level of dryness and other benefits of VPD.

1.14.1.1 Bracing of Windings

- The windings and connections of all transformers shall be braced to withstand socks, which may occur during transport or due to switching and other transient conditions during service.

- The winding shall be clamped securely in place, so that they will not be displaced or deformed during short circuit. The assembled core and winding shall vacuum dried and suitably impregnated before removing from the treating tank.

- Coil clamping rings, if provided shall be of steel.

- If the transpose winding is built up of section of disc coils, separated by spacers, the clamping arrangements shall be such that equal pressures are applied to all columns of spacers. All such spacers shall be securely located, shall be of suitable material and shall receive adequate shrinkage treatment before assembly.

- Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

- Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

- Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive, be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.

- Winding and connections shall be braced to withstand shocks during transport or short circuit.

- Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil steel bolts, if used, shall be suitably treated.

- Terminals of all windings shall be brought out of the tank through bushings for external connections.

- The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.

- Coils shall be made of continuous smooth high-grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.

- Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances. The TM is to submit the process at the time of the bid.

- Tappings shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.

- Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

1.14.1.2 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.

1.14.1.3 Winding terminations into bushings

- 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.

- 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.

- 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.

- 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.

- 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.

1.15.0 Transformer Loading

- The limits of temperature rise are given in general technical parameters.

- The transformer shall be capable of remaining in operation at full load without the measured winding hot spot temperature exceeding 150°C for:

    - 10 minutes with complete (i.e.,100%) failure of cooler system.
    - 20 minutes with 50% of cooler system in service.

- The permissible temperature of the top oil shall refer to the specific loading combination for which the total losses are the highest. Individual permissible winding temperature rise shall be considered relative to the specified loading combination which is the most severe for the particular winding under consideration.

1.16.0 Terminal Arrangement

Specific requirement of bushings and their ratings etc. are as per general technical parameters.

1.17.0 Bushings

- The electrical and mechanical characteristics of bushings shall be in accordance with IS: 2099 and IS: 3347 (Part-III/Section-I). Dimensions and requirements of condenser bushings shall be in accordance with IS 12676, 1989.

- Bushings shall be robust and designed for adequate cantilever strength **(Heavy Load of Level-II as per latest revision of IEC 60137)** 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. **Transformer HT and LT Bushings shall be designed to withstand the seismic effect of 0.36g..**

- 420kV, 245kV, 145kV and **72.5kV** 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 **72.5kV**
  Bushings..

  36kV and below voltage class bushing shall be solid or oil communicating type with porcelain housing.

  No arcing horns shall be provided on any bushing.

  (c) Condenser type bushings shall be provided with-

  i) Oil level gauge.
  ii) Oil filling plug and drain valve if not hermetically sealed;
  iii) Tap for capacitance/tan delta measurement.

  (d) 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.

  (e) Where turret type current transformers are specified, the bushings shall be removable without disturbing the current transformers.

  (f) Bushing for voltage of 52 kV and above shall be RIP/RIS bushing with composite polymer insulator. 36 kV and below voltage class bushing shall be solid porcelain or oil communicating type.

  (g) No arcing horns shall be provided on the bushings. Bushing shall be as per technical particulars furnished. Bushings of identical rating shall be interchangeable to optimise the requirement of spares.

  (h) 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. 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.

(i) The terminal marking and their physical position shall be as per IEC: 60076.

(j) Tan delta measurement 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 as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

(k) 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.

(l) Special precaution shall be taken to eliminate moisture from paper insulation during manufacture, assembly, transport and erection.

(m) Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.

(n) To accommodate the bushing current transformers, space provided on the various voltage class bushings shall be as under:

420kV: 400 mm *

245kV: 300 mm *
: 600 mm **

145kV: 100 mm *
: 300 mm **
: 600 mm ***

Note:
*** = for one BCT**
**** = For two BCTs**
***** = For three BCTs**

1.17.1.0 Terminal Connectors

- Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors should have been successfully type tested strictly as per IS: 5561.

- **All connections with ACSR/AAAC conductors shall be Nut and bolt type.**
- Connectors shall be of **electrolytic grade copper forged and silver plated/tinned.** No part of a clamp shall be less than 10 mm thick.

- Non-magnetic stainless-steel nuts, bolts and plain washers shall be used. Nuts and bolts shall have hexagonal head with threads as per IS and shall be fully threaded type. Instead of spring washers, check/lock nuts shall be provided.

- The connectors shall be designed for minimum 120% of the maximum current carrying capacity of the ACSR conductor and the temperature rise under these conditions shall not

be more than 50% of that of the main conductor.

1.17.2.0 Bushing current transformers

- Current transformers shall comply with IS: 2705.
- It shall be possible to remove turret mounted CTs from the transformer tank without removing the tank cover. Necessary precaution shall be taken to minimize the eddy currents and local heat generated in the turret.
- All secondary leads shall be brought to a terminal box near each bushing. These terminals shall be wired up to the Cooler Control Cabinet using separate cables for each core/phase.
- Bushing CT parameters indicated in the specification are tentative and liable to change within reasonable limits. The Bidder shall obtain the Purchaser's approval before proceeding with design of Bushing CTs.

1.17.3.0 Terminal Marking

The terminal marking and their physical position shall be in accordance with IS: 2026 unless otherwise specified.

1.17.4.0 Neutral Formation and Earthing Arrangement

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.

1.18.0 Cooling Equipment and its Control

1.18.1.0 Cooling Equipment for Radiator Bank

- The cooler shall be designed using radiator banks or tank mounted radiators. Design of Cooling system shall satisfy the performance requirements.
- In case of separately mounted radiator bank arrangement, **radiator bank shall generally be placed on left side of the tank while watching from HV side of the transformer**. However, the main tank shall have provision such that cooler banks can be placed on either side of the main tank by simple reconnection without the need of any extra member/pipe maintaining the electrical clearances..

- 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:

    - Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
    - Top and bottom shut off valve
    - Drain Valve and sampling valve
    - Top and bottom oil filling valves
    - Air release plug
    - Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised Steel flats.
    - Thermometer pockets with captive screw caps at cooler inlet and outlet.
    - Lifting lugs: 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.

- 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.

- One number standby fan shall be provided with each radiator bank.

- 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.

- 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.

- 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.

- 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.

- 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.
- 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.

- 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.

1.18.1.1 Cooling Equipment Control for Radiator banks

- 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.

- 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. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

- In addition to the traditional starting of fan and pump by winding & oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds. 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.

- Following lamp indications shall be provided in cooler control cabinet:
    - Cooler Supply failure (main)
    - Cooler supply changeover
    - Cooler Supply failure (standby)
    - Control Supply failure
    - Cooling fan failure for each bank
    - Cooling pump failure for each pump
    - Common thermal overload trip

- 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.

- 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.

- All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Marshalling Box.

- 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 CLAUSE 7.1.2 OF CHAPTER 7.

1.18.1.2 Unit cooler arrangement for transformer (if applicable)

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.

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.

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.

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.

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: 325/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: 4691/IEC: 34-5

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.

Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.

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.

1.18.1.2.1 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.

1.19.0 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 – D**. 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.

1.20.0 Insulating Oil

a) The required transformer oil shall be in the scope of transformer manufacturer.
b) The supplier shall dispatch the transformer filled with Nitrogen. The Bidder shall take care of the weight limitation on transport and handling facility at site. Necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure-testing valve with necessary pressure gauge and adapter valve shall be provided.
c) The quality of the oil supplied with transformer shall conform to the oil parameters specified in this clause.
d) No inhibitors shall be used in the oil.
e) The oil samples will be drawn as follows:
   i) Prior to filling
   ii) Before and after heat run test
   iii) Before energizing

   All tests as per IEC: 60296 shall be conducted on all samples.
f) The insulating oil shall be subjected to testing in the oil manufacturer's works, before supply, in the presence of the representative of AEGCL and the representative of the transformer manufacturer.
g) Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiators at the proper level along with 10% extra oil by weight for topping up shall be supplied in non-returnable containers suitable for outdoor storage.
h) The Bidder shall warranty that characteristic of oil furnished shall comply with the requirements specified in IEC: 60296 with the latest amendment /revision and shall be suitable for EHV grade transformers.

(Note: The color of the barrels in which Naphthenic based transformer oil is to be supplied shall be Red)

Insulating oil shall be unused un-inhibited highly refined naphthenic base oil [not containing Polychlorinated Biphenyls (PCBs)], conforming to IEC 60396-2020 & all parameters specified at Annexure – 4(T) (attached), while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at Annexure – 4(T), prior to despatch of oil from refinery to site. The Unused Un Inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached

at Annexure – 4(T). 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.

1.20.1.0 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.

1.20.1.1 Oil filling

- Procedures for site drying, oil purification, oil filling etc. shall be done as per EMPLOYER Field Quality Plan (FQP).

- 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.

- 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 relays.

- 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.

- 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 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 deg C to 80 deg C.

- The above oil treatment plant (Filtration unit) shall be arranged by the bidder at his own cost.

1.20.2.0 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 / 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.

1.21.0 Valves

- 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.
- Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.
- Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.
- 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.
- All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- 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.
- Valves or other suitable means shall be provided to fix various on-line condition monitoring systems to facilitate continuous monitoring.
- Gland packing/gasket material shall be of “O” ring of nitrile rubber for all the valve’s flanges. All the flanges shall be machined.
- 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.

Sl. 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

- 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.

- 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 **Type Tested design** and 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.
- All hardware used shall be hot dip galvanised/strainless steel.

1.21.2 Cabling

1.21.2.1 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.

Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-M** Contractor shall provide type tested cables from approved sources. No type testing for cables is 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.

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.

1.22.0 Tap Changing Equipment
Each transformer shall be provided with On Load Tap changing equipment as specified elsewhere.

1.22.1.0 ON Load Tap Changing (OLTC) Equipment (Oil type)
1.22.1.1 Main OLTC Gear Mechanism
Each 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.

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.

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.

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.

Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

1.22.1.2 Local OLTC Control Cabinet (Drive Mechanism Box)
Each transformer unit of OLTC gear shall have following features:

- 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.
- 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:
  a. Mechanical tap position indicator which shall be clearly visible from near the transformer.
  b. 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.
  c. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
  d. 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.
  e. The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
  f. 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.

- 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. 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 provided with anti-condensation metal clad heaters to prevent condensation of moisture
  iv. Padlocking arrangement for hinged door of cabinet
  v. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
  vi. The cabinet shall be tested at least IP 55 protection class.

- All relays and operating devices shall operate correctly at any voltage within the limits specified below. 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.

Nominal Voltage	Variation in Voltage	Frequency in Hz	Phase/Wire	Neutral Connection
415 V	+/- 10%	50 +/- 5%	¾ Wire	Solidly earthed
240 V	+/- 10%	50 +/- 5%	½ Wire	Solidly earthed
220 V	190 V to 240 V	DC	Isolated 2 wire system	-
110 V	95 V to 120 V	DC	Isolated 2 wire system	-
48 V	-	DC	2 wire system (+) earthed	-

Note: Combined voltage and frequency shall be limited to +/- 10%

- 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.
- 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.
- 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.
- 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.

- '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.
- 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
  c. Supply to DM Motor fail
  d. OLTC IN PROGRESS
  e. Local / Remote Selector switch position
  f. OLTC upper/lower limits reached
- 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.
- A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

1.22.1.3 OLTC Control from Common Marshalling Box (CMB)

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.

Independent-combined-remote selector switch, raise/lower switch and emergency stop Push Button shall be provided in the common marshalling box for OLTC control.

When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

In '**combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

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.

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.

a) 415V Main AC supply Fail

b) 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.

1.23.0 Digital RTCC Panel

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.

The contractor shall also provide Digital RTCC panel consisting of 1 Nos. Digital RTCC relays. Further, one spare Digital RTCC relay shall also be provided in the same panel. Each digital RTCC relay shall be used to control 1 bank of transformers (i.e., 1 No. 3-Phase unit)

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.

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.

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.

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.

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

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.

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 analysing 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.

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.

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 affected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

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

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.

1.24.0 SCADA Integration and Interconnection

All required power & control cables including optical cable, patch chord (if any) upto MB (for 3-Ph unit) shall be in the scope of contractor. Further, any special cable between MB (for 3-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).

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.

Cooling and OLTC of transformers shall be monitored and controlled from SCADA.

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.

1.25.0 Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box/ Junction Box / Outdoor cubicle and Digital RTCC Panel:

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.

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 hall be at least 450 mm above ground level (for ground mounted panel).

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 –D**.

The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

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.

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.

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.

1.26.0 Current Transformer

Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 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.

Current transformer secondary leads shall be brought out to a weather proof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

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.

Secondary resistance and magnetising current characteristics of PX class (protection) (as per IEC) CT of same rating shall be similar. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

1.27.0 Hand Tools:

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.

1.28.0 Test Kit:

BDV Kit as per Annexure-N of specification.
Portable DGA Kit as per Annexure-O of Specification.

1.29.0 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:

- 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.

- Oil preservation equipment, Thermosyphon filter with valves.
- Pressure relief devices including canopy with special shroud to direct oil
- Sudden pressure relief relay including canopy.
- 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)
- Air release plug
- Conservator air cell rupture detection relay
- Inspection openings and covers
- Bushing of each type with metal parts and gaskets to suit the termination arrangement
- Winding & Oil temperature indicators
- Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs
- Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator as applicable
- Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus
- Roller Assembly (as per clause 1.10.1.6)
- On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable
- Cooling equipment
- Bushing current transformers, Neutral CT (if applicable)
- Oil flow indicators (if applicable)
- Terminal marking plates
- Valves schedule plate & All the valves as per clause 1.13.1.1.4, 1.13.1.1.7 and 1.21.1.
- **Valves List**: 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 Transformer 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, Flow sensitive conservator Isolation valve, Valve for UHF sensors, valves for NIFPS system etc.
- 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.
- 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.
- Haulage lugs
- Neutral bus connection arrangement. (3-Phase Transformer)

- Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & IV terminals.
- On line insulating oil drying system.
- Online Dissolved Gas (Multi-gas) and Moisture Measuring Equipment
- On line dissolved Hydrogen and Moisture Measuring Equipment
- Fibre optic sensor-based temperature measuring system.
- Nitrogen Injection Type Fire Prevention & Extinguishing System.
- Automatic Mulsifire System (or High Velocity Water Spray System)
- RTCC 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 panel/ employer's C&R panel.
- Managed Ethernet switch, LIU patch cords etc. shall be provided in CMB/MB. All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

1.30.0 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.

1.31.0 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-H & Annexure-I".** All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-H".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

1.32.0 Type Tests on fittings:
Following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with drawings and GTP of the equipment / fittings.

1) Bushing (Type Test as per IEC:60137 including Snap back & Seismic test for 400 kV and above voltage class bushing)
2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)
3) Buchholz relay
4) OTI & WTI
5) Pressure Relief device Test (including IP 55 test in terminal box)
6) Sudden Pressure Relay Test (including IP 55 test in terminal box)
7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016
9) Marshalling & common marshalling box and other outdoor cubicle (IP-55 test)
10) RTCC (IP-43)

1.33.0 Pre-Shipment Checks at Manufacturer's Works

Check for inter-changeability of components of similar transformers for mounting dimensions.

Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

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 5g to 10g.

Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

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.

1.34.0 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.

1.35.0 Receipt and Storage Checks

Check and record condition of each package, visible parts of the transformer etc. for any damage. Check and record the gas pressure in the transformer tank as well as in the gas cylinder. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

1.36.0 Installation Checks

Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc. Check the direction of rotation of fans and pumps and check the bearing lubrication. Check whole assembly for tightness, general appearance etc.

Oil leakage test.

Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

Leakage check on bushing before erection.

Measure and record the dew point of gas in the main tank before assembly.

1.37.0 Commissioning Checks

Check the colour of silicagel in silicagel breather. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

Check the bushing for conformity of connection to the lines etc.
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

Check for the adequate protection on the electric circuit supplying the accessories.
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

Check for cleanliness of the transformer and the surroundings.

2 kV for 1-minute test between bushing CT terminal and earth.
Phase out and vector group test.
Ratio test on all taps.

Magnetising current test.
Capacitance and Tan delta measurement of winding and bushing.
Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

DGA of oil just before commissioning and after 24 hours energisation at site.
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.

Continuously observe the transformer operation at no load for at least 24hours.
Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures forward to Purchaser for future record.

1.38.0 NITROGEN INJECTION TYPE FIRE PREVENTION & EXTINGUSHING SYSTEM

Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer tank and the fire during internal faults resulting from arc and also to extinguish the external oil fires on transformer due to tank explosion and/or external failures like bushing fires, OLTC fires and fire from surrounding equipments, etc.

The system shall work on the principle of Drain & stir. On activation, it shall drain a predetermined 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.

NIFPS system shall be supplied with operating curves indicating the actuation time of various sensors and nitrogen injection. For NIFPS system, probes and sensor locations shall not be placed inside the transformer.

1.38.1.0 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:

1.38.1.1 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 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.

1.38.1.2 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.

1.38.2.0 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 Nitrogen regulator 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.

1.38.3.0 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 AEGCL.
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 Data Sheet. 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

1.38.4.0 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 drain pipe 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

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.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

Detailed specification of Nitrogen Injection Type Fire Protection System (NIFPS) shall be as per **Annexure-R.**

1.39.0 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, water proof, epoxy coated (from Inside) mild steel (minimum thickness 6 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per Clause 1.16.0. 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 rain water. The design of tank and pit shall be finalized during detailed engineering. **All underground oil and gas storage tanks design shall be certified by petroleum and explosive safety organisation, Nagpur, India.**

1.39.1.1 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.

1.39.1.2 Online Insulating oil drying system

On-line insulating oil drying system (Cartridge type) along with all required accessories shall be provided with each transformer. 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 tank/cooler bank mounted and no separate foundation shall be provided. 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.

(ii). The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system. The moisture in inlet & outlet oil (PPM) shall have to be displayed in Local SCADA besides local HMI.

(iii). 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.

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.

Addition detailed specification of On-line insulating oil drying system shall be as per **Annexure-Q**

1.40.0 On Line Dissolved Hydrogen and Moisture Monitor

The Monitor shall be a microprocessor based Intelligent Electronic Device (IED), designed to continuously detect and measure dissolved Hydrogen and Water content, even at very low concentrations, in Transformer Oil. It should be easy to install and it should be possible to retrofit it on an energized transformer, without shutting down the transformer.

The monitor shall be designed for permanent outdoor use in high voltage sub-station environments, for ambient temperatures of 0 deg C to 55 deg C and oil temperatures of 5 deg C to 105 deg C.

The monitor shall be suitable to detect and measure dissolved Hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall also be suitable to detect Water Content measured in ppm.

The Hydrogen sensors shall have long lifetime in oil. The sensors shall be able to withstand pressure from vacuum to 10 psi.

1.40.1.0 Technical Parameters:

Sr. No.	Parameters	Requirements
1	**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
2	**Alarms/Indication (High & Very High)**	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
3	**Environment**	
	Operating Ambient Temperature	0 to + 55 deg C
	Operating Oil Temperature	5 to + 105 deg C
	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
4	Exterior enclosure and components	made of corrosion proof material to IP - 55
5	Communications	RJ45/RS–232 ports and suitable for Ethernet connectivity

Addition detailed specification of On-Line Dissolved Hydrogen and Moisture Monitor shall be as per **Annexure-P**

1.41.0 Condition Controlled Maintenance Free Type Breather

The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel **(Colour: Orange)** Breather which shall be equipped with a humidity sensor, a condition-based microprocessor control unit and LED status indication.

1.41.1.0 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 colourless, moisture absorbing 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.

1.41.1.1 Technical Features:

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 0° C to +80° C.

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).

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.

Control unit shall be equipped with a USB / RS 485 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.

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.

The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment.

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.

The control unit shall be equipped with suitable heater to prevent moisture condensation.

The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

For OLTC conservator, conventional breather shall be supplied as per technical specification.

Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.

Addition detailed specification of Condition Controlled Maintenance Free Type Breather shall be as per **Annexure-U**

1.42.0 Automatic Mulsifire System (or High Velocity Water Spray System)

1.42.1.0 Description:

This system is widely used for firefighting of outdoor transformers. Spray type fire protection essentially consists of a network of projectors and an array of heat detectors used to sense high temperature near the transformer to be protected. If the temperature exceeds the set value, the automatic mulsifire system sprays water at high pressure through a Deluge valve from the pipe network laid for this system. Fire detectors located at various strategic points are on the surface of the transformer to control fire on any burning oil spilled over.

1. 43.1.1 Subsystems used to make a complete mulsifire system:

a) Main Hydrant

The main hydrant system shall be designed based on NFPA-16. This is used to carry the water to various parts of the switchyard ot transformer substation and forms the backbone of the system. Sturdy corrosion-free pipes and valves are used for this purpose. The materials should be able to withstand fire for a withstand fire for a reasonable duration.

b) Fire Detector

Fire detectors can either be thermocouples or specially designed bulbs which burst when they experience a high temperature and release any valves or checking device to start the water supply.

c) Ring Mains and Nozzles

Ring mains, which surround the transformer are provided to feed the water to the nozzles at various levels. Since the water pressure is high, the ring mains should be designed to withstand this pressure. Nozzles should be located such that the water spray, in the event of a fire, envelopes the entire surface of the transformer. The whole system should be periodically checked to detect any leakages.

Pumps

Pumps are provided to fill the hydrants initially and to maintain its pressure. Pumps driven by electrical motors are a standard provision; however, the standby pumps should preferably be diesel engine driven. It is recommended that the main and standby pumps in a pump house be segregated.

1.43.1.2 Electrical Safety

As per IEEMA specification, from safety considerations, the following electrical clearances are recommended between the mulsifier system pipe work and live parts of the transformer to be protected.

- 420 kV bushing 3500 mm
- 245 kV bushing 2150 mm
- 145 kV bushing 1300 mm
- 52 kV bushing 630 mm
- 36 kV bushing 320 mm

1.43.1.3 Installation Care

- Deluge Valve shall be water pressure operated manual reset type.
- Each Deluge valve shall be provided with a local panel from which will enable manual electrical operation of the valve.
- In addition to this, each valve shall be provided with local operation latch.

- Test valves shall simulate the operation of Deluge valves and shall be of quick opening type.

1.44.0 Transformer – Connection to GIS:

Transformer connection enclosure shall be part of gas insulated metal enclosed switchgear which shall house one end of a completely immersed bushing fitted on a power transformer and main circuit end terminal of GIS. The transformer connection enclosure shall be designed as per the recommendations of IEC 62271-211 and the limit of supply of switchgear manufacturer and the transformer manufacturer shall also be as per the scope mentioned in the IEC. The switchgear manufacturer shall supply connection between the enclosures of different phases as per requirement to limit the circulating current in the transformer tanks. The manufacturer of the connection enclosure shall take into account the total dynamic forces generated during short circuit and the enclosure as well as bushings shall be capable of withstanding vacuum during evacuation process. The switchgear manufacturer shall make necessary arrangement to limit the very fast front transient ground potential rises which may occur during switching operation. The detailed scope of transformer manufacturer and GIS manufacturer as per IEC 62271-211.
Suitable spring bellows shall be provided on the connecting GIS busduct at suitable location to prevent any vibration generating from transformer to GIS busduct.

1.45.0 CENTRE OF GRAVITY:

The center of gravity of assembled transformer shall be as low and as near the vertical center line as possible. The transformer shall be stable with and without oil. The location of the center of gravity, relative to track shall be clearly marked in the outline drawing, accompanying bid.

Annexure – A 1.0

Technical Particulars / Parameters of Transformers (500MVA [3 phase] 400/220/33 kV, Auto Transformer): Annexure-2(T) (Attached)

ClauseNo.	Description	Unit	Technical Parameters
1.1	Rated Capacity		
	HV	MVA	500
	IV	MVA	500
	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)
1.5	Applicable Standard		IEC 60076 / IS 2026
1.6	Cooling		ONAN / ONAF / OFAF or ONAN / ONAF / ODAF

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 50 deg 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	kVp	1300
	IV	kVp	950
	LV	kVp	250
	Neutral	kVp	95
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1430
	IV	kVp	1045
	LV	kVp	275
iii)	Switching Impulse withstand Voltage		
	HV	kVp	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	570

	IV	kVrms	395
	LV	kVrms	95
	Neutral	kVrms	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	72.5
	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	kVp	1425
	IV	kVp	1050
	LV	kVp	325
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	695
	IV	kVrms	505
	LV	kVrms	155
	Neutral	kVrms	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	2248
	Neutral	mm	1116
vii)	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	LV	pC	10
	Neutral		-
1.23	Max Partial discharge level at 1.58 * Ur /	pC	100

	√3		
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		Same for constant ohmic And constant percentage type
i)	Max. No Load Loss at rated voltage and frequency	kW	90
ii)	Max. Load Loss at rated current and frequency at75°C between HV and IV windings, at principal tap position	kW	500
iii)	Max. I2R loss at rated current and at 75°C for HV and IV at principal tap	kW	375
iv)	Max. Auxiliary Loss at rated voltage and frequency	kW	15

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 are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 2.0

1.0 Technical Particulars / Parameters of Transformers
(220/132/33 kV 160 MVA & 200 MVA 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° 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
	LV	kVp	540
ii)	Chopped wave lightning impulse withstand voltage		
	HV	kVp	750
	LV	kVp	540
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)	Tan delta of bushing at ambient temperature	%	≤0.5	
vi)	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to theline-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 ofTransformers**		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 are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 3.0

Technical Particulars/Parameters
(132/33 KV, 3-Phase 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 ambienttemperature	^{O}C	50
7.21	Windings		
i)	Lightning Impulse withstand Voltage		
	HV	kVp	650
	LV	kVp	170
	HV Neutral	kVp	95
	LV Neutral	kVp	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	715
	LV	kVp	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	540
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	275
	LV	kVrms	70
	HV Neutral	kVp	38
	LV Neutral	kVp	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	kVp	650		
	LV, HV Neutral and LV Neutral	kVp	170		
iv)	One Minute Power Frequency withstand Voltage				
	HV	kVrms	305		
	LV, HV Neutral and LV Neutral	kVrms	77		
	Tan delta of bushing at ambient temperature	%	≤0.5%		
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 Um 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 75O C at principal tap between HV & LV**	kW	**200**	**125**	**110**
iii)	**Max. I2R Loss at rated current and frequency and at 75O 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, percentage impedance, OLTC connection & range, vector group and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. External minimum clearances in air for Phase to Phase and Phase to Earth shall be providedas per IS 2026 (Part 3) / IEC60076-3

Annexure – A 4.0

Technical Particulars/Parameters
(220/33 KV, 100 MVA 3-Phase 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
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	kVp	950
	LV	kVp	170
	HV Neutral	kVp	95
	LV neutral	kVp	170
ii)	Chopped Wave Lightning Impulse Withstand Voltage		
	HV	kVp	1045
	LV	kVp	187
iii)	Switching Impulse withstand Voltage		
	HV	kVp	750
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	395
	LV	kVrms	70
	HV Neutral	kVrms	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	kVp	1050
	LV	kVp	170
	HV Neutral	kVp	170

	LV neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	850
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	505
	LV	kVrms	77
	Neutral	kVrms	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 Um		
	HV	pC	10
6.22	Max Partial discharge level at 1.58 * Ur / √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°C for HV and LV windings at principal tap position	kW	245
iii)	Max. I2R Loss at rated current and at 75° 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, percentage impedance, OLTC connection & range, vector group and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**
5. 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

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-C

UNDERTAKING

We, M/s. ---------- , have participated in Tender No. ---------- for supply of:

1) -------- kV class -------- MVA Auto/Power Transformers
2) -------- kV class -------- MVA Auto/Power Transformers
3) -------- kV class -------- MVA Auto/Power Transformers
4) -------- kV class -------- MVA Auto/Power Transformers

to AEGCL.

In accordance with the terms of the said tender, we hereby undertake that we shall use imported prime CRGO steel lamination and not the second grade CRGO steel lamination for the manufacturing of the transformers against this Tender. Further, we shall produce the following documents at the time of inspection of transformers:

a) Invoice of supplier
b) Mill's Test Certificate issued by Customs
c) Packing list
d) Bill of lading
e) Bill of entry Certificate issued by Customs.

Signature of the Tenderer :

Name :

Designation :

Seal of the Company :

(On Rs 100/- stamp paper duly notarized)

Annexure – D
Painting Procedure

PAINTING	Surface Preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank,	Shot Blast	Epoxy	Epoxy high	Aliphatic	Minimum	RAL 7035

pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	cleaning Sa 2 ½*	base Zinc primer (30-40µm)	build Micaceous iron oxide (HB MIO) (75µm)	polyurethane (PU) (Minimum 50µm)	155µm	
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	--	--	--	--
Digital RTCC Panel	Seven tank process as	Zinc chromate	--	EPOXY paint with PU top	Minimum 80µm / for	RAL 7035 shade for

	per IS:3618	Primer		coat or POWDER	powder coated	exterior and Glossy
	& IS:6005	(two coats)		coated	minimum 100µm	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

RATING & DIAGRAM PLATE

The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in indelibly marked.

Minimum Information to be provided on the plate:

Manufacturer's name, country and city where the transformer was assembled					
MVA Rating, Voltage ratio, Type of transformer (for example 315MVA 400/220/33kV Auto Transformer)					
Type of Cooling			Applicable Standard		
Rated Power at different cooling			Rated frequency	Hz	
HV/IV	MVA	--/--/--	Number of phases		
LV	MVA		% Impedance / Ohmic Impedance		
Rated Voltage			(a) HV-IV		
HV	kV		Min. tap	%	
IV	kV		Principal Tap	%	
LV	kV		Max. Tap	%	
Rated Current			(b) HV-LV	%	
HV	A		(c) IV-LV	%	
IV	A		Vector Group		
LV	A		Core mass	kg	
Rated Thermal Short Circuit withstand	kA (sec)		Copper Mass		
capability Current and Duration					
Basic Insulation Level (Lightening Impulse/Switching Impulse/Power Frequency Withstand Voltage)			(a) HV	Kg	
HV	kVp/ kVp/ kVrms		(b) IV	Kg	
IV	kVp/ kVp/ kVrms		(c) LV	Kg	

LV	kVp/ kVp/ kVrm s		(d) Regulating	Kg	
Neutral	kVp/ kVp/ kVrm s		Core & Coil Mass	Kg	
Guaranteed Temperature rise over ambient temperature of 50 Deg. C			Transportation Mass	Kg	
(a) Top Oil	0C		Tank & Fitting mass		
(b) Winding	0C		Type & total mass of insulating oil	Kg	
Vacuum withstand Capability of the tank	mm of Hg		Total mass	Kg	
OLTC make and rating (current & Voltage class)			Quantity of oil in OLTC	Ltrs	
Noise level at rated voltage and at principal tap	dB		Transformer oil Quantity	Ltrs	
Tan delta ofwinding			Paint Shade		
Moisture content	ppm		No load loss at rated voltage & frequency	KW	
Manufacturer's Serial number			Load loss at ratedcurrent & frequency (at75^0C) for HV & IV/LVwinding	KW	
Year of manufacture			I^2R loss at rated current & frequency (at 75^0C) for HV & IV/LV winding	KW	
Work Order No.			Auxiliary loss at rated voltage & frequency	KW	

Purchaser's Order No. & Date					
OGA Drg. No.					
Vector Group Diagram					
Winding Connection diagram (Connection between all windings including tap windings, ratings of built-in current transformers, etc. shall be presented on the diagram)					
Table giving details of OLTC like tap position Nos. and corresponding tapping voltage, tapping current & connection between terminals for different tap positions etc.					
Details of Current Transformers (e.g. Bushing CTs, CT for WTI) installedin transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximumCT secondary resistance, terminal marking and application of the current transformer					
Warning: "Main conservator is fitted with an air cell"					
Tie-in-resistor has been used in OLTC (if applicable)					
Purchaser's Name					

When a transformer is intended for installation at high altitude, the altitude, power rating and temperature rise at that altitude shall be indicated on the nameplate.

Plates with identification and characteristics of auxiliary equipment according to standards for such components (bushings, tap-changers, current transformers, cooling equipment etc.) shall be provided on thecomponents themselves.

Annexure- G

1.0 Bushing Current Transformer and Neutral Current Transformer Parameters (On each phase) for 3-ph, 500MVA 400/220/33 kV Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**		
	HV Side	IV Side	Neutral Side

Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	-
CORE 3	Refer to note 1		
Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, PX / PS	1600V, PX / PS	1600V, PX / PS
CORE 2	0.2S Class 20VA ISF≤5	0.2S Class 20VA ISF≤5	-
CORE 3	Refer to note 1		
Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	-
CORE 3	Refer to note 1		
Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
CORE 3	Refer to note 1		
Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	-
CORE 3	Refer to note 1		

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 Technical Parameters of Bushing Current Transformers and Neutral Current Transformers for 160MVA 220/132 kV 3-Ph Transformers:

Description	**Bushing 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	-
CORE 3	Refer to note 1		
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	600V, PX / PS	600V, PX / PS	600V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	0.2S Class 15VA ISF ≤ 5	-
CORE 3	Refer to note 1		
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
CORE 3	Refer to note 1		
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
CORE 3	Refer to note 1		
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-
CORE 3	Refer to note 1		

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 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 50 MVA 132/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	1000/1	1000/1
CORE 2	300/1	300/1	1000/1	1000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	1000V, PX / PS	1000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	1000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm
CORE 3	Refer to note 1			
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth fault	Metering	Restricted Earth Fault
CORE 3	Refer to note 1			

(e)Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
CORE 3	Refer to note 1			

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 Technical Parameters of Bushing Current Transformer and Neutral Current Transformer for 100 MVA 220/33 kV 3-Ph Transformers:

Description	**Bushing Current Transformer Parameters (Transformer)**			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(a) Ratio				
CORE 1	300/1	300/1	2000/1	2000/1
CORE 2	300/1	300/1	2000/1	2000/1
CORE 3	Refer to note 1			
(b)Minimum knee point voltage or burden and accuracy class				
CORE 1	600V, PX / PS	600V, PX / PS	2000V, PX / PS	2000V, PX / PS
CORE 2	0.2S Class 15VA ISF ≤ 5	600V, PX / PS	0.2S Class 15VA ISF ≤ 5	2000V, PX / PS
CORE 3	Refer to note 1			
(c)Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	1.5 Ohm	-	1.5 Ohm

CORE 3	Refer to note 1			
(d)Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Restricted Earth Fault	Metering Fault	Restricted Earth Fault
CORE 3	Refer to note 1			
(e)Maximum Magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	100 mA	100 mA
CORE 2	-	100 mA	-	100 mA
CORE 3	Refer to note 1			

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.

Annexure- H

Test Procedures

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 unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) assembled.

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 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 kV (DC) for 1 minute. Insulation resistance shall be minimum 1 GΩ for all cases mentioned above.

2. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 hr, 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.

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.

3. No-load loss and current measurement

As per IEC 60076-1:2011 clause 11.5

4. 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).

5. Short term 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

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.

6. Temp. Rise Test as per IEC: 60076

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.

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.

3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (Max MVA).

The Contractor before carrying out such 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 results 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.

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.

i. Test conditions for temperature rise test:

- This test shall be generally carried out in accordance with IEC 60076-2

- For each cooling combination with cooler bank, tests shall be done on the maximum current tap 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.

- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

- Purchaser's order number and transformer site designation.
- Manufacturer's name and transformer serial number.
- Rating of transformer
- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30-minute intervals:

- Time
- Voltage between phase

- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes) (if applicable)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every four hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/OFAF).

Notes: The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long-life expectancy.

v. Winding temperature rise test

- Record the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half-hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information;
  a) Time after shut- down:
  b) Time increment:
  c) Winding resistance: At least 20 minutes reading
  d) Resistance increment:
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

7. Dielectric Tests

Following Test shall be performed in the sequence given below as per IEC 60076-3:2013 clause 7.2.3 shall be followed:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Induced voltage test with partial discharge measurement (IVPD)

8. Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse:

Following tests shall be carried out with applying 20% to 80% of rated Impulse & Switching impulse (upto 60% for IV, Sr. No. 7 & 8 of below table) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

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
5	FW	2.1	1.1, N & 3.2	-	3.1
6	FW	2.1	1.1, N & 3.1	-	3.2

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap.

Where 1.1 : HV Terminal
2.1 : IV Terminal
3.1 & 3.2 : LV or Tertiary Terminal

Acceptance criteria

Transfer surge at Tertiary should not exceed 250kVp at any conditions for 400kV Voltage class Transformer. For other transformer it shall be below the impulse level of LV winding.

9. Chopped wave & full wave lightning impulse test for the line terminals (LIC & LI) and Switching impulse test

Chopped wave lightning impulse and switching impulse test shall be performed at normal and extreme taps on Unit-1, Unit-2 and Unit-3 respectively for 1-Ph unit, otherwise R ph, Y Ph and B Ph respectively for 3-Ph unit. All the parameters as per IEC shall be mentioned in the report.

10. 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 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.

11. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or 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 and 1 hour for air during which no leakage shall occur.

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. 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 (in mm)	Permanent deflection of flat plate (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.

12. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV 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. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

13. Routine test on bushings shall be done as per IEC 60137.

Annexure - I

Test Plan

No.	Test	132 ≥ Um ≤ 170kV	U_m > 170kV
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
10.	Induced voltage withstand test (IVW)	Routine	-
11.	Applied voltage test (AV)	Routine	Routine
12.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
13.	On-load tap changer test (Ten complete cycle before LV test)	Routine	Routine
14.	Gas-in-oil analysis	Routine	Routine
15.	Core assembly dielectric and earthing continuity test	Routine	Routine
16.	Oil leakage test on transformer tank	Routine	Routine
17.	Appearance, construction and dimension check	Routine	Routine

18.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
19.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
20	Frequency Response analysis (Soft copy of test report to be	Routine	Routine
	submitted to site along with test reports)		
21.	High voltage with stand test on auxiliary equipment and wiring after Assembly	Routine	Routine
22.	Tank vacuum test	Routine	Routine
23.	Tank pressure test	Routine	Routine
24.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	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	Type	Type

ANNEXURE J

PT 100 Resistance (Temperature Vs Resistance)
(BS 1904: 1984 & IEC 751: 1985)

TEMP °C	RESISTANCE (OHMS)		
	LOW	NOMINAL	HIGH
0	99.88	100.00	100.12
10	103.76	103.90	104.04
20	107.63	107.79	107.95
30	111.49	111.67	111.85
40	115.35	115.54	115.73
50	119.19	119.40	119.61
60	123.01	123.24	123.47
70	126.82	127.07	127.32
80	130.62	130.89	131.16
90	134.42	134.70	134.98
100	138.20	138.50	138.80
110	141.97	142.29	142.61
120	145.72	146.06	146.40
130	149.46	149.82	150.18
140	153.21	153.58	153.95
150	156.92	157.31	157.70

PT 100 (Temperature Vs Output Signal)
Temperature Range: 0 - 150 ^{O}c
Signal Range: 4-20 mA

TEMPERATURE °C	NOMINAL RESISTANCE (OHMS)	OUTPUT SIGNAL RANGE (4 - 20mA)		
		LOW	NOMINAL	HIGH
0	100.00	3.800	4.000	4.200
10	103.90	4.867	5.067	5.267
20	107.79	5.933	6.133	6.333
30	111.67	7.000	7.200	7.400
40	115.54	8.066	8.266	8.466
50	119.40	9.133	9.333	9.533
60	123.24	10.200	10.400	10.600
70	127.07	11.266	11.466	11.666
80	130.89	12.333	12.533	12.733
90	134.70	13.399	13.599	13.799
100	138.50	14.466	14.666	14.866
110	142.29	15.533	15.733	15.933
120	146.06	16.599	16.799	16.999
130	149.82	17.666	17.866	18.066
140	153.58	18.732	18.932	19.132
150	157.31	19.800	20.000	20.200

ANNEXURE - K

Online Dissolved Gas (Multi-gas) and Moisture Analyser

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 have facility 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 Steel enclosure, 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.

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

LIST OF TESTING EQUIPMENT

Sr. No.	Testing Equipment	Make & Model *
1	Automatic Transformer Oil BDV Testing Kit	DTA-100C (BAUR), OTS100AF-UKU-PX (Megger)
2	Oil Storage Tank (With Wheels)- 20kL Capacity	VPI / CEE DEE VACUUM / SICORP
3	Stainless Steel Oil sampling bottle (One Litre Capacity)	SCIENO TECH 1 litre
4	Syringes for sampling oil	Tomopol (Industrial Grade)

**** Bidder may offer equivalent or superior testing equipment.***

ANNEXURE - M

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from reputed 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.

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 plus or minus 2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC (70°C) insulated 1100V grade power cables s hall be of FR type, C1 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 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 multi core cables. For multi core 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. The contractor can used copper cable of required size.

1.14 PVC Control Cables

1.14.1 The 1100V grade control cables shall be of FR type C1 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 to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer 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 forvarious conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 secduration 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	

Sr. No	Description	Parameters	
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 oC	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15 a	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 ofcable (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 ofproject)	

Sr. No	Description	Parameters
17	Whether progressive sequential marking on outersheath 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 c x 70	3.5 c x 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 conductortemp. of 70 deg C of PVC Cables [For information only]	202	105	70	41	24	28
7	Rating factors applicable to thecurrent 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	shapedconductor	shaped condu	shaped condu	Non-compacted	Non-compacted

		Stranded circular		ctor	ctor	Stranded circular	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 20oC 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 roundarmour 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 infoonly	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 forsteel					
g)	g) DC resistance at 20 °C (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 at27oC	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 oxygenindex	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 drumfor 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

Sl. No	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 orunearthed system	for both							

6	Continuous current rating when laid in air in a ambient temp. of 50oCand 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 IS8130/84)							
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 overthe 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 ofcable (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 offeredare ISI marked	YES
20	Whether Cables offered are suitable for laying asper IS 1255	YES

$'- As per manufacturer design data

ANNEXURE-N

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 months 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.

ANNEXURE - O

Technical Specification of Portable Dissolved Gas Analysis of Oil (If specified in BPS)

Sl.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.
04	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

05	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.
06	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-50 Deg. C 02. 85% non-condensing 03. Portable
07	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.
08	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.
09	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

ANNEXURE - P

On Line Dissolved Hydrogen and Moisture Monitor

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 Steel enclosure, 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:

i) Fault indication
ii) IEEE, IEC or user configurable levels of dissolved gases
iii) 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:

Software

i) Operation Manual (2 set for every unit),
ii) Software Manual and
iii) 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 - Q

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.

iv. 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.

v. 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.

vi. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vii. 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.

viii. 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.

ix. 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 - R

Nitrogen Injection Type Fire Prevention & Extinguishing System

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 AEGCL.

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 (30-40□m)	Epoxy high build Micaceous iron oxide (HB MIO) (75□m)	Aliphatic polyurethane (PU) (Minimum 50□m)	Minimum 155□m	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-S

Oil sampling bottles

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, 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 fingertip 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 - T

Oil Storage Tank

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 deg 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 deg. 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 – U

Condition Controlled Maintenance Free Type Breather

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.

Annexure-V

LIST OF CODES/STANDARDS/REGULATIONS/PUBLICATIONS

A list of Codes/Standards/Regulations/Publications which shall be used fordesign review, manufacturing, testing, erection, transportation etc. has been given below. In case of revision/amendment of these, revised/amended versions shall be followed.

IS 2026: Part 1 : 2011 (Reaffirmed Year : 2016)	-	Power transformers: Part 1 General
IS 2026: Part 2 : 2010 (Reaffirmed Year : 2020)	-	Power transformers Part 2 Temperature-rise
IS 2026: Part 3 : 2018	-	Power Transformers Part 3 InsulationLevels, Dielectric Tests and ExternalClearances in Air (Fourth Revision)
IS 2026: Part 4 : 1977 (Reaffirmed Year : 2016)	-	Power transformers: Part 4 TerminalImarking, tappings and connections
IS 2026 : Part 5 : 2011 (Reaffirmed Year : 2016)	-	Power Transformers Part 5 Ability toWithstand Short Circuit
IS 2026 : Part 6 : 2017	-	Power Transformers Part 6 Reactors
IS 2026 : PART 7 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers Part 7 Loading Guidefor Oil-Immersed Power Transformers

IS 2026 : Part 8 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 8 Applications guide
IS 2026 : Part 10 : 2009 (Reaffirmed Year : 2019)	-	Power Transformers : Part 10 Determinationof sound levels
IS 2026 : Part 10 : Sec 1 : 2018	-	Power Transformers part 10 Determinationof Sound Levels Section 1 Application guide
IS 2026 : Part 14 : 2018	-	Power Transformers Part 14 Liquid- Immersed Power Transformers Using High- Temperature Insulation Materials
IS 2026 : Part 18 : 2018	-	Power Transformers Part 18 Measurement of Frequency Response
IEC 60076 All parts	-	Power Transformers
IS 3024 : 2015	-	Grain Oriented Electrical Steel Sheet and Strip (Third Revision)
IS 8468 : Part 1 : 2018 IEC 60214-1 : 2014	-	Tap-Changers Part 1 Performance Requirements and Test Methods (First Revision)
IEC / IEEE 60214- 2:2019		Tap-changers- Part 2: Application guidelines
IS 8478 : 1977 (Reaffirmed Year : 2016)	-	Application guide for on-load tap changers
IS 649 : 1997 (Reaffirmed Year : 2018)	-	Methods for testing steel sheets for magnetic circuits of power electrical apparatus
IS-10028 (Part 1, 2 & 3)	-	Code of practice for selection, installation & maintenance of transformer
IS 3639 : 1966 (Reaffirmed Year : 2016)	-	Fittings and Accessories for Power Transformers
IS 3637 : 1966 (Reaffirmed Year : 2016)	-	Gas Operated Relays
IS 335 : 2018	-	New Insulating Oils — Specification (Fifth Revision)
IEC 60296-2020	-	Fluids for electrotechnical applications – Mineral insulating oils for electrical equipment

IEC 60422 : 2013	-	Mineral insulating oils in electrical equipment - Supervision and maintenance guidance
IS 6792 : 2017	-	Insulating Liquids - Determination of the Breakdown Voltage at Power Frequency - Test Method (Second Revision)
IS/IEC 60137 : 2017	-	Bushings for alternating voltages above 1000 Volts
IS 12676 : 1989 (Reaffirmed Year : 2016)	-	Oil Impregnated Paper Insulated Condenser Bushings - Dimensions and Requirements
IS 4257 : Part 1 : 1981 (Reaffirmed Year : 2019)	-	Dimensions for Clamping Arrangements for Porcelain Transformer Bushings - Part I : For 12 kV to 36 kV Bushings
IS 4257 : Part 2 : 1986 (Reaffirmed Year : 2019)	-	Dimensions for clamping arrangements for porcelain transformer bushings: Part 2 For 72.5 kV and 123 kV bushings
IS 8603 : 2008 (Reaffirmed Year : 2019)	-	Dimensions for porcelain transformers bushings for use in heavily polluted atmospheres 12/17.5kV, 24kV and 36kV
IS 8603 : Part 4 : 2003 (Reaffirmed Year : 2019)	-	Dimensions for Porcelain Transformer Bushings for Use in Heavily Polluted Atmospheres - Part 4 : 52 kV Bushings
ANSI-C57.12.80	-	General requirements for Distribution, Power and Regulating Transformers
ANSI-C57.12.90	-	Test Code for Distribution, Power and Regulation Transformers
NEMA-TR-1	-	Transformers, Step Voltage Regulators and Reactors
IS 1747 : 1972 (Reaffirmed Year : 2016)	-	Nitrogen
IS-5: 2007	-	Colours for Ready Mixed Paints and Enamels
IS 3043 : 2018	-	Code of Practice for Earthing
IS 8263 : 2018	-	Radio Interference Test on High -Voltage Insulators (First Revision)
IS 8269 : 1976 (Reaffirmed Year : 2014)	-	Methods for switching impulse tests on high voltage insulators

IS 2071 : Part 1 : 2016	-	High-voltage Test Techniques Part 1 General Definitions and Test Requirements (Third Revision)
IS 16803 : 2018	-	High Voltage Test Techniques - Measurement of Partial Discharges by Electromagnetic and Acoustic Methods
IS/IEC 60270 : 2000 (Reaffirmed Year : 2016)	-	High — Voltage Test Techniques — Partial Discharge Measurements
IS 13235 : Part 1 : 2019	-	Short-Circuit Currents — Calculation of Effects Part 1 Definitions and Calculation Methods (First Revision)
IS 13235 : Part 2 : 2019	-	Short-Circuit Currents — Calculation of Effects Part 2 Examples of Calculation (First Revision)
IS 16227 : Part 1 : 2016 IEC 61869-2 : 2007	-	Instrument Transformers: Part 1 General requirements
IS 16227 : Part 2 : 2016 IEC 61869-2 : 2012	-	Instrument Transformers Part 2 Additional Requirements for Current Transformers
IS 16227 : Part 100 : 2018	-	Instrument Transformers Part 100 Guidance for Application of Current Transformers in Power System Protection
IS/IEC 60529 : 2001 (Reaffirmed Year : 2019)	-	Degrees of protection provided by enclosures (IP CODE)
IS/IEC-60947	-	Low voltage switchgear and control gear
IS 2062 : 2011 (Reaffirmed Year : 2016)	-	Hot Rolled Medium and High Tensile Structural Steel
IS 9595 : 1996 (Reaffirmed Year : 2019)	-	Metal arc welding of carbon and carbon manganese steels – Recommendations
IS 10801 : 1984 (Reaffirmed Year : 2016)	-	Recommended procedure for heat treatment of welded fabrications
IS 4253 : Part 1 & 2 : 2008 (Reaffirmed Year : 2019)	-	Cork Composition Sheets
IS 11149 : 1984 (Reaffirmed Year : 2019)	-	Rubber Gaskets
IS 12444 : 1988 (Reaffirmed Year : 2015)	-	Continuously cast and rolled electrolytic copper wire rods for electrical conductors

IS 513 : 2016	-	Cold Reduced Carbon Steel Sheet and Strip
IS 12615 : 2018	-	Line Operated Three Phase A.C. Motors (IE CODE) "Efficiency Classes and Performance Specification" (Third Revision)
IS/IEC 60034 : PART 5 : 2000 (Reaffirmed Year : 2018)	-	Rotating electrical machines : Part 5 Degrees of protection provided by the integral design of rotating electrical machines (IP CODE) – Classification
IS 5561 : 2018	-	Electric Power Connectors- Specification
IS 2932 : Part 1 : 2013 (Reaffirmed Year : 2018)	-	Enamel, Synthetic, Exterior : (a) Undercoating (b) Finishing - Specification : Part 1 for Domestic and Decorative Applications
IS 2074 : Part 1 : 2015	-	Ready Mixed Paint, Air Drying, Red Oxide - Zinc Chrome, Priming – Specification
IS 3400	-	Methods of Test for Vulcanized Rubber
IS 456 : 2000 (Reaffirmed Year : 2016)	-	Plain and Reinforced Concrete - Code of Practice (Including Amendment 1, 2, 3,& 4)
IS 13238 : 1991 (Reaffirmed Year : 2017)	-	Epoxy Based Zinc Phosphate Primer (two Pack)
IS 2848 : 1986 (Reaffirmed Year : 2016)	-	Industrial Platinum Resistance Thermometer Sensors
IS/IEC 61850	-	Communication Networks and Systems for Power Utility Automation
IS 16683 : Part 1, 2 & 3 : 2018	-	Selection and Dimensioning of High Voltage Insulators Intended for Use in Polluted Conditions
IEEE 1538-2000		Guide for determination of maximum winding temperature rise in liquid filled transformers
IEEE Standard C57.156-2016		Guide for tank rupture mitigation of oil immersed transformers
IEEE Standard C57.150-2012		Guide for Transformer Transportation
IEEE Standard C57.149-2012		Guide for the application and interpretation of Frequency Response Analysis of oil immersed transformers

IEEE Standard C57.104-2019		Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
IEC 60599-2015		Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis
IEEE Std. C57.12.10 - 2017		Standard requirements for liquid immersed power transformers
IEEE Std. 57.104-2019		Guide for the Interpretation of Gases Generated in Mineral Oil-Immersed Transformers
IEC 60599		Mineral oil-filled electrical equipment in service – Guidance on the interpretation of dissolved and free gases analysis
IEEE Std. 62-1995		Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors
CIGRE Technical Brochure No. 529 -2013		Guide lines for conducting design reviews for Power Transformers
CIGRE Technical Brochure No. 673-2016		Guide on Transformer Transportation
CIGRE Technical Brochure No. 530-2013		Guide for conducting factory capability assessment for Power Transformers
CIGRE Technical Brochure No. 761 (WG A2.49)		Condition assessment of power transformers
CIGRE TB 209		Short Circuit Performance of Power Transformers
CIGRE TB 436		Experiences in service with new insulating liquids
Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations		
Central Electricity Authority (Technical Standard for Construction of Electrical Plants and Electric Lines) Regulations		
Central Electricity Authority (Installation and Operation of Meters) Regulations		
CBIP Manual on Transformers (Publication No. 317)		
ISO 9001: Quality System – Model for Quality Assurance in Design/Development.		

ISO-14001 (Environmental Management System)
OHSAS 18001 (Occupational Health and Safety Management System)

Annexure-W

BASIC MANUFACTURING FACILITY & MANUFACTURING ENVIRONMENT

Customer/Purchaser always desires that transformer/reactor manufactured and delivered is of good quality and must perform trouble free service for its “Specified Design Life”. The consistency in quality of material used & manufacturing

process are main cause for variation in quality of transformer/reactor. It is also equally very important that transformer/reactor is manufactured in a clean dust free and humidity-controlled environment. Any compromise on this aspect will have adverse effect in expected design life of transformer/reactor, however good is the quality of material used. A broadlist of facilities the transformer/reactor manufacturers should have are given below:

Basic manufacturing facility

Following manufacturing facility should be available for use with transformer and reactor manufacturer:

1. EOT Crane for main manufacturing bay and other shops (With Load Cell).
2. Vapor Phase Drying Oven (adequately sized to accommodate offered transformer and have facility to record temperature, vacuum, moisture etc.)
3. Air Casters for material handling
4. Core cutting line (if applicable)
5. Vacuum auto claves
6. Air oven
7. Adjustable Horizontal and vertical winding machine
8. Winding Mandrels
9. Hydraulic Press
10. Brazing equipment
11. Mechanical platform
12. Tools and fixtures
13. Mechanical power press
14. Welding machines
15. Crimping tools
16. Faraday's cage
17. Motor Generator Set/ Static Power System Set
18. Testing transformer
19. Capacitor bank
20. Impulse voltage generator
21. Capacitance & Tan delta bridge
22. Power Analyzer
23. Current & Voltage transformer
24. Partial Discharge (PD) measuring kit (for all manufacturers) & PD Diagnostic Kit (for 400 kV & above voltage class Transformer/reactor manufacturer)
25. Temperature data logger
26. Noise measurement kit
27. Thermo vision camera

28. Loss measurement kit
29. Insulation tester
30. Winding resistance meter
31. Turn ratio meter
32. Transformer oil test lab
33. Dissolved Gas Analysis (DGA) test kit
34. Sweep Frequency Response Analyzer (SFRA) kit
35. Frequency Domain Spectroscopy (FDS) kit
36. NABL Accredited laboratory for testing
37. Oil Storage tanks
38. Oil filter plant with requisite level of vacuum and filter
39. Tensometer for Oil Surface tension
40. Particle Count Kit (for 400 kV & above Transformer/reactor)
41. Multimeters

Manufacturing environment (Clean, dust free and humidity-controlled environment)

A. Transformer must be manufactured in a bay having positive pressure w.r.t. external environment. Winding shall be manufactured ina clean, dust free and humidity-controlled environment. The dust particleshall be monitored regularly in the manufacturing areas. Further, there shall be positive atmospheric pressure, clean, dust free and humidity-controlled environment for following:

1. Insulation storage
2. Core storage
3. Glue stacking area
4. Core cutting line
5. Winding manufacturing bay
6. Core building area
7. Core coil assembly area
8. Testing lab
9. Packing & dispatch area

B. Following accessories to be kept in clean and covered location:

1. Piping
2. Radiator
3. Tank
4. Bushing (as per manufacturer's guideline)
5. Marshalling box
6. Turret
7. Conservator
8. Insulating oil

Schedule-1

List of drawings to be submitted by successful bidder for approval of the

Project & Design Department

Sr. No.	Particulars of Drawing
1	General Arrangement (with provision of pockets for PT-100 sensors for remote /SCADA oil & Winding Temperature Indications) Overall dimensions to be restricted as per Clause 5.3

2	List of fittings as per G.A.
3	Rating and diagram plate (additional information such as Guaranteed /Measured losses; Guaranteed /Measured impedances at extreme and normal taps; Guaranteed /Measured Temperature rises for oil & winding; Core weight; Copper weight and Core & winding weight shall be invariably mentioned)
4	Over loading plate
5	Valve Schedule Plate
6	Foundation Plan
7	Transport Outline
8	H.V. Bushing
9	I.V. Bushing (as per requirement)
10	L.V. Bushing
11	Neutral Bushing
12	Terminal connector for
	I) HV
	ii) I.V. (as per requirement)
	iii) LV.
	iv) Tertiary (as per requirement)
13	Neutral Grounding bar Assembly
14	L.V. grounding Assembly
15	Conservator Tank.
16	Magnetic Circuit Earthing Details
17	Equalizing Pipe arrangement.
18	Oil filling Instruction plate
19	OLTC shaft connection diagram.
20	OLTC equalizing Pipe arrangement
21	General Arrangement of RTCC
22	OLTC Schematic with group simultaneous mode of control. Connectivity for tap raise -lower operations and Tap Position Indication through SCADA & TMCTS
23	OLTC legend

24	Schematic wiring for RTCC panel
25	RTCC legend
26	Radiators.
27	General Arrangement of Cooling Control Cabinet
28	Cable termination plan (Co-ordination) between OLTC & RTCC
29	Schematic for Facia Annunciator
	Schematic wiring for cooler control comprising
	i) Cooler control legend
	ii) Main and standby supply circuit alongwith heater and lighting circuit
	iii) Power circuit for Fans Gr. I, Gr. II & Standby
	iv) Control circuit for Fans Gr. I, Gr. II & Standby
	v) Power circuit for pumps Gr. I, Gr. II and Standby (as per requirement)
	vi) Control circuit for Pumps Gr. I, Gr. II, (as per requirement)
	vii) Lamp indication circuit
	viii) Annunciation Circuit
	ix) Oil & Winding Temperature Local indicating circuit / Alarm & Trip circuit for oil temp and winding temperature.
	x) Alarm & Trip Circuit (for MOG, PRV, Main Buchholz & OLTC Buchholz
	xi)) Wiring diagram of PT - 100 (for remote / SCADA WDG Temp. and Oil Temp. Indication)
	xii) Cable Termination Plan (Co-ordination) between a) FCC to RTCC
	b) FCC to OLTC
	c) FCC to C&R Panel
	xiii) Notes & Instructions
	xiv) REF Protection CT circuit.
30	Schematic wiring for TMCTS
31	General arrangement of optic fibre temperature measurement system. GA of Monitor Box and its schematic wiring diagram
32	General arrangement of on-line multi gas DGA for transformer oil and its schematic wiring diagram (as per requirement)
33	General arrangement of Condition controlled (Maintenance Free) Regenerating Silica Gel

	Breather for transformer oil (as per requirement)
34	Cable schedule
35	Roller Assembly
36	N2 Injection fire protection system drawing with Bill of material. (As per requirement)
37	HVWS fire protection system drawing with Bill of material. (As per requirement)
38	GTP for approval
39	Complete Bill of Materials.
40	QAP
41	Type Test Report conducted on identical transformer within last 5 years (if any)
42	I^2R calculations
43	Impedance calculations
44	Short circuit calculations
45	Cooling calculations
46	Core cutting schedule (Core shall be cut at Mill's authorised processing unit only)

Schedule-2

Details of Loss Calculation
(To be filled in by the Bidder)

Sl. No	**Particulars**	**Values**
1.	Flux density at	
	(i) (145/36, 245/145, 245/145/36, 420/245) kV & 48.5 Hz, Tesla	
	(ii) (132/33, 220/132/33, 220/132, 132/33) kV & 50 Hz, Tesla.	
2.	Core Data	
	(i) Core weight in Kg.	
	(ii) Gross core area [mm²]	
	(iii) Stacking factor.	
	(iv) Net core iron area [mm²] [ii x iii]	
3.	Specific losses [W/Kg.]	
	(i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ.	
	(ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz.	

Sl. No	Particulars	Values
4.	Volt ampere/Kg	
	(i) At maximum flux density corresponding to (145/36, 245/145, 245/145/36, 420/245) KV and 48.5 HZ.	
	(ii) At maximum flux density corresponding to (132/33, 220/132/33, 220/132, 132/33) KV and 50Hz.	
5.	Calculated/guaranteed iron loss in KW at:	
	(i) Rated voltage and rated frequency	
	(ii) Rated voltage and rated frequency	
6.	Current density [A/Sq. mm] for	
	(i) HV	
	(ii) LV	
7.	Conductor size [in mm^2]	
	(i) HV winding	
	a) Bare	
	b) Insulated	
	c) No of conductors in parallel	
	(ii) LV winding	
	a) Bare	
	b) Insulated	
	c) No of conductors in parallel	
8.	Copper weight	
	(i) H.V. windings	
	(ii) LV windings	
	(iii) For Tap connections,	
	(iv) Total copper weight [i]+[ii]+[iii]	
9.	L.V. winding resistance in ohms at 75°C/Phase.	
10.	H.V. winding resistance in ohms at 75°C/Phase.	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
11.	Stray losses and eddy current losses [in KW] at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
12.	Resistively of copper to be used for winding	
13.	I^2R loss at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
14.	Calculated guaranteed copper losses [in KW] at 75°C	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	
15.	Guaranteed Auxiliary loss	

Sl. No	Particulars	Values
16.	Computed/guaranteed total loss in KW at rated	
	(i) At normal tap position	
	(ii) At maximum tap position	
	(iii) At minimum tap position	

NB: - 1. Approximate values in weight and losses etc. are not allowed.

2. Tolerance of + 5% in weights may be quoted without any approximation

Place:

Date:

Bidder's name:
Signature, designation, seal

Schedule-3

Maximum Flux Density and Core Weight Calculation

(To be filled in by the Bidder)

Step No	Width of steps [mm]	Stack Thickness [mm]	Gross Iron Area [mm²]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Bmax = **E/ (4.44 x f x Ai x N)**

Where, E = L.V. winding phase voltage / phase
f = Rated frequency = 50 HZ.
Bmax. = Maximum flux density in Tesla.
Ai = Net iron area in sq. m = Gross iron area x stacking factor in sq. m

N = Number of L.V. winding, turns/phase
Stacking Factor = 0.97 maximum

Core weight calculation: -
Core dia [in mm] =
Window height [in mm] = Limb centre [in mm] =
Weight of core = [3 x window height + 4 x limb centre + 2 x max. width] x Net iron area x Density of core

NB: -
1 Specific loss vs. flux density graph for the type of core lamination to be used has to be furnished.
2. VA/Kg. Vs flux density graph for the core lamination to be used has to be furnished.
3. Any other factor assumed for above calculation to be explained with reasons.

N.B: - The bidder may use its own method of calculation towards determination of maximum flux Density and weight of the core. But the same shall be supported with proper explanation and Justification.

Place:
Date:

Signature of Bidder
With seal of Company.

Schedule-4

Manufacturer Quality Plan (MQP)

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
1.0	**MATERIAL**							
1.1	**Copper Conductor**							
1.1.1		Samplecheck on winding conductor for electrical conductivity	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	CHP at Vendor end
1.1.2		Dimensions Width & Thickness (Bare) & Visual for scratches, dentarks	Measurem ent	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end
1.1.3		Sample check on insulating paper for pH value, electric strength	Testing	-Do-	TM Spec	-Do-	-Do-	TC Review
1.1.4		check for bonding of the insulating paper with conductor	Visual	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end

1.1.5		Check for the reaction of hot oil andinsulating Paper	Testing	-Do-	TM Spec	-Do-	-Do-	TC Review
1.1.6		Check & ensure that physical condition of all materials taken for winding is satisfactory and dust free.	Visual	-Do-	TM Spec	-Do-	-Do-	CHP at Vendor end
1.2	**Core Material**							
1.2.1		Sample testing of core materials for checking specific core loss properties, magnetization characteristics & Thickness	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	CHP at Vendor end
1.2.2		Amount of burr	Measurement	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
1.3	**Insulating Material**							
1.3.1		Physical Properties	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.3.2		Dielectric Strength	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.3.3		Reaction of hot oil on insulating Materials	Testing	Sampling/lot	TM Spec	Insp.record	Vendor/TM QC	TC Review
1.4	**OIL**							
1.4.1		Appearance	Visual	Sampling	IS 335/TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
1.4.2		Density	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.3		Viscosity	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.4		Interfacial Tension	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.5		Neutralisation Value	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.6		Dielectric Strength	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.7		Tan Delta	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.8		Specific Resistance	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.9		Water content	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.10		Flash point	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.11		Pour point	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.12		Corrosive sulphur	Testing	-Do-	-Do-	-Do-	-Do-	

1.4.13		Oxidation stability (a)Neutralization after oxidation (b)Total sludge after Oxidation	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.14		Ageing characteristics after accelerated Ageing	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.15		Presence of oxidation Inhibitor	Testing	-Do-	-Do-	-Do-	-Do-	
1.4.16		SK value	Testing	-Do-	-Do-	-Do-	-Do-	
2.0	**FITTINGS AND ACCESSORIES**							
2.1	Tank & Conservator Raw material							
2.1.1		Type of material	TC Verif	Sampling	TM Spec	Insp Record	Vendor/TM QC	
2.1.2		Thickness	Testing	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
2.2	**Tank & conservator Assembly**							
2.2.1		Inspection of major welds.	Visual	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.2		NDT for load bearing(Jacking pad, lifting bollard)	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Recod	Inspection Agency	Remarks
		Welds(DP test)						
2.2.3		dimensions between wheels, demonstrate turning of wheels through 90 deg. & further dimensional check	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.4		Leakage Test of conservator	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at Vendor end
2.2.5		Measurement of film thickness of	Testing	Each Unit	TM Spec	Insp Record	Vendor/TM QC	CHP at TM for total DFT measurement during final inspection
		(i) Zinc chromate Paint	Meas	-Do-	-Do-	-Do-	-Do-	
		(ii) Finished coat	Meas	-Do-	-Do-	-Do-	-Do-	

2.2.6		-Pressure &Vacuum test	One unit/Rating	-Do-	-Do-	-Do-	-Do-	CHP at Vendor end
2.3	**Radiator**							
2.3.1		Visual&Dimension	Measurement	Each Unit	TM Spec	Insp Record	Vendor/TM QC	
2.3.2		Pressure test & leakage test	Testing	-Do-	-Do-	-Do-	-Do-	
2.3.3		Paint thickness	Measurement	-Do-	-Do-	-Do-	-Do-	
2.4	**Marshalling box & RTCC**							
2.4.1		Dimension (WxDxH of panel)	Measurement	Each Unit	TM Spec	Insp Record	Vendor/TM QC	
2.4.2		Meas. of 2 kV dielectric test	Testing	-Do-	-Do-	-Do-	-Do-	CHP
2.4.3		Component make & Rating	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.4		Completeness, label Fixing & Finishing	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.5		Functional test	Visual	-Do-	-Do-	-Do-	-Do-	
2.4.6		IP:55 test for M. Box	Testing	1 unit/rating	IS 2147	-Do-	-Do-	CHP
2.5	**Temperature indicators (OTI, WTI)**							
2.5.1		Type	Visual	Each Unit	TM Spec	Insp Record	Vendor/TM 's QC	
2.5.2		Continuity check	Manual	-Do-	-Do-	-Do-	-Do-	
2.5.3		Switch setting & Calibration	-Do-	-Do-	-Do-	-Do-	-Do-	
2.6	**Buchholz Relay**							
2.6.1		Type/Model	Visual	-Do-	-Do-	-Do-	-Do-	
2.6.2		Continuity of Contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.6.3		Operationof Contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.7	**Bushings**							
2.7.1		Test for leakage on	TC Verify	Each Unit	IS 2099/TM	Insp	Vendor/TM	

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
		internal fillings (Tightness test)			Spec	Record	's QC	
2.7.2		Dry power frequency test on terminal & tapping	TC Verif	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	
2.7.3		Measurement of dielectric dissipation factor & Capacitance	TC Verif	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	
2.7.4		Partial discharge test followed by dielectric dissipation factor & capacitance measurement for condenser bushings & creepage distance measurement.	Testing	Each Unit	IS 2099/TM Spec	Insp Record	Vendor/TM 's QC	CHP at Vendor end

2.8	**Current Transformers**							
2.8.1		Type & finish	Visual	Each lot	TM's Spec	Insp Record	Vendor/TM 's QC	
2.8.2		Dimensions (OD,ID & H)	Measur	Each Unit	-Do-	-Do-	-Do-	
2.8.3		Verification of Terminal Marking & Polarity	Testing	Each Unit	-Do-	-Do-	-Do-	
2.8.4		P.F.dry withstand Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.8.5		Overvoltage interturn test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.8.6		Determination of Errors	-Do-	-Do-	-Do-	-Do-	-Do-	
2.9	**Pressure relief Valve/Sudden pressure relay**							
2.9.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.9.2		Manual operation of Switch contacts	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.9.3		Operating pressure	Testing	-Do-	-Do-	-Do-	-Do-	
2.10	**MOLG**							
2.10.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.10.2		Dial Calibration	TC Verif	-Do-	-Do-	-Do-	-Do-	
2.10.3		Switch Continuity	Manual Check	-Do-	-Do-	-Do-	-Do-	
2.11	**Valves**							
2.11.1		Type & Size	Visual	Each Unit	Customer Spec	Insp Record	Vendor/TM 's QC	
2.11.2		Open & shut marking	-Do-	-Do-	-Do-	-Do-	-Do-	
2.11.3		Leakage test	TC Varif					
2.12	**Silica gel breather**							
2.12.1		Type/ Model	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.13	**Online H_2 & Moisture monitoring**							
2.13.1		Type / Model	Visual	Each Unit	TMs Spec	Insp	Vendor/TM	

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
						Record	's QC	
2.14	**Tap changer**							
2.14.1		Type & Rating	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.2		Physical condition	Visual	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.3		Mechanical Operation Check	Testing	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.14.4		Insulation Resistance Test	Testing	Each Unit	TMs Spec	Insp Record	Vendor/TM 's QC	
2.15	**Cooling fan**							
2.15.1		HV test	Testing	Each Unit	IS 2312	Insp Record	Vendor/TM 's QC	
2.15.2		Insulation Resistance Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.15.3		Performance Test	-Do-	-Do-	-Do-	-Do-	-Do-	
2.15.4		DFT of Galvanization on Fan guard	-Do-	-Do-	TM's Spec	-Do-	-Do-	

3.0	**MANUFACTURING**							
3.1	**Assembled Core**							
3.1.1		Visual & dimensional check during assembly stage	Visual/ Meas	Each Assembly	TM's Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.1.2		Check on completed core for measurement of iron loss	Meas/T esting	Each Assembly	Customer Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.1.3		2KV H.V.test (Core insulation test) between Core & clamps for one minute And Insulation resistance test of core & clamps (clamps)	Testing	Each Assembly	Customer Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.1.4		Visual & dimensional checks for straightness & roundness of core, thickness of limbs and suitability of clamps	Visual	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.2	**Wound Coils**							
3.2.1		Visual check for brazed joints wherever Applicable	Visual	Sampling/L ot	TM's Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.2.2		Visual check of insulation on the conductors & between the windings	Visual	Sampling/L ot	TM's Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
3.2.3		Check for the absence of short circuit between parallel strands of PICC	Testing	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.3	**Coil & Core assembled**							
3.3.1		Active part before drying						
		(i) Visual check	Visual	Each Unit	TM's Spec	Insp Record	Vendor/TM 's QC	CHP at TM's Works
		(ii) Checkinsulation distance between high voltage connections, between high voltage connection cables & earth and other live parts	Meas	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks

		(iii) Check insulating distance between low voltage connections and earth and other parts	Meas	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
		(iv) 2KV core insulation test	Testing	-Do-	-Do-	-Do-	-Do-	CHP at TM's Works
3.3.2	Active part after drying							
		(i) Measurement & recording of temperature & drying time during vacuum treatment	VPD Data	Each Unit	TM's Spec	Insp Record	TM's testing/TM's QC	**In process check card review by Customer**
		(ii) Check for completeness of drying	VPD Data	Each Unit	TM's Spec	Insp Record	TM's testing/TM's QC	**In process check card review by Customer**
3.4	**Assembled Transformer**							
3.4.1		Check Completed transformer against approved outline drawing, provision for all fittings, finish levels etc.	Visual	One Transformer of each rating	Approved GA drawing	Insp Record	TM's testing/TM's QC	**CHP at TM's Works**
3.4.2		Jacking test	Visual	-Do-	-Do-	-Do-	-Do-	**CHP at TM's Works**
3.5	**Final Testing**							
3.5.1	**Routine Tests**							

Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
3.5.1.1		Winding resistance Test	Testing	Each Unit	IS 2026/IEC 60076	Insp Record	Customer/ TM	**CHP at TM's Works**
3.5.1.2		Turn ratio, Polarity						
3.5.1.3		Vector group test and Phase vector relationship test						
3.5.1.4		Load loss & impedance voltage						
3.5.1.5		No-load loss and current Measurement						

3.5.1.6		Measurement of magnetization current at low voltage.						
3.5.1.7		Insulation Resistance Measurement						**CHP a t TM's Works**
3.5.1.8		Separate source voltage withstand test for all windings (1 Minute)						
3.5.1.9		Induced over-voltage withstand test for 60 Sec. @ 100 Hz						
3.5.1.10		Full wave lightning impulse on three Phases						
3.5.1.11		Measurement of partial discharge at the time of induced over voltage test						
3.5.1.12		Frequency response analysis (FRA)						
3.5.1.13		Measurement of zero sequence impedance of three phase transformers.						
3.5.1.14		Measurement of acoustic noise level						
3.5.1.15		Measurement of the harmonics of the no-load current						
3.5.1.16		Measurement of capacitance and ten δ to determine capacitance between winding and earth. Value of tanδ should not be more than 0.5% at 20°C						
3.5.1.17		Oil leakage test on						
Sl No.	Component	Characteristics	Type of Inspection	Quantum of Inspection	Ref Doc & Acceptable Norm	Form of Record	Inspection Agency	Remarks
		transformer tank as per CBIP						
3.5.1.18		Test on OLTC						
3.5.1.19		Magnetic balance Test						
3.5.2	**Type Test**							
3.5.2.1		Temperature-rise test with 2 x 50% radiator banks including DGA test after & before temp rise test	Testing	One Unit on each rating	IS 2026/IEC 60076	Insp Record	Customer/ TM	**CHP a t TM's Works**

3.5.2.2		Measurement of the power taken by the fans						**CHP at TM's Works**
3.5.2.3		Pressure & Vacuum test on transformer tank as per CBIP						
3.6	**Pre-shipment check**							
3.6.1		Detach accessories for despatch	Visual	Each unit	TM's spec	Insp Record	TM	
3.6.2		Blanking of Openings	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.3		Adjustment of oil Level/ Draining of Oil	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.4		Finishing, cleaning & Painting touch up	-Do-	-Do-	-Do-	-Do-	-Do-	
3.6.5		Dew point measurement before despatch	Testing	-Do-	-Do-	-Do-	-Do-	**Reqd for only Transfo r mer despat ch without oil**
3.6.6		Gas tightness test to confirm tightness	Testing	-Do-	-Do-	-Do-	-Do-	
3.6.7		Check for proper packing of detached accessories for dispatch & Check for proper provision of bracing to arrest the movement of core &winding assembly inside the Tank	Testing	-Do-	-Do-	-Do-	-Do-	

Note:

1. TM – Transformer Manufacturer

2. CHP – Customer Hold Point

3. Further details of MQP shall be as per 'Guidelines for Model Quality Assurance Plan (MQAP) for major equipment of Power sector' of CEA.

Annexure-1

GTR Data	
Outdoor temperature	35° C
Minimum outdoor temperature	40° C
Maximum Oil Temperature	60° C
Maximum relative Humidity	86%
Minimum relative Humidity	65%
Average no of thunderstorm Days per annum	70
Average no of rainy days Per annum	150
No of months of tropical Monsoon conditions	4
Design Ambient Temperature	50° Centigrade
Minimum temperature	0° Centigrade
Wind Zone	Zone 5
Average annual rainfall	3200 mm
Wind Pressure	793 N/m2
Altitude not exceeding	1000M
Seismic Data	IS:802 Part1/Sec 1-2015, ZONE-V
Snow Fall	Not Applicable
Altitude	1000 mm
Coastal Area Consideration	No