Technical Specification

for

Power and Auto Transformers

(From 132 kV up to 400 kV level)

Revision 1

May 2025

Contents

1 GENERAL

This specification encompasses the design, engineering, manufacturing, testing, and delivery of the equipment, including all associated materials, accessories, spares, unloading, handling, storage, erection, testing, and commissioning at the site.

2 COMPLIANCE STANDARDS

The Transformer supplied by the OEM shall fully comply with the relevant Indian Standards (IS). In case of any discrepancy between IS and other international standards, the IS provisions shall prevail. If no applicable IS standard exists, other recognized international standards (e.g., IEC or equivalent) shall be followed, subject to approval as per this specification.

3 IMPLIED REQUIREMENTS

Any materials, equipment, or components not explicitly mentioned in this specification but essential for the proper and satisfactory operation of the equipment shall be deemed included in the scope, unless expressly excluded. Such items shall be supplied without additional cost.

4 INTERCHANGEABILITY OF COMPONENTS

All identically rated components shall be fully interchangeable.

5 TRANSPORTATION

The Contractor/OEM shall:

a. Determine the optimal transportation route and method, ensuring compliance with all applicable regulations;
b. Obtain all required permits and approvals from relevant authorities for equipment transport;
c. Ensure packaged equipment dimensions conform to all loading gauges, clearance limits, and weight restrictions along the designated route;
d. Manage and coordinate all transportation logistics from the manufacturer's facility to the final installation site, including:
    i. Loading and securing of equipment;
    ii. Transit arrangements;
    iii. Unloading at site;
e. Bear full responsibility for any transportation-related damages or delays.

6 ROUTE SURVEY AND TRANSPORTATION METHODOLOGY

a. The Contractor/OEM shall conduct a comprehensive route survey in coordination with the appointed transporter to:
    i. Identify the optimal transportation route for the transformer;
    ii. Assess all infrastructure requirements along the selected route;
    iii. Determine the complete transportation methodology.

b. Based on the route survey findings, the Contractor/OEM shall be responsible for:
    i. Implementing any necessary modifications to existing infrastructure including roads, bridges, and culverts;
    ii. Executing required extensions or improvements to ensure safe passage;
    iii. Obtaining all necessary permits for such modifications.
c. All infrastructure modifications, including but not limited to:
    i. Road widening or reinforcement;
    ii. Bridge strengthening;
    iii. Culvert modifications;

shall be within the Contractor's/OEM scope of work and at the Contractor's/OEM expense.

7 INLAND TRANSPORTATION REQUIREMENTS:

a. Transportation Equipment Specifications:
    i. All trailers shall be equipped with operational GPS tracking systems
    ii. Hydraulic trailers shall be mandatory for loads exceeding 40 metric tons
b. Tracking and Monitoring Obligations:
    i. The Contractor shall implement continuous real-time monitoring of the transformer's location
    ii. Regular position updates shall be maintained throughout transit
    iii. Tracking data shall be made available to site and regional headquarters personnel
c. Reporting Requirements:
    i. Full tracking details shall be provided to the designated site after dispatch
    ii. The tracking system shall remain active from factory departure until site arrival
    iii. The Contractor shall immediately report any deviations from planned route or schedule

8 TRANSPORTATION PROTECTION AND HANDOVER REQUIREMENTS:

a. Scope of included components:
    i. All metal blanking plates and protective covers specifically required for:
        - Safe transportation of the transformer
        - Proper storage prior to installation
    ii. Shall be considered integral parts of the transformer supply
b. Handover Requirements:
    i. These components shall be properly preserved during installation
    ii. All items shall be handed over to the Purchaser upon completion of erection
c. Documentation Requirements:
    i. A complete Bill of Quantity for these components shall be:

- Clearly listed in the relevant technical drawings
- Included in the transformer documentation package

ii. Documentation shall specify:
- Item descriptions
- Quantities
- Material specifications

9 TRANSFORMER PRESERVATION AND HANDLING REQUIREMENTS

a. Pre-Dispatch Requirements:
   i. The transformer shall be dispatched filled with dry air at positive pressure
   ii. A complete dry air pressure maintenance system shall be provided, including:
      - Pressure testing valve
      - Accurate pressure gauge
      - Standard adapter valve
b. Transit and Storage Preservation:
   i. The Contractor shall maintain positive dry air pressure throughout:
      - Transportation
      - On-site storage
      - Until oil filling is completed
   ii. Storage duration with dry air preservation shall not exceed three months
   iii. Beyond three months, the transformer shall be processed per manufacturer's recommendations
c. Special Provisions:
   i. For separately transported turrets with insulation assembly:
      - Same dry air positive pressure requirements apply
   ii. Contractor may reclaim dry air cylinders after successful oil filling
d. Pressure Maintenance System:
   i. The system shall automatically compensate for pressure drops
   ii. Adequate spare capacity shall be provided for extended transit/storage periods

9.1 TRANSPORTATION IMPACT MONITORING

a. Impact Recorder Requirements:
   i. Minimum two (2) electronic impact recorders shall be installed
   ii. Devices shall measure and record:
      - Impact magnitude (g-forces)
      - Duration of impacts
      - Three-axis directional data (X, Y, Z axes)
   iii. All recorders shall be provided on returnable basis
b. Impact Tolerance Limits:
   i. Maximum permissible impact shall not exceed:
      - 3g peak acceleration
      - 50 millisecond duration

- 20Hz frequency content

ii. The stricter of the following shall apply:

- Specified 3g/50mSec limit

c. Data Analysis and Reporting:

i. Impact data shall be analysed post-transportation

ii. Full impact reports shall be submitted for review

Any exceedance shall be immediately reported

9.2 PERFORMANCE:

- The transformers shall be used for bi-directional flow of rated power. The major technical parameters of single phase and three phase transformer units are defined at Annexure – A.
- Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially ONAF (or ONAF1, as specified) up to specified load and then as OFAF (ONAF2 or ODAF or ODWF, as specified). Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140° 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° C at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.
- 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.
- **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**.
- The transformers shall be capable of being over loaded in accordance with IS 2026 (PART 7) IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.
- Tank hotspot shall not exceed 110 Deg. Celsius. The above condition shall be verified during temperature rise test.
- The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

400kV system	- 63kA for 1 sec (sym, rms, 3 phase fault)
220kV system	- 50 kA for 1 sec (sym, rms, 3 phase fault)

132kV system - 40 kA for 1 sec (sym, rms, 3 phase fault)
33kV system - 31.5 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_s = 0$).

- 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 ,LV and tertiary transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.
  The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.
- **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.**
- 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.

- The air core reactance of HV winding of transformer of 400 kV and above voltage class shall not be less than 20%.

- **Tertiary Windings (if applicable as per Annexure – A, 500MVA Auto)**

  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.**

- **Radio Interference and Noise Level**

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at Annexure - A, when measured under standard conditions.

9.3 MAXIMUM LOSSES:

The maximum permissible losses (no-load loss, I2R loss, auxiliary loss and load loss) at rated voltage/current (at 75°C) have been specified in Annexure-A for various ratings of transformers/ reactors covered under this specification. The following penalties shall be levied on the manufacturer/contractor (as the case may be) if losses measured during routine tests are found to be within a +2% tolerance of the losses specified in Annexure–A, beyond which the transformer/reactor shall be liable for rejection. No benefit shall be given for supply of transformer/reactor, with losses (measured during routine tests) less than the losses specified in Annexure A.

Sl. No.	Differential of specified losses vs Measured losses	RATE (in INR per KW)
1)	No load Loss	Rs. 10,00,000/KW
2)	I^2R Losses/Load Losses (Differential of whichever loss is higher shall be considered for penalty)	Rs. 8,00,000/KW
3)	Auxiliary Losses	Rs. 8,00,000/KW
Note: For a fraction of a kW, the penalty shall be applied on pro rata basis.		

10 DYNAMIC SHORT CIRCUIT TEST REQUIREMENT AND VALIDITY:

As per latest CEA guideline in line with IS-2026(part-5)

11 TYPE TESTS REQUIREMENT AND VALIDITY

The offered transformer/reactor or the transformer/reactor, the design of which is similar to the offered transformer/reactor, should have been successfully type tested before the last date of submission of bid. The manufacturer may use the same or different approved make of bushings, tap changers, and other accessories used in the type-tested or short-circuit-tested unit in their transformer/reactor. Further,

A type test report of the transformer/reactor shall only be acceptable provided the offered transformer/reactor has been manufactured in the same plant.

The Central Electricity Authority's "Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission systems" shall be followed for details regarding the validity of type tests.

12 DESIGN REVIEW:

The transformer/reactor shall be designed, manufactured, and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. An 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 a long life for the transformer/reactor with the least maintenance.

Design reviews shall be conducted by the purchaser or by an appointed consultant during the procurement process; however, the entire responsibility of design shall be with the manufacturer. The purchaser may also visit the manufacturer's works to inspect design, manufacturing, and test facilities.

The design review shall be finalized before commencement of manufacturing activity and shall be conducted generally following the "CIGRE TB 529: Guidelines for Conducting Design Reviews for Power Transformers." However, salient points on design review have been specified in Annexure C.

The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer/reactor meets the requirements of mechanical strength and inrush current.

The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric, vibration, etc. in design to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include, but not be limited to, the requirement as mentioned in Annexure C.

Each page of the design review document shall be duly signed by the authorized representatives of the manufacturer and purchaser and shall be provided to the purchaser for record and reference before commencement of manufacturing

13 Construction Details

13.1 TANK &COVER:

- **The tank shall be of proven design of either Bell type with bolted/ welded joint or conventional (preferable) with bolted/welded top cover. Bell type tank, if provided, shall have joint as close as possible to the bottom of the tank**.
- The tank shall be designed in such a way that **Reactor can be placed directly on plinth and the Transformer can be rested on concrete plinth foundation directly or on roller assembly**
- Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with IS 2062.
- 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

- 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.
- All seams and joints which are not required to be opened at site, shall be factory welded, and shall be double welded [i.e. with a continuous cord on both sides of the plate (inside and outside of the tank), bottom & cover of the tank, turrets, flanges, etc.] to ensure adequate strength. Butt welds on parts that are mechanically stressed or under pressure must have full penetration. Welding shall conform to IS 9595. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of IS 10801.
- 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.
- Tank stiffeners shall be provided for general rigidity and welded to the tank continuously along its ends and sides (Intermittent welds will not be accepted). These shall be designed to prevent retention of water. Sharp edges on stiffeners should be avoided for better paint adhesion.
- 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.
- After fabrication of tank and before painting, Non-destructive test (dye penetration test) is mandatory on the load bearing members such as base plate joints, jacking pads and lifting devices etc.
- Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the covers & windings and the bottom of the tank for collection of any sediment.
- Tank should be provided with adequately sized inspection covers, either in circular shape or in rectangular shape, preferably at diagonally opposite sides of the tank to access the active part and one at each end of the tank cover for easy access of the lower end of the bushings, earthing connections and tap changers etc. for inspection. Inspection covers shall be bolted type and shall not weigh more than 25 kgs. Handles shall be provided on the inspection cover to facilitate its lifting.
- The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets (for OTI, WTI & RTDs including two spare pockets) shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs/probes 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.

- It should be possible to inspect Buchholz relay or Oil surge relay, standing on tank cover or suitable arrangement shall be made to access Buchholz relay safely.
- The tank cover shall be designed to prevent retention of rain water 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.
- Minimum four symmetrically placed lifting lugs of adequate size shall be provided so that it will be possible to lift the complete transformer/reactor when filled with oil & without structural damage to any part of the transformer/reactor. The factor of safety at any lug shall not be less than 2. Suitable haulage holes shall also be provided.
- A minimum of four jacking pads (not fouling with rail, rollers or other accessories) shall be provided in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. The location shall be such that it should not interfere with loading & unloading from trailer.
- **Each jacking pad shall be designed with an adequate factor of safety to support at least half of the total mass of the transformer filled with oil in addition to maximum possible misalignment of the jacking force to the centre of the working surface.**
- The tank shall be provided with suitable valves as **specified in Clause 17:** Location of valves shall be finalized during design review.
- **Suitable provision (valves, etc.) as required for installation of Nitrogen Injection Fire Protection System in transformer shall be provided.**
- **The tank cover and bushing turret shall be fixed to the transformer using copper links in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.**
- The transformer/reactor shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket at the highest point of the transformer / reactor for maintaining vacuum in the tank.
- The transformer/reactor cover and generally the internal spaces of the transformer/reactor and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer/reactor to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer/reactor is being mounted.

13.2 Gasket for tank & cover

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak proof and maintenance free operation. All gasketed joints shall preferably be O-ring and designed with gasket-in-groove arrangement. If gasket/O-rings is compressible metallic stops/other suitable means shall be provided to prevent over-compression. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. All matching flanges of gasket sealing joints should be machined (except curb joints). Gasket with intermediate stops are not acceptable. To the extent possible, the seamless gasket

should be used for openings on tank/cover such as turrets, bushing, inspection covers etc. All tank gaskets/O-rings used shall be of NBR (Acrylonitrile Butadiene Rubber) suitable for temperature conditions expected to be encountered during operation. The gasket material and additives should be fully compatible with transformer insulating fluid/oil. The gasket should not contain oil soluble sulphur compounds. The properties of all the above gaskets/O-Rings shall comply with the requirements of type-IV rubber of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

13.3 Foundation, Roller Assembly and Anti Earthquake Clamping Device

- Transformer shall be placed on foundation either directly or on roller assembly. Reactor shall be placed directly on concrete plinth foundation.
- For transformer/reactor to be placed directly on foundation, one set of rollers shall be provided for movement within the yard. The rollers for transformer/reactor 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/reactor 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. Single Phase auto transformers of 765kV class and 3-Phase auto transformers of 400kV class shall have four (4) rails and other voltage class transformers shall have two (2) rails. However, Generator transformers of 765kV & 400kV class (single phase units) may have two (2)/three (3) rails.
- To prevent movement during earthquake, suitable clamping devices shall be provided for fixing the transformer/reactor to the foundation.
- In case rail is not required for smaller rating transformers, arrangement of unidirectional roller mounted on channel shall be provided and channel shall be locked with the plinth suitably.
- For foundation of separately mounted cooler bank of transformer/reactor, fixing of cooler support shall be through Anchor Fastener with chemical grouting and no pockets for bolting shall be provided.
- For support of cooler pipes, Buchholz pipe (if required) and fire-fighting pipe pylon supports, Pre-fabricated metallic support from pit shall be provided which shall be further encased with concrete to prevent rusting.
- All control cubicles shall be mounted at least one meter above Finished Ground Level (FGL) to take care of water logging during flooding. Suitable arrangement (ladder and platform) shall be provided for safe access to control cubicles.

13.4 Conservator

- The conservator of main tank 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 and prismatic oil level gauge.

- The conservator shall preferably be on the left side of the tank while viewing from HV side.
- 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 100 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.
- 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.
- **The conservator shall be positioned so as not to obstruct any electrical connection to transformer**
- 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 100 Deg C during operation. As such air cell used shall be suitable for operating continuously at this temperature**.**
- 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/reactor is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer/reactor rating and diagram plate shall bear a warning statement that the "**Main conservator is fitted with an air cell".**
- The transformer/reactor manual shall give 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.
- 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.
- 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.
- Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be externally installed on the top of conservator to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

13.5 Piping works for conservator

- Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.
- The feed pipe to the transformer/reactor tank shall enter the cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer/reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 3 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm. The Gas-venting pipes shall be connected to the final rising pipe between the transformer/reactor and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.
- No metal corrugated bellow (Flexible metal system) should be used in the feed pipe connecting main tank to conservator.
- 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.
- Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

13.6 Dehydrating Silica gel Filter Breather

Conservator of Main Tank and OLTC shall be fitted with dehydrating silica gel filter breathers of adequate size. 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 25mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer/reactor, or other structure supplied by the manufacturer, 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) Silica gel 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/reactor and two breathers (of identical size) for below 220kV class transformer/reactor shall be connected in series for main tank conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.
f) To minimise the ingress of moisture, two breathers in series of identical size shall be connected to OLTC Conservator. Manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.

13.7 Pressure Relief Device (PRD)

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/reactor. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation.

The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa.

It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

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

13.8 Sudden Pressure Relay/ Rapid Pressure Rise Relay (for 220kV and above transformer/reactor)

One number of Sudden Pressure Relay/ Rapid Pressure Rise Relay with alarm or trip contact (Terminal connection plug & socket type arrangement) shall be provided on tank of transformer/reactor. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water.

Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay/ Rapid Pressure Rise Relay.

13.9 Buchholz Relay

Double float, reed type Buchholz relay complying with IS:3637 shall be connected through pipe between the oil conservator and the transformer/reactor tank with minimum distance of five times pipe diameters between them. Any gas evolved in the transformer/reactor shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located

about 1200 mm above ground level to facilitate sampling while the transformer/reactor in service. Suitable canopy shall be provided to prevent ingress of rain water. It 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.

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/reactor during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

13.10 Oil Temperature Indicator (OTI)

The transformer/reactor shall be provided with a dial type thermometer of about 150mm diameter for top oil temperature indication with angular sweep of 270°. Range of temperature should be 0-150°C with accuracy of ±1.5% (or better) of full scale deflection. The instruments should be capable of withstanding high voltage of 2.5kV AC rms, 50Hz for 1 minute. The terminal provided for auxiliary wiring should be Press-fit type.

The thermometer shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment (if any), maximum reading pointer and resetting device, switch testing knob & anti-vibration mounting grommets (for projection mounting). Type of switch (NO/NC) shall be heavy duty micro switch of 5A at 220V DC. Adjustable range shall be 20-90% of full scale range. The instruments case should be weather proof with epoxy coating at all sides. Instruments should meet degree of protection of IP55 as per IS/IEC- 60529. 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 OTI instrument by means of flexible stainless steel armour to protect capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. The setting of alarm and tripping contacts shall be adjustable at site.

The OTI 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.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with PT100 sensor

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IS 2848 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 manufacturer. 4-20mA signal shall be wired to Digital RTCC panel/BCU for further

transfer data to SCADA through IS/**IEC 61850 compliant communications.**

13.11 Winding Temperature Indicator (WTI)

The transformer/reactor shall be provided with a dial type hot spot indicator of about 150mm diameter for measuring the hot spot temperature of each winding [HV, IV ,LV & Tertiary (if applicable)]. It shall have angular sweep of 270°. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. The instruments should be capable of withstanding high voltage of

2.5kV AC rms, 50Hz for 1 minute. The terminal provided for auxiliary wiring should be Press-fit type.

The thermometer shall have adjustable, potential free alarm, trip contacts besides that required for control of cooling equipment, if any. Instrument should be provided with maximum reading pointer and resetting device, switch testing knob & anti-vibration mounting grommets (for projection mounting). Type of switch (NO/NC) shall be heavy duty micro switch of 5A at 220V DC. Adjustable range shall be 20-90% of full scale range. The instruments case should be weather proof and epoxy coating at all sides. Instruments should meet degree of protection of IP55 as per IEC60529. 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 stainless-steel armour to protect capillary tubing. WTI shall have image coil and auxiliary CTs, if required to match the image coil mounted in local control box. The setting of alarm and tripping contacts shall be adjustable at site.

The 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.

In addition to the above, the following accessories shall be provided for remote indication of winding temperature:

Temperature transducer with PT100 sensor for each winding

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IS 2848 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 and Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IS/IEC 61850 compliant communications.

13.12 Earthing Terminals

- 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.

- 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., (if provided), double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.
- Equipotential flexible copper links of suitable size shall be provided between turret & tank, between tank & cover or between Bell & lower tank. Other components like - pipes, conservator support etc. connected to tank may also be provided with equipotential flexible copper link.
- Each transformer/reactor unit should have provision for earthing and connection to grounding mat when not in service.

13.13 Core

- The core shall be constructed from non-ageing, Cold Rolled Grain Oriented (CRGO) silicon steel laminations. Indian transformer manufacturers shall use core material as per above specification with BIS certification.
- 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. The step-lap construction arrangement is preferred for better performance in respect of noise, no-load current and no-load loss.
- **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.**
- Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.
- **All steel** sections **used for supporting the core shall be thoroughly sand/ shot blasted after cutting, drilling and welding.**
- Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.
- 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.
- Adequate lifting lugs shall be provided to enable lifting of active part (core & winding).
- Core assembly shall be manufactured in such a way that lamination shall remain flat and finally assembled core shall be free from distortion.

- **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.**
- 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.
- **Insulation of core to clamp/frame shall be tested at 2.5 kV DC for 1 minute** without **breakdown after the transformer is filled with liquid and insulation resistance should be at least 500 Mega ohm for new transformer.**
- In addition to above following additional provisions for reactors shall be applicable**:**

a) The leg magnetic packets (cheeses) shall be made from state of the art low loss electrical steel CRGO (conventional/regular grade or better). The "Cheeses" shall be designed to minimize losses and equalize the distribution of flux in the legs.

b) The "cheeses" shall be bonded using high temperature epoxy resins to assure that they will remain bonded in service at the maximum temperatures that will occur in the magnetic circuit and for the full expected life. Vacuum impregnation is preferred. The contractor shall present data on the characteristics of the packets at the time of design review.

c) Material with high temperature withstand capability such as ceramic/ slate spacers shall be used to separate the packets. High temperature, mechanically stable material shall be used between the end packets and the top and bottom yokes. Special care shall be taken not to impede the cooling in these areas.

d) Means shall be provided to distribute the flux from the "cheeses" and the windings to the top and bottom yokes to prevent concentrations of flux with resulting high temperatures in the yokes.

e) The yokes shall be designed such that high temperatures resulting from unequal distribution of the flux in the yokes will not occur.

f) The spaces between "cheeses" will be designed so that high temperatures will not result due to fringing of flux at the oil gaps between them. The designer shall calculate the temperatures resulting from fringing.

g) The structural design shall be made so that pressure will be maintained to prevent loosening resulting from thermal expansion and contraction

during all loading cycles.

h) The design shall be made in such a way that excessive vibration does not occur in the windings, structural supports of the windings and magnetic circuit and this will be subjected to design review.

i) The structure shall be designed to withstand the clamping and magnetic forces. The calculated magnetic forces will be furnished at the time of design review.

13.14 Windings

- The manufacturer shall ensure that windings of all transformers/reactors are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity controlled environment with positive atmospheric pressure.
- **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 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 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.
- 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 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 pre-**compressed **pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.**
- 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 insulating materials and structures shall be protected from contamination and the effects of humidity during and after fabrication, and after receipt, by storing them in a

separate, climate-controlled area. All blocks shall be installed such that the grain is oriented in the horizontal direction, perpendicular to the winding compressive forces. Aspect ratio of selected conductor shall be chosen suitably based on manufacturer experience to result in stable winding under normal and abnormal service condition after assembly.

- 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.
- **Winding paper moisture shall be less than 0.5%.**
- 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.

13.15 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.

13.16 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/reactor 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.

14 PAINT SYSTEM AND PROCEDURES

The typical painting details for transformer/reactor 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

15 INSULATING OIL

The insulating oil shall be unused inhibited (Type A, High Grade) (should be preferred) or uninhibited Transformer Oil conforming to IEC-60396-2020 & all parameters specified at Annexure–E, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at Annexure–E, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and thereafter be brought up to the specified parameter by circulation within the transformer. The Unused Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at Annexure– E. The oil test results shall form part of equipment test report.

A minimum of 5% of the oil quantity shall be supplied as spare (in addition to first filling) for maintaining required oil level in case of leakage in tank, radiators, conservator etc.

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.

15.1 Particles in the oil (For 400 kV and above transformer & reactor)

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.

16 BUSHINGS

For various voltage class of transformer/reactor, type of bushings shall be as follows:

Voltage rating	Bushing type
36KV,145KV,245KV and 420KV Bushing for 400KV and below voltage class transformer and Rectors	RIP/RIS

- Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare transformer/reactor with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IS/IEC: 60137. All details of the bushing shall be submitted for approval and design review.
- **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.**
- Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.
- **Bushings of identical rating of different makes shall be interchangeable to optimise the requirement of spares. The standard dimensions for lower portion of the condenser bushings shall be as indicated in Annexure-M.**
- Polymer insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP. The weather sheds of the insulators shall be of alternate shed profile as per IS 16683-3/IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IS 9947. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The polymer insulator shall be capable of high pressure washing**.**
- End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

- **The hollow silicone composite insulators shall comply with the requirements of IEC-61462 and the relevant parts of IEC-62217. The design of the composite insulators shall be tested and verified according to IEC-61462 (Type & Routine test).**
- Clamps and fittings shall be of hot dip galvanised/stainless steel.
- Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- **No** arcing **horns shall be provided on the bushings.**
- Corona shield, wherever required, shall be provided at bushing terminal (air end) to minimize corona.
- 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. 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.
- Oil end portion of RIP/RIS type bushings 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. The pressure of dry air need to be maintained in case of leakage.
- **The** terminal **marking and their physical position shall be as per IS 2026.**
- **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/ RIS) 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.**
- **Tan δ value of OIP/RIP/RIS condenser bushing shall be 0.005 (max.) in the temperature range of 10°C to 40°C. If tan delta is measured at a temperature beyond above mentioned limit, necessary correction factor as per IEEE shall be applicable.**

17 NEUTRAL FORMATION AND EARTHING ARRANGEMENT

For 3-Phase Unit

The neutral of the transformer/reactor shall be brought out through bushing. The neutral of the shunt reactor shall be grounded either directly or through a neutral grounding reactor (NGR) as the case may be. The neutral terminal of transformer/ reactor/NGR shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to a convenient location at the bottom of the tank, for making connection (using bimetallic strip of adequate size) to grounding mat through separate earth pits using two (2) numbers 75 x 12 mm galvanised steel flats. Aluminium clamps & connectors of suitable size shall be provided for connection with neutral of the transformer/ reactor, surge arrester and the neutral grounding reactor (NGR).

18 COOLING EQUIPMENT AND ITS CONTROL

18.1 Radiator based cooling for Power/Auto transformer & Reactor

The transformer/reactor shall be designed with cooler system as specified in **Annexure-A** and with following provisions, as applicable

- The cooler shall be designed using separately mounted 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 complying with IS 513 and minimum thickness 1.2 mm. Each radiator bank shall be provided with the following accessories:**

  (a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
  (b) Top and bottom shut off valve of at least 80mm size
  (c) Drain Valve and sampling valve
  (d) Top and bottom oil filling valves
  (e) Air release plug at top
  (f) Two grounding terminals suitable for termination of two (2) Nos. 75x12 mm galvanised steel flats.
  (g) Thermometer pockets fitted with captive screw caps at cooler inlet and outlet.
  (h) Lifting lugs

- Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint (for separately/ ground mounted cooler banks) shall be provided on top and bottom cooler pipe connection**.**
- **One number standby fan shall be provided with each radiator bank.**
- Cooling fans shall not be directly mounted on radiator. The supporting frames for the cooling fans shall be fixed preferably on separate support or to the main tank in such a manner that the fan vibration does not affect the performance of the radiators and its valves. Fans 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) nos., 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.

- The changeover to standby oil pump in case of failure of service oil pump shall be automatic.
- An oil flow indicator shall be provided for the confirmation of the oil flow direction. 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.
- Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The manufacturer shall recommend the setting of WTI for automatic changeover of cooler control over entire operating range depending on types of cooling system like ONAN/ONAF/OFAF (or ODAF) or ONAN/ONAF1/ONAF2. 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.
- **Following lamp indications shall be provided in cooler control cabinet:**

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan supply failure for each bank
f) Cooling pump supply failure for each pump
g) Common thermal overload trip
h) Thermal overload trip for each fan/pump
i) No oil flow/reverse flow for pumps
j) Stand by fan/pump ON

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and

for single phase unit connection shall be extended further to Common Marshalling Box.

- 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 up to the terminal board in the Cooler Control Cabinet. 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.
- AC power for Cooler Control Circuitry shall be derived 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.

19 VALVES

Type of valves shall be used for transformer/reactor as per following table. The location and size of valves for other application shall be finalised during design review. Utility may specify any other valve required for some other applications.

Sl. No.	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

- All valves up to and including 50 mm shall be of gun metal or of cast steel. 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**.**
- Gland packing/gasket material shall be of "O" ring of nitrile rubber for all the valve's flanges. All the flanges shall be machined**.**
- 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.**
- After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS: 2932 and of a shade (Preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS: 2074 followed by two coats of fully glossy finishing paint.
- 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, if specified, to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.
- All hardware used shall be hot dip galvanised/stainless steel.
- **Flow** sensitive **conservator Isolation valve (if specified)**

    a) In order to restrict the supply of oil in case of a fire in transformer/reactor, flow sensitive valve shall be **provided to isolate the conservator oil from the main tank.** The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall **not operate when oil pumps are switched on or off**. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

    b) When the **flow from conservator** to main tank is **more than the normal operating conditions, the valve shall shut off** by itself and will have to be reset manually. It shall be provided **with valve open/close position indicator along with alarm contact indication in control room** during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset.

20 CABLING

- All interconnecting control and power cables emanating from various parts of transformer/reactor like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Cable terminations shall be through stud type TB and ring type lugs. Type tested cables from approved sources shall be provided. 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. Typical technical specification for cables is attached at **Annexure-H**. 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).

21 TAP CHANGING EQUIPMENT

- Single/ three phase transformer as specified in Annexure-A shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load. The OLTC shall conform to IS 8468/IEC 60214 (Part 1& 2). The requirement of voltage regulation (on HV or LV sides), location (physical and electrical) of tap winding (end of common/ series winding or at neutral end), range of voltage variation, no. of steps etc. shall be as given in **Annexure-A.**
- The OLTC shall be of high-speed transition resistor type. 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 and the chamber shall be designed to withstand the vacuum. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.
- The voltage class, maximum tapping current, step voltage of OLTC shall have adequate design margin for safe & reliable service life of both OLTC and transformer. OLTC shall have long contact life, quick & easy to disassemble diverter switch inserts, simple to adjust & control and easy to replace diverter's contacts etc.
- 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, 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. Provision of a suitable device like tie-in-resistor has to be made, wherever required, to limit the recovery voltage to a safe value. The use of tie-in-resistor (if used) shall be clearly marked in rating and diagram plate of the transformer. The whole of the driving mechanism shall be of robust design and capable of giving satisfactory service without undue maintenance.

- Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.
- As an alternative to conventional OLTC with traditional diverter switch immersed in oil (where arcing takes place in oil), vacuum type OLTC (where arcing takes place in a hermetically sealed vacuum interrupter) may also be provided. However, provisions as specified above shall be followed as far as applicable.

21.1 Local OLTC Control Cabinet (Drive Mechanism Box)

- OLTC shall be suitable for manual (handle operated) and electrical (motor operated) operation. 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 (preferably at a height less than1800mm). The mechanism shall be complete with the following:

  (a) Mechanical tap position indicator, which shall be clearly visible 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, 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 operating 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 following:

    (a) A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor

    (b) Emergency Push Button to stop OLTC operation

    (c) Cubicle light with door switch

    (d) Anti-condensation metal clad heaters to prevent condensation of moisture

    (e) Padlocking arrangement (or locking arrangement suitable for long term operation) for hinged door of cabinet

    (f) All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.

    (g) The cabinet shall be tested at least IP 55 protection class.

- In case auxiliary power supply requirement for OLTC Drive Mechanism (DM) Box is different than station auxiliary AC supply, then all necessary converters shall be provided.
- 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 for digital RTCC/relevant BCU (as applicable)/SCADA system. The tap position indicator shall also be provided in control room.
- 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (i.e. digital RTCC, SCADA, SAS 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 Driving Mechanism (DM) Box. In remote mode electrical commands from digital RTCC/SCADA/SAS etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.
- For 3-phase transformer, the following minimum LED indications shall be provided in DM box:

    (a) INCOMPLETE STEP

(b) OLTC motor overload protection operated
(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

- The following minimum contacts shall be available in DM Box. For three phase unit, and these contacts shall be further wired to digital RTCC panel/relevant BCU (as applicable):

(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. Both ends of all the wires (control & power) connected to Drive Mechanism Box must be provided with proper ferrule nos. for tracing and maintenance.
- A permanently legible lubrication chart and control circuit drawing shall be fitted within the OLTC local control cabinet.

21.2 Remote Control & Monitoring of OLTC (Digital RTCC Relay Panel)

- The digital RTCC relay shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features to remotely control and monitor OLTC.
- Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large LCD (or better) 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 suit 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.
- It shall be possible to communicate/integrate with all digital RTCC relays of different make located at different locations in the substation by making hardwire and using IS/IEC 61850 communication link. The integration of existing conventional RTCC panel with digital RTCC panel of different make shall also be possible.

- The digital RTCC relay shall have Raise/Lower push buttons, Manual/ Automatic mode selection feature, Local/Remote selection feature, Master / Follower/ Independent/ Off mode selection feature for control of OLTC. Touch screen option in the relay (instead of electrical push button/switch) is also acceptable.
- The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA/ SAS, with a facility to have the possibility of additional set points command from SCADA/ SAS.
- **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** is required in Digital RTCC relay for parallel/group operation of transformers. 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 IS/IEC 61850 through fibre optic port to monitor, parameterise and 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.
- Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol.

Suitable communication hardware shall be provided to communicate up to distance of 1 km 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

- The Digital RTCC relay shall have additional programmable Binary Inputs (minimum 8 Nos.) and Binary outputs (minimum 8 Nos.) for 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 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.
- The relay shall incorporate an under voltage / over voltage blocking facility which shall make the control inoperative if voltage falls/ rises by percentage value of set point value with automatic restoration of control when nominal voltage rises / falls to value.
- The relay shall have facility to monitor operating hours of tap changer and register the tap changer statistics. In the statistics mode, the relay shall display the no. of tap changing operations occurred on each tap.
- The relay shall have self-check of power on and shall continually monitor all functions and the validity of all input values to make sure the control system is in a healthy condition. Any monitoring system problem shall initiate the alarm.
- **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

22 CONSTRUCTIONAL FEATURES OF COOLER CONTROL CABINET/ INDIVIDUAL MARSHALLING BOX/ COMMON MARSHALLING BOX/ OUTDOOR CUBICLE/DIGITAL RTCC PANEL

- Each transformer unit shall be provided with local OCTC/OLTC Drive Mechanism Box (DMB), Cooler Control Cabinet/Individual Marshalling Box, Digital RTCC panel (as applicable) and Common Marshalling Box (for a bank of three 1-phase units). Each

reactor unit shall be provided with Individual Marshalling Box and Common Marshalling Box (for a bank of three single phase unit).

- The Cooler Control Cabinet (CCC)/Individual Marshalling Box (IMB), Common Marshalling Box (CMB), and all other outdoor cubicles (except OLTC Drive Mechanism box) shall be made of **stainless-steel sheet of minimum Grade SS 304 and of minimum thickness of 1.6 mm**. Digital RTCC panel shall be made of CRCA sheet of minimum thickness of 2.0 mm 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/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 other (approved) material of better quality, whereas for all indoor control cabinets/Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any other (approved) material of better quality. The gaskets shall be tested in accordance with approved quality plan and IS: 3400.
- All the contacts of various protective devices mounted on the transformer/reactor and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Marshalling Box. All the CT secondary terminals in the Marshalling Box shall have provision for shorting to avoid CT open circuit while it is not in use.
- 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.

23 AUXILIARY POWER SUPPLY FOR OLTC, COOLER CONTROL AND POWER CIRCUIT

- Two auxiliary power supplies of 415 volt, three phase four (4) wire shall be provided by the Purchaser at Cooler Control Cabinet / Marshalling Box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the Cooler Control Cabinet/Marshalling Box.
- For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided in cooler control cabinet/ Marshalling Box.
- Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the manufacturer/contractor .Further any special cable from MB to Digital RTCC panels is also in the scope of the manufacturer/contractor .
- All relays and operating devices shall operate correctly at any voltage within the limits specified below

Normal Voltage	Variation in voltage	Frequency (in Hz)	Phase/Wire	Neutral connection
415 V	±10%	50±5%	3 Phase 4Wire	Solidly earthed
240 V	±10%	50±5%	1 Phase 2 Wire	Solidly earthed
220 V	190 V to 240 V	DC	Isolated 2 wire system	--

- Design features of the transfer scheme shall include the following:

  a) Provision for the selection of one of the feeder as normal source and other as standby.
  b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
  c) Indication to be provided at cooler control cabinet/Individual Marshalling Box/Common Marshalling Box for failure of normal source and for transfer to standby source and also for failure to transfer.
  d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
  e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

- For spare unit which is not connected through isolator switching arrangement, 415 volt, three phase four (4) wire AC supply shall be provided for heater, On line drying system, On line DGA etc. as applicable.

24 BUSHING CURRENT TRANSFORMER AND NEUTRAL 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 provided at **Annexure–F**. The CTs 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. Purchaser's approval shall be obtained before proceeding with the design of bushing current transformers.

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

25 FITTINGS & ACCESSORIES

The following fittings & accessories shall be provided with each transformer/reactor/NGR covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the equipment are deemed to be included.

(a) Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge, prismatic oil level gauge and dehydrating silica gel filter breather with flexible connection pipes to be used during replacement of any silica gel breather.

(b) Conservator for OLTC (for transformer) with drain valve, oil surge relay, filling hole with cap, magnetic oil level gauge, prismatic oil level gauge and dehydrating breather (for transformer only) with flexible connection pipes to be used during replacement of any silica gel breather.

(c) Pressure relief devices with special shroud to direct the hot oil

(d) Sudden pressure relief relay (for 220 kV and above Transformer/Reactor)

(e) Buchholz relay (double float, reed type) with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm/trip contacts.

(f) Conservator air cell rupture detection relay

(g) Air release plug

(h) Inspection openings and covers

(i) Bushing of each type with metal parts and gaskets to suit the termination arrangement

(j) Winding & Oil temperature indicators (local & remote)

(k) Cover lifting eyes, transformer/reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

(l) Protected type alcohol in glass thermometer or magnetic or micro-

switch type dial type temperature indicator as applicable (mercury should not be used)

(m) Rating and diagram plates (in English & Hindi or as specified by the utility) on transformers and auxiliary apparatus

(n) Roller Assembly (flanged bi-directional wheels)

(o) One complete set of all metal blanking plates & covers

(p) On load tap changing gear, DM Box, individual marshalling box/Common Marshalling Box, Cooler control cabinet, and Digital RTCC Panel

(q) Cooling equipment including fans & pumps (as applicable)

(r) Bushing current transformers, Neutral CT

(s) Oil/water flow indicators (if applicable)

(t) Terminal marking plates

(u) Valves schedule plate

(v) Bottom oil sampling valve, Drain valves (provided to drain each section of pipe work independently), Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank & the main 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, Valves for cable box (if applicable), Valve for on line DGA , valves for Drying out system , water inlet and outlet valves (applicable for water cooled transformers), Flow sensitive Conservator Isolation Valve (if applicable), Gate Valve (4 Nos. of min. 50 NB) for UHF sensors for PD Measurements (applicable for 400kV and above voltage class Transformer only), valves for firefighting system (as applicable) and other valves as specified in the specification.

(w) Ladder (suitably placed to avoid fouling with bushing or piping) to climb up to the transformer/reactor tank cover with suitable locking arrangement to prevent climbing during charged condition. Additional ladder for conservator in case it is not tank mounted .

(x) 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/reactor top.

(y) Haulage/ lifting lugs

(z) Suitable terminal connectors on bushings

(aa) Suitable neutral bus connection

(bb) Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing of neutral, HV & IV terminals as per specification.

(cc) On line insulating oil drying system (in 400 kV and above level Transformers/ Reactors) as per **Annexure-K**

(dd) Online DGA (Multi gas)

(ee) NIFPES

(ff) Oil Sampling Bottle & Oil Syringe (if specified) .

(gg) All cables (power, control, and shielded/twisted pair for 4-20mA cables shall be included in this scope. Any special cables required for inclusion up to the Digital RTCC panel

26 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'/OEM 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.

Type tests and FAT are to be performed as per the MQP.

27 DRAWINGS/DOCUMENTS/CALCULATIONS

- **The list of** drawing**/documents/calculations to be submitted by the manufacturer is given in Annexure-C.**
- **All the drawing ,MQP and calculation sheet should in digital format(soft copy with digitally signed). No hard copy allowed.**

28 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.

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					
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/ kVrms		(d) Regulating	kg	
Neutral	kVp/ kVp/ kVrms		Core & Coil Mass	kg	
Guaranteed Temperature rise over ambient temperature of 50 Deg. C			Transportation Mass	kg	
(a) Top Oil	^{0}C		Tank & Fitting mass		
(b) Winding	^{0}C		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 of winding			Paint Shade		
Moisture content	ppm		No load loss at rated voltage & frequency	KW	

Manufacturer's Serial number			Load loss at rated current & frequency (at 75^0C) for HV & IV/LV winding	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) installed in transformer like the location, core Nos., ratio(s), accuracy class, rated output (VA burden), knee point voltage, magnetizing current, maximum CT secondary resistance, terminal marking and application of the current transformer					
Warning: "Main conservator is fitted with an air cell"					

Annexure – A(Technical Parameter)

TECHNICAL PARTICULARS

A. 500MVA (400/220/33 KV, 3-PHASE AUTO TRANSFORMER):(Existing)

Sl. No.	Description	Unit	Technical Parameters
1.	Rated Capacity		
1.1.	HV	MVA	500
1.2.	IV	MVA	500
1.3.	LV (Tertiary)	MVA	5MVA (Thermal loading)
2.	Voltage ratio (Line to Line)		400/220/33
3.	Vector Group (3-Phase)		YNaOd11
4.	Single / Three Phase Design		3 (THREE)
5.	Applicable Standard		IEC 60076 / IS 2026
6.	Cooling		ONAN / ONAF / OFAF
7.	Rating at different cooling	%	60 / 80 / 100
8.	Cooler Bank Arrangement		2 X 50%
9.	Frequency	Hz	50
10.	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation
11.	Type of Transformer		Constant Ohmic impedance type
12.	Impedance at 75 Deg C		
12.1.	HV – IV		
i.	Max. Voltage tap	%	10.3
ii.	Principal tap	%	12.5
iii.	Min. Voltage tap	%	15.4
12.2.	HV – LV		
i.	Principal tap (minimum)	%	60.0
12.3.	IV – LV		
i.	Principal tap (minimum)	%	45.0
13.	Tolerance on Impedance (HV-IV)	%	Positive Tolerance per IEC
14.	Service		Outdoor
15.	Duty		Continuous
16.	Overload Capacity		IEC-60076-7
17.	Temperature rise over 50deg C ambient Temp		
17.1.	Top oil measured by thermometer	℃	45
17.2.	Average winding measured by resistance method	℃	50
18.	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	℃	61
19.	Tank Hotspot Temperature	℃	110
20.	Maximum design ambient temperature	℃	50
21.	Windings		

21.1.	Lightning Impulse withstand Voltage		
i.	HV	kV_p	1300
ii.	IV	kV_p	950
iii.	LV	kV_p	250
iv.	Neutral	kV_p	95
21.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kV_p	1430
ii.	IV	kV_p	1045
iii.	LV	kV_p	275
21.3.	Switching Impulse withstand Voltage		
i.	HV	kV_p	1050
ii.	IV	kV_p	750
21.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kV_{rms}	570
ii.	IV	kV_{rms}	395
iii.	LV	kV_{rms}	95
iv.	Neutral	kV_{rms}	38
21.5.	Neutral Grounding		Solidly grounded
21.6.	Insulation		
i.	HV		Graded
ii.	IV		Graded
iii.	LV		Uniform
21.7.	Tertiary Connection		Ungrounded Delta
21.8.	Tan delta of winding	%	≤ 0.5
22.	Bushing		
22.1.	Rated voltage		
i.	HV	kV	420
ii.	IV	kV	245
iii.	LV	kV	52
iv.	Neutral	kV	72.5
22.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	IV	A	2000
iii.	LV	A	1250
iv.	Neutral	A	2000
22.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1425
ii.	IV	kVp	1050
iii.	LV	kVp	250
iv.	Neutral	kVp	325
22.4.	Switching Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	IV	kVp	850
22.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	695
ii.	IV	kVrms	505

iii.	LV	kVrms	105
iv.	Neutral	kVrms	155
22.6.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
i.	HV	mm	13020
ii.	IV	mm	7595
iii.	LV	mm	1612
iv.	Neutral	mm	2248
22.7.	Tan delta of bushing at ambient Temperature(Temp correction as per IEEE(Beyond 10-40 Degree)	%	≤ 0.5
22.8.	Max Partial discharge level at U_m		
i.	HV	pC	10
ii.	IV	pC	10
iii.	LV	pC	10
iv.	Neutral		-
23.	Max Partial discharge level at 1.58 * Ur / √3	pC	100
24.	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80
25.	**Maximum Permissible Losses of Transformers**		
25.1.	Max. No Load Loss at rated voltage and frequency	kW	90
25.2.	Max. Load Loss between HV & IV at rated current and frequency and at 75^O C	kW	500
25.3.	Max. I^2R Loss at rated current at 75^O C	kW	375
25.4.	Max. Auxiliary Loss at rated voltage and frequency	kW	15
25.5.	Current density of all winding	A/mm2	≤2.8
25.6.	Polarization index		≥1.5

Note:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3.

B. 315MVA, 400/220/33 KV AUTO TRANSFORMER(EXISTING)

Sl. No	Description	Unit	Technical Parameters
1.	Rated Capacity		
1.1.	HV	MVA	315
1.2.	IV	MVA	315
1.3.	LV (Tertiary)	MVA	5MVA (Thermal loading)
2.	Voltage ratio (Line to Line)		400/220/33
3.	Vector Group (3-Phase)		YNaOd11
4.	Single / Three Phase Design		3 (THREE)
5.	Applicable Standard		IEC 60076 /IS 2026
6.	Cooling		ONAN / ONAF / OFAF
7.	Rating at different cooling	%	60 / 80 / 100
8.	Cooler Bank Arrangement		2 X 50%
9.	Frequency	Hz	50
10.	Tap Changer (OLTC)		+10% to -10% in 1.25% steps on common end of series winding for 400kV side voltage variation
11.	Type of Transformer		Constant Ohmic impedance type
12.	Impedance at 75 Deg C		
12.1.	HV – IV		
i.	Max. Voltage tap	%	10.3
ii.	Principal tap	%	12.5
iii.	Min. Voltage tap	%	15.4
12.2.	HV – LV		
i.	Principal tap (minimum)	%	60.0
12.3.	IV – LV		
i.	Principal tap (minimum)	%	45.0
13.	Tolerance on Impedance (HV-IV)	%	Positive Tolerance as per IEC
14.	Service		Outdoor
15.	Duty		Continuous
16.	Overload Capacity		IEC-60076-7
17.	Temperature rise over 50deg C ambient Temp		
17.1.	Top oil measured by thermometer	˚C	45
17.2.	Average winding measured by resistance method	˚C	50
18.	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	˚C	61
19.	Tank Hotspot Temperature	˚C	110
20.	Maximum design ambient temperature	˚C	50
21.	Windings		
21.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1300

ii.	IV	kVp	950
iii.	LV	kVp	250
iv.	Neutral	kVp	95
21.2.	Chopped Lightning Impulse withstand Voltage		
i.	HV	kVp	1430
ii.	IV	kVp	1045
iii.	LV	kVp	275
21.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	IV	kVp	750
21.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	570
ii.	IV	kVrms	395
iii.	LV	kVrms	95
iv.	Neutral	kVrms	38
21.5.	Neutral Grounding		Solidly grounded
21.6.	Insulation		
i.	HV		Graded
ii.	IV		Graded
iii.	LV		Uniform
21.7.	Tertiary Connection		Ungrounded Delta
21.8.	Tan delta of winding	%	≤ 0.5
22.	Bushing		
22.1.	Rated voltage		
i.	HV	kV	420
ii.	IV	kV	245
iii.	LV	kV	52
iv.	Neutral	kV	72.5
22.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	IV	A	1250
iii.	LV	A	1250
iv.	Neutral	A	2000
22.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1425
ii.	IV	kVp	1050
iii.	LV	kVp	250
iv.	Neutral	kVp	325
22.4.	Switching Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	IV	kVp	850
22.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	695
ii.	IV	kVrms	505
iii.	LV	kVrms	105

iv.	Neutral	kVrms	155
22.6.	Tan delta of bushing at ambient Temperature	%	≤ 0.5
22.7.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
i.	HV	mm	13020
ii.	IV	mm	7595
iii.	LV	mm	1612
iv.	Neutral	mm	2248
22.8.	Max Partial discharge level at Um		
i.	HV	pC	10
ii.	IV	pC	10
iii.	LV	pC	10
iv.	Neutral		-
23.	Max Partial discharge level at 1.58 * Ur / √3	pC	100
24.	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80
25.	**Maximum Permissible Losses of Transformers**		
25.1.	Max. No Load Loss at rated voltage and frequency	kW	75
25.2.	Max. Load Loss between HV & IV at rated current and frequency and at 75^{O} C	kW	440
25.3.	Max. I^2R Loss at rated current at 75^{O} C	kW	330
25.4.	Max. Auxiliary Loss at rated voltage and frequency	kW	10
25.5.	Current density of all winding	A/mm2	2.8
25.6.	Polarization index		≥1.5

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

C. 200 &160MVA 220/132 KV 3-PHASE AUTO TRANSFORMER(NEW)

Sl. No.	Description	Unit	Technical Parameters	
1.	Rated Capacity			
1.1.	HV	MVA	200	160
1.2.	LV	MVA	200	160
2.	Voltage ratio	kV	220/132	
3.	Single / Three Phase Design		Three	
4.	Vector Group (3-Phase)		Yna0	
5.	Applicable Standard		IEC 60076 /IS 2026	
6.	Cooling		ONAN / ONAF / OFAF	
7.	Rating at different cooling	%	60 / 80 / 100	
8.	Cooler Bank Arrangement		2 X 50%	
9.	Frequency	Hz	50	
10.	Tap changer			
10.1.	Type		OLTC	
10.2.	Tap Range & steps		–5% to +15% in steps of 1.25% for 132 kV variation	
10.3.	Location of Tap changer		On the 132 kV line end	
11.	HV-LV Impedance at 75 Deg C			
i.	Max. Voltage tap	%	9.5	
ii.	Principal tap	%	12.5	
iii.	Min. Voltage tap	%	14.0	
12.	Tolerance on Impedance	%	Tolerance as per IEC	
13.	Service		OUTDOOR	
14.	Duty		CONTINUOUS	
15.	Overload Capacity		IEC 60076-7	
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	
17.	Winding hot spot rise over yearly weighted temperature of 32 O C	O C	61	
18.	Tank Hotspot Temperature	O C	110	
19.	Maximum design ambient temperature	O C	50	
20.	Windings			
21.	Lightning Impulse withstand Voltage			
i.	HV	kVp	950	
ii.	LV	kVp	650	
iii.	Neutral	kVp	95	
22.	Chopped wave lightning impulse withstand voltage			
i.	HV	kVp	1045	
ii.	LV		715	

23.	Switching Impulse withstand Voltage		
i.	HV	kVp	750
ii.	LV	kVp	540
24.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	395
ii.	LV	kVrms	275
iii.	Neutral	kVrms	38
25.	Neutral Grounding		Solidly grounded
26.	Insulation		
i.	HV		GRADED
ii.	IV		GRADED
27.	Tan delta of winding	%	≤0.5%
28.	Bushings		
28.1.	Rated voltage		
i.	HV	kV	245
ii.	LV	kV	145
iii.	Neutral	kV	72.5
28.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	LV	A	1250
iii.	Neutral	A	2000
28.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	LV	kVp	650
iii.	Neutral	kVp	325
28.4.	Switching Impulse withstand Voltage		
i.	HV	kVp	850
28.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	505
ii.	LV	kVrms	305
iii.	Neutral	kVrms	155
28.6.	Tan delta of bushing at ambientTemperature,(Beyond 10-40 degree correction as per IEEE.)	%	≤ 0.5
28.7.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
i.	HV	mm	7595
ii.	LV	mm	4495
iii.	Neutral	mm	2248
29.	Max Partial discharge level at Um		
i.	HV	pC	10

ii.	LV	pC	10	
30.	Max Partial discharge level at 1.5Um/√3	pC	100	
31.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75	
32.	**Maximum Permissible Losses of Transformers**		200MVA	160MVA
i.	Max. No Load Loss at rated voltage and frequency	kW	35	30
ii.	Max. Load Loss between HV & LV at rated current and frequency and at 75^{O} C	kW	260	200
iii.	Max. I^2R Loss at rated current at 75^{O} C	kW	190	145
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW	8	6
v.	Current density of all winding	A/mm2	≤2.8	≤2.8
vi.	Polarization index		≥1.5	≥1.5

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

D. 100 MVA, 220/33 kV 3-ph Power Transformer(NEW)

Sl. No.	Description	Unit	Technical Parameters
1.	Voltage ratio (Line-to-Line)	kV	220/33
2.	Rated Capacity		
i.	HV	MVA	100
ii.	LV	MVA	100
3.	No of phases		3 (Three)
4.	Vector Group		YNyn0
5.	Type of transformer		Power transformer
6.	Applicable Standard		IEC 60076 / IS 2026
7.	Cooling type		ONAN / ONAF / OFAF
8.	Rating at different cooling	%	60 / 80 / 100
9.	Frequency	Hz	50
10.	Cooler Bank Arrangement		2 X 50%
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
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
13.	Tolerance on Impedance		As per IEC
14.	Service		Outdoor
15.	Duty		Continuous
16.	Overload Capacity		IEC-60076-7
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
18.	Winding hot spot rise over yearly weighted temperature of 32 ^{o} C	^{O}C	61
19.	Tank Hotspot Temperature	^{O}C	110
20.	Maximum design ambient temperature	^{O}C	50
21.	Windings		
21.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	950
ii.	LV	kVp	170
iii.	HV Neutral	kVp	95
iv.	LV neutral	kVp	170

21.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kVp	1045
ii.	LV	kVp	187
21.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	750
21.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	395
ii.	LV	kVrms	70
iii.	HV Neutral	kVrms	38
iv.	LV neutral		70
21.5.	Neutral Grounding (HV & LV)		Solidly grounded
21.6.	Insulation		
i.	HV		Graded
ii.	LV		Uniform
21.7.	Tan delta of winding	%	≤ 0.5
22.	Bushing		
22.1.	Rated voltage		
i.	HV	kV	245
ii.	LV	kV	52
iii.	HV Neutral	kV	52
iv.	LV Neutral	KV	52
22.2.	Rated current		
i.	HV	A	1250
ii.	LV	A	3150
iii.	HV Neutral	A	3150
iv.	LV neutral		3150
22.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	LV	kVp	250
iii.	HV Neutral	kVp	250
iv.	LV neutral	kVp	250
22.4.	Switching Impulse withstand Voltage		
i.	HV	kVp	850
22.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	505
ii.	LV	kVrms	105
iii.	Neutral(HV & LV)	kVrms	105
22.6.	Tan delta of bushing at ambient Temperature	%	≤0.5

22.7.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
i.	HV bushing	mm	7595
ii.	LV bushing	mm	1612
iii.	HV neutral / LV neutral	mm	1612
22.8.	Max Partial discharge level at U_m		
i.	HV	pC	10
22.9.	Max Partial discharge level at 1.58 * U_r / $\sqrt{3}$	pC	100
22.10.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	80
23.	**Maximum Permissible Losses of Transformers**		
i.	Max. No Load Loss at rated voltage and frequency	kW	43
ii.	Max. Load Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	245
iii.	Max. I^2R Loss at rated current and at 75^{O} C for HV and LV windings at principal tap position	kW	200
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW	5
v.	Current density for all winding	A/mm2	≤2.8
vi.	Polarization Index		≥1.5

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

E. 80, 50 & 31.5MVA 132/33 kV 3-Phase Power Transformer(NEW)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS		
1.	Voltage ratio (Line-to-Line)	kV	132/33		
2.	Rated capacity (HV and LV)	MVA	80	50	31.5
3.	No of phases		3 (Three)		
4.	Vector Group		YNyn0		
5.	Type of transformer		Power Transformer		
6.	Applicable Standard		IEC 60076 / IS 2026		
7.	Cooling type		ONAN/ONAF		
8.	Rating at different cooling	%	60 / 100		
9.	Cooler Bank Arrangement		1 X 100%		
10.	Frequency	Hz	50		
11.	Tap changer				
11.1.	Type		On-load tap changer		
11.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation		
11.3.	Location of tap changer		On HV neutral end		
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		
12.1.	Tolerance on Impedance	%	As per IEC		
13.	Service		Outdoor		
14.	Duty		Continuous		
15.	Overload Capacity		IEC 60076-7		
16.	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		
17.	Winding hot spot rise over yearly weighted temperature of 32 ^{o} C		61		
18.	Tank hot spot temperature		110		
19.	Maximum design ambient temperature	^{O}C	50		
20.	Windings				
20.1.	Lightning Impulse withstand Voltage				
i.	HV	kVp	650		
ii.	LV	kVp	170		
iii.	HV Neutral	kVp	95		

iv.	LV Neutral	kVp	170
20.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kVp	715
ii.	LV	kVp	187
20.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	540
20.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	275
ii.	LV	kVrms	70
iii.	HV Neutral	kVp	38
iv.	LV Neutral	kVp	70
21.	Neutral Grounding (HV and LV)		Solidly grounded
22.	Insulation		
i.	HV		Graded
ii.	LV		Uniform
23.	Tan delta of winding	%	≤0.5%
24.	Bushings		
24.1.	Rated voltage		
i.	HV	kV	145
ii.	LV, LV Neutral & HV Neutral	kV	52
24.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	LV	A	1250 for (50 & 31.5MVA) 2000 (for 80MVA)
iii.	HV Neutral & LV Neutral	A	1250
24.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	650
ii.	LV, HV Neutral and LV Neutral	kVp	250
24.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	305
ii.	LV, HV Neutral and LV Neutral	kVrms	105
25.	Tan delta of bushing at ambient Temperature(Beyond 10-40, correction as per IEEE)	%	≤0.5%
25.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)

i.	HV	mm	4495		
ii.	LV, HV Neutral and LV Neutral	mm	1612		
26.	Max Partial discharge level at Um on HV	pC	10		
27.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
28.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	75 for 80MVA & 50MVA 70 for 31.5MVA		
29.	**Maximum Permissible Losses of Transformers**		**80MVA**	**50 MVA**	**31.5 MVA**
i.	Max. No Load Loss at rated voltage and frequency	kW	35	25	18
ii.	Max. Load Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW	200	125	110
iii.	Max. I^2R Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW	170	105	93.5
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW	5	3	2
v.	Current density for all winding	A/mm2	≤2.4	≤2.4	≤2.4
vi.	Polarization Index		≥1.5	≥1.5	≥1.5

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

F. 63 &40MVA 132/33 kV 3-Phase Power Transformer (Existing)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS	
1.	Voltage ratio (Line-to-Line)	kV	132/33	
2.	Rated capacity (HV and LV)	MVA	63	40
3.	No of phases		3 (Three)	
4.	Vector Group		YNyn0	
5.	Type of transformer		Power Transformer	
6.	Applicable Standard		IEC 60076 / IS 2026	
7.	Cooling type		ONAN/ONAF/OFAF(63MVA) ONAN/ONAF(40MVA)	
8.	Rating at different cooling	%	60 / 80/100(63MVA) 80/100(40MVA)	
9.	Cooler Bank Arrangement		2 X 50%(63MVA) 1X 100%(40MVA)	
10.	Frequency	Hz	50	
11.	Tap changer			
11.1.	Type		On-load tap changer	
11.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation	
11.3.	Location of tap changer		On HV neutral end	
12.	HV-LV Impedance at 75 °C, at highest MVA base			
i.	Max. Voltage tap	%		
ii.	Principal tap	%	12.5(Positive tolerance as per IEC)	
iii.	Min. Voltage tap	%		
12.1.	Tolerance on Impedance	%	As per IEC(for other tap)	
13.	Service		Outdoor	
14.	Duty		Continuous	
15.	Overload Capacity		IEC 60076-7	
16.	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	
17.	Winding hot spot rise over yearly weighted temperature of 32 ^{o} C	^{O}C	61	
18.	Tank hot spot temperature	^{O}C	110	
19.	Maximum design ambient temperature	^{O}C	50	
20.	Windings			
20.1.	Lightning Impulse withstand Voltage			
i.	HV	kVp	650	

ii.	LV	kVp	170
iii.	HV Neutral	kVp	95
iv.	LV Neutral	kVp	170
20.2.	Chopped Wave Lightning Impulse Withstand Voltage		
iii.	HV	kVp	715
iv.	LV	kVp	187
20.3.	Switching Impulse withstand Voltage		
ii.	HV	kVp	540
20.4.	One Minute Power Frequency withstand Voltage		
v.	HV	kVrms	275
vi.	LV	kVrms	70
vii.	HV Neutral	kVp	38
viii.	LV Neutral	kVp	70
21.	Neutral Grounding (HV and LV)		Solidly grounded
22.	Insulation		
iii.	HV		Graded
iv.	LV		Uniform
23.	Tan delta of winding	%	≤0.5%
24.	Bushings		
24.1.	Rated voltage		
iii.	HV	kV	145
iv.	LV, LV Neutral & HV Neutral	kV	72.5,52
24.2.	Rated current (Min.)		
iv.	HV	A	1250
v.	LV	A	1250 for (40 MVA) 2000 (for 63MVA)
vi.	HV Neutral & LV Neutral	A	1250
24.3.	Lightning Impulse withstand Voltage		
iii.	HV	kVp	650
iv.	LV, HV Neutral and LV Neutral	kVp	325,250
24.4.	One Minute Power Frequency withstand Voltage		
iii.	HV	kVrms	305
iv.	LV, HV Neutral and LV Neutral	kVrms	155,105
25.	Tan delta of bushing at ambient Temperature.Temp. correction as per IEEE.	%	≤0.5%
25.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system

			voltage)		
iii.	HV	mm	4495		
iv.	LV, HV Neutral and LV Neutral	mm	2248,1612		
26.	Max Partial discharge level at U_m on HV	pC	10		
27.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
28.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	As per NEMA		
29.	**Maximum Permissible Losses of Transformers**		**63MVA**	**40 MVA**	**20 MVA**
vii.	Max. No Load Loss at rated voltage and frequency	kW	31	16	
viii.	Max. Load Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW	130	102	
ix.	Max. I^2R Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW	-	-	
x.	Max. Auxiliary Loss at rated voltage and frequency	kW	5	1.5	
xi.	Current density of all winding	A/mm2	2.4	2.4	
xii.	Polarization index		≥1.5	≥1.5	

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

G. 40MVA 220/33 kV 3-Phase Power Transformer(Existing)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS
1.	Voltage ratio (Line-to-Line)	kV	220/33
2.	Rated capacity (HV and LV)	MVA	40
3.	No of phases		3 (Three)
4.	Vector Group		YNyn0
5.	Type of transformer		Power Transformer
6.	Applicable Standard		IEC 60076 / IS 2026
7.	Cooling type		ONAN/ONAF
8.	Rating at different cooling	%	80 / 100
9.	Cooler Bank Arrangement		1 X 100%
10.	Frequency	Hz	50
11.	Tap changer		
11.1.	Type		On-load tap changer
11.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation
11.3.	Location of tap changer		On HV neutral end
12.	HV-LV Impedance at 75 °C, at highest MVA base		
i.	Max. Voltage tap	%	
ii.	Principal tap	%	12.5(Positive tolerance as per IEC)
iii.	Min. Voltage tap	%	
12.1.	Tolerance on Impedance	%	As per IEC(for other tap)
13.	Service		Outdoor
14.	Duty		Continuous
15.	Overload Capacity		IEC 60076-7
16.	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
17.	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61
18.	Tank hot spot temperature		110
19.	Maximum design ambient temperature	^{O}C	50
20.	Windings		
20.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	950

ii.	LV	kVp	170
iii.	HV Neutral	kVp	95
iv.	LV Neutral	kVp	170
20.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kVp	1045
ii.	LV	kVp	187
20.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	750
20.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	395
ii.	LV	kVrms	70
iii.	HV Neutral	kVp	38
iv.	LV Neutral	kVp	70
21.	Neutral Grounding (HV and LV)		Solidly grounded
22.	Insulation		
i.	HV		Graded
ii.	LV		Uniform
23.	Tan delta of winding	%	≤0.5
24.	Bushings		
24.1.	Rated voltage		
i.	HV	kV	245
ii.	LV, LV Neutral & HV Neutral	kV	52
24.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	LV	A	1250
iii.	HV Neutral & LV Neutral	A	1250
24.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	LV, HV Neutral and LV Neutral	kVp	250
24.4.	Switching Impulse Withstand		
i.	HV	kVp	850
24.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	505
ii.	LV, HV Neutral and LV Neutral	kVrms	105
25.	Tan delta of bushing at ambient Temperature(temp correction beyond 10-40 degree as per IEEE.)	%	≤0.5

25.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)		
i.	HV	mm	7595		
ii.	LV, HV Neutral and LV Neutral	mm	1612		
26.	Max Partial discharge level at Um on HV	pC	10		
27.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
28.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	As per NEMA		
29.	**Maximum Permissible Losses of Transformers**		**40MVA**		
i.	Max. No Load Loss at rated voltage and frequency	kW		18.5	
ii.	Max. Load Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW		129	
iii.	Max. I^2R Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW		-	
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW		1.5	
v.	Current density of all winding	A/mm2		≤2.4	
vi.	Polarization index			≥1.5	

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

H. 20MVA 220/33 kV 3-Phase Power Transformer(Existing)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS
1.	Voltage ratio (Line-to-Line)	kV	220/33
2.	Rated capacity (HV and LV)	MVA	20
3.	No of phases		3 (Three)
4.	Vector Group		YNyn0
5.	Type of transformer		Power Transformer
6.	Applicable Standard		IEC 60076 / IS 2026
7.	Cooling type		ONAN/ONAF
8.	Rating at different cooling	%	80 / 100
9.	Cooler Bank Arrangement		1 X 100%
10.	Frequency	Hz	50
11.	Tap changer		
11.1.	Type		On-load tap changer
11.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation
11.3.	Location of tap changer		On HV neutral end
12.	HV-LV Impedance at 75 °C, at highest MVA base		
i.	Max. Voltage tap	%	
ii.	Principal tap	%	10(Positive tolerance as per IEC)
iii.	Min. Voltage tap	%	
12.1.	Tolerance on Impedance	%	As per IEC(for other tap)
13.	Service		Outdoor
14.	Duty		Continuous
15.	Overload Capacity		IEC 60076-7
16.	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
17.	Winding hot spot rise over yearly weighted temperature of 32 ^{o} C		61
18.	Tank hot spot temperature		110
19.	Maximum design ambient temperature	^{O}C	50
20.	Windings		
20.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	950
ii.	LV	kVp	170
iii.	HV Neutral	kVp	95

iv.	LV Neutral	kVp	170
20.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kVp	1045
ii.	LV	kVp	187
20.3.	Switching Impulse withstand Voltage		
ii.	HV	kVp	750
20.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	395
ii.	LV	kVrms	70
iii.	HV Neutral	kVp	38
iv.	LV Neutral	kVp	70
21.	Neutral Grounding (HV and LV)		Solidly grounded
22.	Insulation		
i.	HV		Graded
ii.	LV		Uniform
23.	Tan delta of winding	%	≤0.5
24.	Bushings		
24.1.	Rated voltage		
i.	HV	kV	245
ii.	LV, LV Neutral & HV Neutral	kV	52
24.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	LV	A	1250
iii.	HV Neutral & LV Neutral	A	1250
24.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	LV, HV Neutral and LV Neutral	kVp	250
24.4.	Switching Impulse Withstand		
i.	HV	kVp	850
24.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	505
ii.	LV, HV Neutral and LV Neutral	kVrms	105
25.	Tan delta of bushing at ambient Temperature(beyond 10-40 degree Temp. correction as per IEEE)	%	≤0.5

25.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)		
i.	HV	mm	7595		
ii.	LV, HV Neutral and LV Neutral	mm	1612		
26.	Max Partial discharge level at Um on HV	pC	10		
27.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
28.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	As per NEMA		
29.	**Maximum Permissible Losses of Transformers**		**20MVA**		
i.	Max. No Load Loss at rated voltage and frequency	kW		12	
ii.	Max. Load Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW		64	
iii.	Max. I^2R Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW		-	
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW		1.0	
v.	Current density of all winding	A/mm2		≤2.4	
vi.	Polarization Index			≥1.5	

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

I. 63MVA 220/33KV Power Transformer(Existing)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS
30.	Voltage ratio (Line-to-Line)	kV	220/33
31.	Rated capacity (HV and LV)	MVA	20
32.	No of phases		3 (Three)
33.	Vector Group		YNyn0
34.	Type of transformer		Power Transformer
35.	Applicable Standard		IEC 60076 / IS 2026
36.	Cooling type		ONAN/ONAF/OFAF
37.	Rating at different cooling	%	60/80 / 100
38.	Cooler Bank Arrangement		2 X 50%
39.	Frequency	Hz	50
40.	Tap changer		
40.1.	Type		On-load tap changer
40.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation
40.3.	Location of tap changer		On HV neutral end
41.	HV-LV Impedance at 75 °C, at highest MVA base		
iv.	Max. Voltage tap	%	
v.	Principal tap	%	12.5(Positive tolerance as per IEC)
vi.	Min. Voltage tap	%	
41.1.	Tolerance on Impedance	%	As per IEC(for other tap)
42.	Service		Outdoor
43.	Duty		Continuous
44.	Overload Capacity		IEC 60076-7
45.	Temperature rise over 50°C ambient temp.		
iii.	Top oil measured by thermometer	^{O}C	45
iv.	Average winding measured by resistance method	^{O}C	50
46.	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61
47.	Tank hot spot temperature		110
48.	Maximum design ambient temperature	^{O}C	50
49.	Windings		
49.1.	Lightning Impulse withstand Voltage		
v.	HV	kVp	950
vi.	LV	kVp	170
vii.	HV Neutral	kVp	95
viii.	LV Neutral	kVp	170

49.2.	Chopped Wave Lightning Impulse Withstand Voltage		
iii.	HV	kVp	1045
iv.	LV	kVp	187
49.3.	Switching Impulse withstand Voltage		
iii.	HV	kVp	750
49.4.	One Minute Power Frequency withstand Voltage		
v.	HV	kVrms	395
vi.	LV	kVrms	70
vii.	HV Neutral	kVp	38
viii.	LV Neutral	kVp	70
50.	Neutral Grounding (HV and LV)		Solidly grounded
51.	Insulation		
iii.	HV		Graded
iv.	LV		Uniform
52.	Tan delta of winding	%	≤0.5
53.	Bushings		
53.1.	Rated voltage		
iii.	HV	kV	245
iv.	LV, LV Neutral & HV Neutral	kV	72.5,52
53.2.	Rated current (Min.)		
iv.	HV	A	1250
v.	LV	A	2000
vi.	HV Neutral & LV Neutral	A	1250
53.3.	Lightning Impulse withstand Voltage		
iii.	HV	kVp	1050
iv.	LV, HV Neutral and LV Neutral	kVp	325,250
53.4.	Switching Impulse Withstand		
ii.	HV	kVp	850
53.5.	One Minute Power Frequency withstand Voltage		
iii.	HV	kVrms	505
iv.	LV, HV Neutral and LV Neutral	kVrms	155,105
54.	Tan delta of bushing at ambient Temperature(beyond 10-40 degree Temp. correction as per IEEE)	%	≤0.5
54.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
iii.	HV	mm	7595

iv.	LV, HV Neutral and LV Neutral	mm	2248,1612		
55.	Max Partial discharge level at Um on HV	pC	10		
56.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
57.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	As per NEMA		
58.	**Maximum Permissible Losses of Transformers**		**63MVA**		
vii.	Max. No Load Loss at rated voltage and frequency	kW		25	
viii.	Max. Load Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV(Including Aux. Loss)	kW		140	
ix.	Max. I^2R Loss at rated current and frequency and at 75^{O} C at principal tap between HV & LV	kW		-	
x.	Max. Auxiliary Loss at rated voltage and frequency	kW		1.0	
xi.	Current density of all winding	A/mm2		≤2.4	
xii.	Polarization Index			≥1.5	

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

J. 20MVA 132/33 kV 3-Phase Power Transformer(Existing)

Sl. No.	Description	Unit	TECHNICAL PARAMETERS
1.	Voltage ratio (Line-to-Line)	kV	132/33
2.	Rated capacity (HV and LV)	MVA	20
3.	No of phases		3 (Three)
4.	Vector Group		YNyn0
5.	Type of transformer		Power Transformer
6.	Applicable Standard		IEC 60076 / IS 2026
7.	Cooling type		ONAN/ONAF
8.	Rating at different cooling	%	80 / 100
9.	Cooler Bank Arrangement		1 X 100%
10.	Frequency	Hz	50
11.	Tap changer		
11.1.	Type		On-load tap changer
11.2.	Tapping range and steps		-15% to +5% in steps of 1.25% for HV variation
11.3.	Location of tap changer		On HV neutral end
12.	HV-LV Impedance at 75 °C, at highest MVA base		
i.	Max. Voltage tap	%	
ii.	Principal tap	%	10.0(Only positive tolerance as per IEC)
iii.	Min. Voltage tap	%	
12.1.	Tolerance on Impedance	%	As per IEC(for other tap)
13.	Service		Outdoor
14.	Duty		Continuous
15.	Overload Capacity		IEC 60076-7
16.	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
17.	Winding hot spot rise over yearly weighted temperature of 32 ^{O}C		61
18.	Tank hot spot temperature		110
19.	Maximum design ambient temperature	^{O}C	50
20.	Windings		
20.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	650
ii.	LV	kVp	170
iii.	HV Neutral	kVp	95

iv.	LV Neutral	kVp	170
20.2.	Chopped Wave Lightning Impulse Withstand Voltage		
i.	HV	kVp	715
ii.	LV	kVp	187
20.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	540
20.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	275
ii.	LV	kVrms	70
iii.	HV Neutral	kVp	38
iv.	LV Neutral	kVp	70
21.	Neutral Grounding (HV and LV)		Solidly grounded
22.	Insulation		
i.	HV		Graded
ii.	LV		Uniform
23.	Tan delta of winding	%	≤0.5%
24.	Bushings		
24.1.	Rated voltage		
i.	HV	kV	145
ii.	LV, LV Neutral & HV Neutral	kV	52
24.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	LV	A	1250
iii.	HV Neutral & LV Neutral	A	1250
24.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	650
ii.	LV, HV Neutral and LV Neutral	kVp	250
24.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	305
ii.	LV, HV Neutral and LV Neutral	kVrms	105
25.	Tan delta of bushing at ambient Temperature(beyond 10-40 degree ,correction as per IEEE.)	%	≤0.5
25.1.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)

i.	HV	mm	4495		
ii.	LV, HV Neutral and LV Neutral	mm	1612		
26.	Max Partial discharge level at Um on HV	pC	10		
27.	Max Partial discharge level at 1.58*Ur/√3	pC	100		
28.	Max Noise level at rated voltage, principal tap & no load and all cooling active	dB	As per NEMA		
29.	**Maximum Permissible Losses of Transformers**			**20 MVA**	
i.	Max. No Load Loss at rated voltage and frequency	kW		11	
ii.	Max. Load Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW		60	
iii.	Max. I^2R Loss at rated current and frequency and at 75° C at principal tap between HV & LV	kW		-	
iv.	Max. Auxiliary Loss at rated voltage and frequency	kW		1.0	
v.	Current density of all winding	A/mm2		≤2.4	
vi.	Polarization Index			≥1.5	

Note

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

K. 160MVA 220/132/33 KV 3-PHASE AUTO TRANSFORMER(Existing)

Sl. No	Description	Unit	Technical Parameters
1.	Rated Capacity		
1.1.	HV	MVA	160
1.2.	IV	MVA	160
1.3.	LV (Tertiary)	MVA	5MVA (Thermal loading)
2.	Voltage ratio (Line to Line)		220/132/33
3.	Vector Group (3-Phase)		YNaOd11
4.	Single / Three Phase Design		3 (THREE)
5.	Applicable Standard		IEC 60076 /IS 2026
6.	Cooling		ONAN / ONAF / OFAF
7.	Rating at different cooling	%	60 / 80 / 100
8.	Cooler Bank Arrangement		2 X 50%
9.	Frequency	Hz	50
10.	Tap Changer (OLTC)		+10% to -10% in 1.25% steps (HV end for very HV 220KV)
11.	Impedance at 75 Deg C		
11.1.	HV – IV		
i.	Max. Voltage tap	%	
ii.	Principal tap	%	10.0(only positive tolerance as per IEC)
iii.	Min. Voltage tap	%	
11.2.	HV – LV		
i.	Principal tap (minimum)	%	60.0(tolerance as per IEC)
11.3.	IV – LV		
i.	Principal tap (minimum)	%	45.0(tolerance as per IEC)
12.	Tolerance on Impedance (HV-IV)	%	only positive tolerance as per IEC
13.	Service		Outdoor
14.	Duty		Continuous
15.	Overload Capacity		IEC-60076-7
16.	Temperature rise over 50deg C ambient Temp		
16.1.	Top oil measured by thermometer	℃	40
16.2.	Average winding measured by resistance method	℃	45
16.3.	Winding hot spot rise over yearly weighted temperature of 32 ^{O} C	℃	61
16.4.	Tank Hotspot Temperature	℃	110
16.5.	Maximum design ambient temperature	℃	50
17.	Windings		
17.1.	Lightning Impulse withstand Voltage		
i.	HV	kVp	950
ii.	IV	kVp	650
iii.	LV	kVp	170

iv.	Neutral	kVp	95
17.2.	Chopped Lightning Impulse withstand Voltage		
i.	HV	kVp	1045
ii.	IV	kVp	715
iii.	LV	kVp	
17.3.	Switching Impulse withstand Voltage		
i.	HV	kVp	750
ii.	IV	kVp	540
17.4.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	395
ii.	IV	kVrms	275
iii.	LV	kVrms	70
iv.	Neutral	kVrms	38
18.	Neutral Grounding		Solidly grounded
19.	Insulation		
i.	HV		Graded
ii.	IV		Graded
iii.	LV		Uniform
20.	Tertiary Connection		Ungrounded Delta
21.	Tan delta of winding	%	≤ 0.5
22.	Bushing		
22.1.	Rated voltage		
i.	HV	kV	245
ii.	IV	kV	145
iii.	LV	kV	52
iv.	Neutral	kV	72.5
22.2.	Rated current (Min.)		
i.	HV	A	1250
ii.	IV	A	1250
iii.	LV	A	1250
iv.	Neutral	A	2000
22.3.	Lightning Impulse withstand Voltage		
i.	HV	kVp	1050
ii.	IV	kVp	650
iii.	LV	kVp	250
iv.	Neutral	kVp	325
22.4.	Switching Impulse withstand Voltage		
i.	HV	kVp	850
ii.	IV	kVp	-
22.5.	One Minute Power Frequency withstand Voltage		
i.	HV	kVrms	505
ii.	IV	kVrms	305
iii.	LV	kVrms	105
iv.	Neutral	kVrms	155
22.6.	Tan delta of bushing at ambient	%	≤ 0.5

	Temperature		
23.	Minimum total creepage distances		(Specific creepage distance: 31mm/kV corresponding to the line to line highest system voltage)
23.1.	HV	mm	13020
23.2.	IV	mm	7595
23.3.	LV	mm	1612
23.4.	Neutral	mm	2248
24.	Max Partial discharge level at U_m		
i.	HV	pC	10
ii.	IV	pC	10
iii.	LV	pC	10
iv.	Neutral		-
25.	Max Partial discharge level at 1.58 * U_r / √3	pC	100
26.	Max Noise level at rated voltage and at principal tap at no load and all cooling active	dB	80
27.	**Maximum Permissible Losses of Transformers**		
27.1.	Max. No Load Loss at rated voltage and frequency	kW	30
27.2.	Max. Load Loss between HV & IV at rated current and frequency and at 75^O C	kW	200
27.3.	Max. I^2R Loss at rated current at 75^O C	kW	145
27.4.	Max. Auxiliary Loss at rated voltage and frequency	kW	06
27.5.	Current density of all winding	A/mm2	≤2.4
27.6.	Polarization index		≥1.5

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. External minimum clearances in air for Phase to Phase and Phase to Earth shall be provided as per IS 2026 (Part 3) / IEC60076-3

Annexure –B(Test plan)

TEST PLAN

Sl No.	Test	72.5 ≤Um ≤170kV	Um > 170kV
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement all taps	Routine	Routine
3.	Phase displacement &Vector group test	Routine	Routine
4.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
5.	Measurement of insulation resistance & Polarization Index	Routine	Routine
6.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
7.	No-load loss & No load current measurement .(90,100 &110% of rated voltage &frequency)	Routine	Routine
8.	Short circuit Impedance , load loss measurement and impedance voltage (all Tap)	Routine	Routine
9.	Full wave lightning impulse test for the line terminals (LI)	Routine	-
10.	Chopped wave lightning impulse test for the line terminals (LIC)	Type	Routine
11.	Applied voltage test (AV)	Routine	Routine
12.	Induced voltage withstand test (IVW)	Routine	-
13.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
14.	On-load tap changer test (Ten complete cycle before LV test)	Routine	Routine
15.	Gas-in-oil analysis (before & after dielectric test)& Oil BDV test	Routine	Routine
16.	Core assembly dielectric and earthing continuity test	Routine	Routine
17.	Oil leakage test on transformer tank	Routine	Routine
18.	Appearance, construction and dimension check	Routine	Routine
19.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
20	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
21.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
22.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
23.	Tank vacuum test	Routine	Routine
24.	Tank pressure test	Routine	Routine
25.	Switching impulse test for the line terminal (SI)	Type	Routine
26	Line terminal AC withstand voltage test (LTAC)	Routine	Type
27	Lightning impulse test for the neutral terminals (LIN)	Type	Type
28.	Temperature rise test	Type	Type
29.	Measurement of Zero seq. reactance	Type	Type

30.	Measurement of harmonic level in no load current(1 to 24th)	Routine	Routine
31.	Measurement of acoustic noise level	Type	Type
32.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type	Type
33.	Dynamic Short circuit withstand test (If specified in Tender)	Type	Type
34	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Type	Type
35	IP-55 Test on Cooler Control Cabinet ,DM and RTCC Panel	Type	Type
36	Capacitance and Tan delta of bushing measurement at variable frequency (in the range of 20 Hz to 350 Hz)	Routine	Routine
37	Check of the ratio and polarity of built-in currenttransformers	Routine	Routine
38	Functional test of cooler control cabinet, RTCC & DM	Routine	Routine

Annexure –C(Design Review Documents)

Design Review Document to be submitted by OEM

Sl. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics up to 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 localized 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 – D(Painting Procedure)

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aesthetically matching to tank
	Manufacturer may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40□m (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--

Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

(*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1

Annexure – E(Oil Parameters)

UNUSED INHIBITED HIGH GRADE INSULATING OIL PARAMETERS

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 40degC	IS 1448 Part 25 or ISO 3104 or ASTM D7042	(Max.)12 mm^2/s
1b.	Viscosity at -30degC		(Max.)1800 mm^2/s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	IS 1448 Part 10/Sec 2 or ISO 3016	(Max.) - 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	(Min.) 50kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	Max 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IS 16086 or IEC 60247 or IEC 61620	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins: <50% & balance Naphthenic compounds.
B	**Refining/Stability**		
1.	Colour	ISO 2049	L0.5 (less than 0.5)
2.	Acidity	IEC 62021-2 or 62021-1	(Max) 0.01 mg KOH/g
3.	Interfacial tension at 27degC	IEC 62961 or ASTM D971	0.043 N/m (min)
4.	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)

5.	Corrosive sulphur	DIN 51353	Not-Corrosive
6.	Potentially corrosive sulphur	IEC 62535	Not-Corrosive
7.	DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)
8.	Presence of oxidation inhibitor	IS 13631 or IEC 60666	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
9.	Metal passivator additives	IEC 60666	Not detectable (<5 mg/kg)
10.	2-Furfural content and related compound content	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for each individual compound
11.	Stray gassing under thermooxidative stress	Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H2) and < 50 µl/l methane (CH4) and < 50 µl/l ethane (C2H6)
C	**Performance**		
1.	Oxidation stability	IEC 61125 (method c) Test duration 500 hour	
2.	Total acidity*	4.8.4 of IEC 61125:2018	0.3 mg KOH/g (Max.)
3.	Sludge*	4.8.1 of IEC 61125:2018	0.05 % (Max.)
4.	Dielectric dissipation factor (tan delta) at 90degC	4.8.5 of IEC 61125:2018	0.05 (Max.)
	*values at the end of oxidation stability test		
D	**Health, safety and environment (HSE)**		
1.	Flash point	IS 1448 Part 21 or ISO 2719	(Min.)135deg C
2.	PCA content	IP 346	< 3%
3.	PCB content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		0.04 N/m (min)
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		

1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability		
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)

Annexure – F (Bushing current Transformer & Neutral CT)

TECHNICAL PARAMETERS OF BUSHING CURRENT TRANSFORMERS & NEUTRAL CURRENT TRANSFORMERS(to be finalize at the time of Design review)

A. Current Transformer Parameters (On each phase) for 3-ph 500MVA 400/220/33 kV Transformers

Description	Current Transformer Parameters (Transformer)			
	HV Side	IV Side	Neutral Side	Outdoor type Neutral Current Transformer
Ratio				
CORE 1	1600/1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	-	-
Minimum knee point voltage or burden and accuracy class				
CORE 1	1600V, PX	1600V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 20VA ISF<5	0.2S Class 20VA ISF<5	-	-
Maximum CT Secondary Resistance				
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	-	-
Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	Metering	-	-
Maximum magnetization current (at knee point voltage)				
CORE 1	25 mA	25 mA	25 mA	25 mA
CORE 2	-	-	-	-

Note i) The OEM shall provide the parameters of the WTI CT for each winding.

ii) The CTs used for REF protection must have identical parameters to minimize circulating currents under normal conditions, ensuring the stability of the protection system.

B. Current Transformer Parameters 3-ph 315 MVA 400/220/33 kV Transformers and 3-ph Transformers)

Description	Current Transformer Parameters (Transformer)			
	HV Side	**IV Side**	**Neutral Side**	**Outdoor type Neutral Current Transformer** (for each bank of three 1-ph units)
a) **Ratio**				
CORE 1	1000/1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-	-
b) Minimum knee point voltage or burden and accuracy class				
CORE 1	1000V, PX	1000V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 20VA ISF<5	0.2S Class 20VA ISF<5		
c) Maximum CT Secondary Resistance				
CORE 1	2.5 Ohm	2.5 Ohm	2.5 Ohm	2.5 Ohm
CORE 2	-	-	-	-
d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	REF (High Impedance)
CORE 2	Metering	Metering	-	-
e) Maximum magnetization current (at knee point voltage)				
CORE 1	60 mA	60 mA	60 mA	60 mA
CORE 2	-	-	-	-

Note i) The OEM shall provide the parameters of the WTI CT for each winding.

ii) The CTs used for REF protection must have identical parameters to minimize circulating currents under normal conditions, ensuring the stability of the protection system.

C. Technical Parameters of Current Transformers (for 200MVA, 220/132kV & 160MVA, 220/132kV 3-Ph Transformers)

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
(a) Ratio			
CORE 1	1000/1	1000/1	1000/1
CORE 2	600/1	1000/1	-
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1000V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 15VA ISF < 5	0.2S Class 15VA ISF < 5	-
(c) Maximum CT Secondary Resistance			
CORE 1	1.5 Ohm	1.5 Ohm	1.5 Ohm
CORE 2	-	-	-
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	-
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	100 mA	100 mA	100 mA
CORE 2	-	-	-

Note i) The OEM shall provide the parameters of the WTI CT for each winding.

ii) The CTs used for REF protection must have identical parameters to minimize circulating currents under normal conditions, ensuring the stability of the protection system

D. Technical Parameters of Current Transformers (for 80MVA 132/33kV 3-Ph Transformer)

Description	Current Transformer Parameters (Transformer)			
	HV Side	HV Neutral Side	LV Side	LV Neutral Side
(a) Ratio				
CORE 1	400/1	400/1	1600/1	1600/1
CORE 2	400/1	-	1600/1	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	400V, PX	400V, PX	1600V, PX	1600V, PX
CORE 2	0.2S Class 15VA ISF < 5	-	0.2S Class 15VA ISF < 5	-
(c) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
(d) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	-	Metering	-
(e) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

Note i) The OEM shall provide the parameters of the WTI CT for each winding.

ii) The CTs used for REF protection must have identical parameters to minimize circulating currents under normal conditions, ensuring the stability of the protection system

E. Parameters of Current Transformer for 50MVA (3-ph), 132/33kV and 31.5 MVA (3- ph) 132/33kV Transformers

Description	Current Transformer Parameters (Transformer)			
	HV Side	**HV Neutral Side**	**LV Side**	**LV Neutral Side**
(f) Ratio				
CORE 1	300/1	300/1	1000/1	1000/1
CORE 2	300/1	-	1000/1	-
(g) Minimum knee point voltage or burden and accuracy class				
CORE 1	300V, PX	300V, PX	1000V, PX	1000V, PX
CORE 2	0.2S Class 15VA ISF < 5	-	0.2S Class 15VA ISF < 5	-
(h) Maximum CT Secondary Resistance				
CORE 1	1.5 Ohm	1.5 Ohm	4 Ohm	4 Ohm
CORE 2	-	-	-	-
(i) Application				
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Metering	Restricted Earth Fault
CORE 2	Metering	-	Metering	-
(j) Maximum magnetization current (at knee point voltage)				
CORE 1	100 mA	100 mA	25 mA	25 mA
CORE 2	-	-	-	-

Note

i) The OEM shall provide the parameters of the WTI CT for each winding.

ii) The CTs used for REF protection must have identical parameters to minimize circulating currents under normal conditions, ensuring the stability of the protection system

Annexure – G (Check list)

Check Lists for Transformer & Reactor Tests

Sl. No.	**Test**	**Acceptance Criteria***	**Check list (✓ if conducted)**
1.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Insulation power factor for windings < 0.5% Insulation power factor for Bushing as per GTP/TS	
2.	Measurementof insulation resistance & Polarization Index	PI >≥ 1.5	
3.	Core assembly dielectric and earthing continuity test	IR >1 GΩ	
4.	Measurement of winding resistance	As per GTP	
5.	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	Refer procedure (As Per IEC)	
6.	Switching impulse test for the line terminal (SI)		
7.	Applied voltage test (AV)	No collapse of voltage or other sign of breakdown	
8.	Induced voltage withstand test (IVW)		
9.	Induced voltage test with PD measurement (IVPD)	Refer IEC60076-3	
10.	Temperature rise test	As per GTP/ TS	
11.	Measurement of acoustic noise level	As per GTP/ TS	
12.	High voltage with stand test on auxiliary equipment and wiring after assembly	No voltage collapse or other sign of breakdown	
13.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	For record	
14.	Oil leakage test on transformer/ Reactor tank	No oil leakage	
15.	Tank vacuum test	Refer procedure	
16.	Tank pressure test	Refer procedure	
17.	Appearance, construction and dimension check	Dimensions measured shall match with approved GA drawing	

OTHER TEST

Sl. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Voltage ratio measurement & Polarity check (Vector Group)	≤0.5% as per IEC 60076-1 for Voltage ratio. Vector group as per specification.	
2.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC	For record	
3.	No-load loss and current measurement	As per GTP / TS	
4.	Measurement of harmonic level in no load current	For record	
5.	Magnetic balance test (for three phase Transformer only)	CBIP manual	
6.	On-load tap changer test	IEC 60214	
7.	Measurement of short-circuit impedance and load loss	As per GTP/ TS	
8.	Line terminal AC withstand voltage test (LTAC)	No collapse of voltage or other sign of breakdown	
9.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Refer procedure	
10	Over excitation test	Refer procedure	
11.	Measurement of Zero seq. reactance (for three phase Transformer only)	As per GTP/ TS	
12	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	As per GTP/ TS	
13.	Dynamic Short circuit withstand test (If specified in Tendor)	Refer procedure	

Annexure-H(GTP of PVC Cable)

PVC Power Cables

The PVC-insulated 1100V-grade power cables shall be of Fire Retardant Low Smoke Halogen (FRLSH) type, C2 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification, and shall be suitable for a steady conductor temperature of 85°C. The conductor shall be stranded aluminum H2 grade conforming to IS 8130. The insulation shall be extruded PVC of type C of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multi-core armored cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all cables. The copper cable of the required size can also be used.

PVC Control Cables

The 1100V grade control cables shall be of FRLSH type, C2 category, conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC of type A of IS: 5831. A distinct inner sheath shall be provided in all cables, whether armored or not. The outer sheath shall be extruded PVC of type ST-1 of IS: 5831 and shall be grey in color except where specifically advised by the purchaser to be black.

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).

Annexure-I (TS of Portable DGA)

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

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 &H2Oconcentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47- clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records

06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
07	Operating Temperature, Relative humidity & Dimensions	01. Temperature 0-50 Deg. C 02. 85% non-condensing 03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

Annexure-J(TS of Online Dissolved Gas (Multi-gas) and Moisture Analyser)

Online Dissolved Gas (Multi-gas) and Moisture Analyser (If specified)

A. 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.

B. 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

C. 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.

D. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

E. 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.

F. 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.

G. 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 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

H. The equipment must have an automatic calibration facility at fixed intervals. For calibration, if anything is required, including a cylinder, it must be mounted with the equipment.

The technical features 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

I. 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

J. 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
- Operation Manual (2 set for every unit),
- Software Manual and
- Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

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

L. 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-k(On-line insulating oil drying system (Cartridge type)

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each Transformer shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

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

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

vii. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the test set up. During this period, if the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc. of kit for repair at test lab/works.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

Annexure-L(Nitrogen Injection Type Fire Prevention & Extinguishing System)

1. Scope of work is to design, supply, erection, testing and commissioning of Nitrogen Injection system for protection against the transformer explosion and fire upto 400 KV Transformers including all required civil works of oil sump, foundations, any other required for satisfactory working of system.
2. Each oil filled transformer shall be provided with a dedicated Nitrogen Injection system for prevention against the transformer explosion which shall use nitrogen as quenching medium. The system shall prevent transformer oil tank explosion and possible fire in case of internal / external cause. In the event of fire by external causes such as bushing fire, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water or carbon dioxide. Fire shall be extinguished within reasonable time (not more than 3 minutes so as not to harm the transformer) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The offered NIFPS system should have been in successful operation in Indian installations for at least last five years for protection of transformers of 220 KV and higher voltage class. The list of past supplies in India along with performance certificate from Central or State Government Power sector utilities, using the above system shall be submitted along with the bid offer.

3. Nitrogen Injection system should be a dedicated system for each oil filled transformer. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the firewall (if fire fighting wall exists). The FEC shall be connected to the top of transformer / reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer / reactor tank / or existing oil pit) from its bottom through oil pipes. The FEC should house a pressurized nitrogen cylinder (s) which is connected to the oil tank of transformer /reactor oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to FEC and from TCIV to signal box. Detectors placed on the top of transformer / reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

4. Activation **of the system**

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).

5. Mal-functioning of the Nitrogen injection system could lead to interruption in power supply. The supplier shall ensure that the probabilities of chances of malfunctioning of the Nitrogen injection system are practically zero. To achieve this objective, the supplier shall plan out scheme of activating signals which should not be too complicated to make the system inoperative in case of actual need. The system shall be provided with automatic controls to prevent the explosion of transformers. Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. The following electrical-signals shall be used for activating the system under prevention mode/fire extinguishing mode.

6. **.Auto Mode**
   For prevention:

- Differential relay operation.
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)
- Tripping of all circuit breakers (on HV & LV/IV side) associated transformer / reactor is the pre-requisite for activation of system.

7. **For extinguishing**
   - Fire Detector
   - Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay).

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system.

8. Manual Mode (Local / Remote)

Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

9. Manual Mode (Mechanical)

- Tripping of all circuit breakers (on HV & LV / IV side) associated with transformer / reactor is the pre-requisite for activation of system.

The system shall be designed to be operated manually in case of failure of power supply to the system.

10. Operation

On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

- Electrical isolation of transformer shall be an essential pre-condition for activating the system, to avoid nitrogen injection in energized transformer.
- The system shall have provision of testing on live transformers to ensure healthiness at all times.
- The system shall have mechanical locking arrangement for nitrogen release system as well as oil drain to avoid unnecessary operation during maintenance and /or testing of the transformer and / or system.
- The system shall have provision to monitor nitrogen injection pressure as well as cylinder pressure.
- Pressure monitoring switch for back up protection for nitrogen release as redundancy to first signal of oil draining commencement for nitrogen release shall preferably be provided.
- System shall have individual mechanical release devices and provision for oil drain and nitrogen release to operate manually in case of operation DC supply failure.
- Nitrogen release scheme shall be designed in such a way that the nitrogen gas shall not enter the energized transformer tank even in case of passing / leakage of valve.
- Individual system component / equipment should operate on station DC voltage. AC-DC / DC-DC converter shall not be used for reliable operation.
- All outdoor panels / equipment shall be of IP-55 protection class.

11. **System components:-**

Nitrogen Injection system shall broadly consist of the following components. However, all other components which are necessary for fast, reliable and effective working of the system shall be deemed to be included in the scope of supply.

12. **CUBICLE (FEC):-**

The Cubicle Frame shall be made of Aluminium Alloy sheet of 3 mm (minimum) thick /Stainless steel of 1.5 mm thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5). It shall have hugged / hinged split doors fitted with high quality tamper proof lock. The doors, removable covers and panels shall be gasketted all round with neoprene gaskets. The degree of protection shall be IP55. The following items shall be provided in the Cubicle.

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer / reactors.
- Panel lighting (LED Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.
- Space heater.

13. **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 given table below. 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 pipes and physical connections from transformer to oil pit shall be in the scope of contractor.

Painting	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thickness (DFT)**	**Colour shade**
OilStorageTank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum155µm	RAL 7035

*indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

This storage tank shall be placed in the pit made up 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.

14. **Control box:-**

Control box is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- System Oil.
- TCIV open.
- Oil drain valve closed.
- Gas inlet valve closed
- TCIV closed
- Detector trip
- Buchholz relay trip
- Oil drain valve open
- Extinction in progress
- Cylinder pressure low
- Differential relay trip
- PRV / RPRR trip
- Transformer / reactor trip
- System out of service
- Fault in cable connecting fault detector
- Fault in cable connecting differential relay
- Fault in cable connecting Buchholz relay
- Fault in cable connecting PRV / RPRR / OSR
- Fault in cable connecting transformer reactor trip
- Fault in cable connecting TCIV
- Auto / Manual / Off
- Extinction release on / off
- Lamp test
- Visual / Audio alarm for AC supply fail
- Visual / Audio alarm for DC supply fail

As far as possible, the control box should be so devised that all the transformers and reactors or group thereof should be controlled from single spot.

15. **Transformer Conservator Isolation Valve:-**

Transformer conservator isolation valve (TCIV) is to be fitted in the conservator pipe line, between conservator and buchholz relay, which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer / reactor.

Locking plates shall be provided for pad locking.

16. **Detectors:-**

The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

17. **Signal box:-**

It shall be mounted away from transformer / reactor main tank, preferably near the transformer marshaling box, for terminating cable connections from TCIV & detectors and for further connection to the control box. The degree of protection shall be IP55.

18. **Cables:-**

Fire survival cables (capable to withstand 750º C.) of 4 core x 1.5 sq. mm size for connection of detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.

Fire Retardant Low Smoke(FRLS) cable of adequate size shall be used for connection of signal box / marshaling box near transformer / reactor and FEC mounted near transformer/ reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshaling box to transformer conservator isolation valve connection on transformer / reactor. Separate cables for AC supply & DC supply shall be used.

19. **Pipes:-**

Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

20. **Other items to be supplied:-**

a) Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.
b) Flanges between Buchholz relay and conservator tank for fixing TCIV.
c) Detector brackets on transformer / reactor tank top cover.
d) Spare potential free contacts activating the system i.e. in differential relay, Bucholz relay. Pressure Relief Device / RPRR , Circuit breaker of transformer / reactor.
e) Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.
f) Cabling for detectors mounted on transformer / reactor top cover.
g) Inter cabling between signal box, control box and FEC.
h) Butterfly valves / Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.
i) Supports, signal box etc. which are to be painted with enameled paint.

j) Any other item required for satisfactory operation of system.

21. **Power supply:-**

For Control Box: As per substation DC voltage.

For FEC Auxiliary: 230 V AC

22. **Modification on the transformer:-**

No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.) safety, life etc. or its any other useful parameter. This requirement shall be of paramount importance and shall form the essence of the contract.

However, in any case, performance of transformer should not be affected in any manner by having Nitrogen Injection Fire Prevention Cum Extinguishing System (NIFPES) and the Contractor / Sub-Contractor shall give an undertaking to this effect. All pipes should be washed / rinsed with transformer oil. If any damage is done to the transformer and / or any connected equipment during installation, commissioning, full recovery therefore shall be effected from the Contractor / Sub-Contractor, of NIFPES system.

It shall be solely the responsibility of Contractor / Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at the mentioned Sub-Station in this specification, to the entire satisfaction of the OPTCL.

23. **Interlocks:-**

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PRV shall get closed only if all the connected breakers are open.

24. **Tests:-**

Supplier has to carry out the type test as per relevant IS/IEC. Specifically IP 55 on FEC or have to produce the report from NABL approved Lab.

Reports of all routine test conducted as per relevant IS/IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted by the supplier.

The supplier shall demonstrate the entire functional tests, associated with the following as Factory Acceptance Tests:

- FEC, Control Box
- Fire Detector
- Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site.

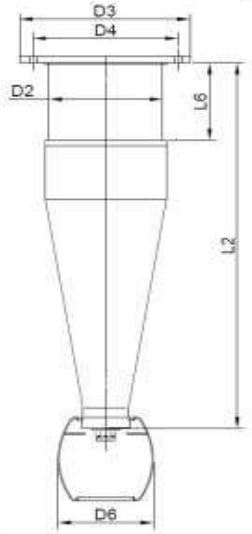
Detailed layout drawings, equipment drawing along with 4 sets of Operation and Maintenance manual along with soft copies shall be submitted by the supplier along with the consignment.

Any other particulars, considered necessary in addition to those listed in that Section may be furnished by the Bidder.

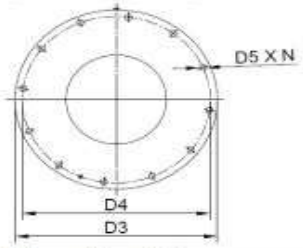
25. **Supervision of Erection, Testing & Commissioning: -** The erection, testing and commissioning of the Nitrogen Injection Type Fire Prevention & Extinguishing System(NIFPES) at OPTCL site shall be carried out under direct supervision of the Service Engineer of NIFPES manufacturer(s). The Bidder shall furnish authorization letter(s) from such manufacturer(s) with their bid.

Annexure-M (Standard dimension for lower portion of condenser Bushing)

STANDARD DIMENSIONS FOR LOWER PORTION OF CONDENSER BUSHINGS
(For 2500 A, 800 kV and 420 kV voltage class Bushings)



Bushing Mounting Flange Details

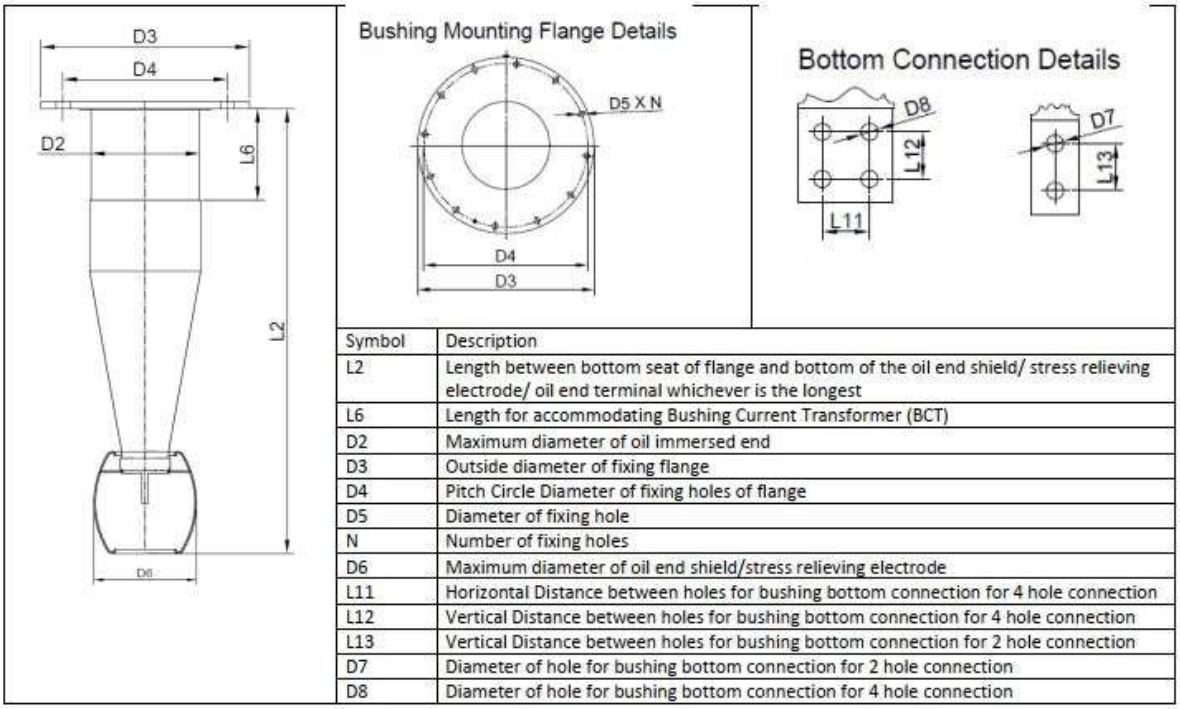


Bottom Connection Details

Symbol	Description
L2	Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest
L6	Length for accommodating Bushing Current Transformer (BCT)
D2	Maximum diameter of oil immersed end
D3	Outside diameter of fixing flange
D4	Pitch Circle Diameter of fixing holes of flange
D5	Diameter of fixing hole
N	Number of fixing holes
D6	Maximum diameter of oil end shield/stress relieving electrode
D8	Diameter of hole for oil end terminal

Voltage Rating (kV)	**800**	**420**
BIL kVp	2100	1425 1550 (for GT)
Creepage Distance (mm) (min.)	24800	13020
Current Rating (A)	**2500**	**2500**
Type of lead	Solid Stem (SS)	SS
L2 ±5	1955 (excluding bottom terminal end shield)	1335
L6 (min.)	600	600
D2 (max.)	528	350
D3±2	780	480
D4±1 (PCD)	711	430
D5xN	32x12	20x8
D6 (max.)	420	350
D8	Φ12	Φ12
No. of holes and depth of bolt for oil end terminal	6; 20	6; 20
Length & Diameter of Air End Terminal	125 & Φ 60	125 & Φ 60

STANDARD DIMENSION FOR LOWER PORTION OF CONDENSER BUSHINGS
(For 420 kV and below voltage class Bushings)



Symbol	Description
L2	Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest
L6	Length for accommodating Bushing Current Transformer (BCT)
D2	Maximum diameter of oil immersed end
D3	Outside diameter of fixing flange
D4	Pitch Circle Diameter of fixing holes of flange
D5	Diameter of fixing hole
N	Number of fixing holes
D6	Maximum diameter of oil end shield/stress relieving electrode
L11	Horizontal Distance between holes for bushing bottom connection for 4 hole connection
L12	Vertical Distance between holes for bushing bottom connection for 4 hole connection
L13	Vertical Distance between holes for bushing bottom connection for 2 hole connection
D7	Diameter of hole for bushing bottom connection for 2 hole connection
D8	Diameter of hole for bushing bottom connection for 4 hole connection

Voltage Rating (kV)	**420**	**245**		**145**		**72.5**		**52**
BIL kVp	1425 1550(for GT)	1050		650		325		250
Creepage Distance (mm)	13020	7595		4495		2248		1612
Current Rating (A)	**1250**	**1250**	**2000**	**1250**	**2000**	**800**	**2000**	**1250**
Type of lead	Solid Stem (SS)	SS	SS	SS	SS	SS		SS
L2 ±5	1640	1130	1230	800/ 1250[a]	1030	695		450
L6 (min.)	400	300		300/500 [a]	300	300		100
D2 (max.)	350	270		165	180	115	165	115
D3±2	720	450		335	335	225	335	225
D4±1 (PCD)	660	400		290	290	185	290	185
D5xN	24x12	20x12		15x12	15 x12	15x6	15x12	15x6
D6 (max.)	350	270		180		115		115
L11	-	-	45	-	45	-	55	-
L12	-	-	40	-	40	-	40	-
L13	40	40	-	40	-	40	-	40
D7	Φ14	Φ14		Φ14	Φ14	Φ14	Φ14	Φ14
D8	-	-	Φ 14	-	-	-	-	-
Length & Diameter of Air End Terminal	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60

Annexure-N (Requirement of Major accessories)

Sl. No.	MVA CAPACITY	REQUIREMENT
1	31.5MVA AND BELOW	NIFPES
2	50MVA,80MVA	NIFPES,ODS
3	100MVA,200MVA,160MVA	NIFPES,ODS,ONLINE DGA
4	315MVA,500MVA	NIFPES,ODS,ONLINE DGA

Annexure-O(Stage and Final inspection Plan)

Sl. No	PARTICULARS	STAGE	FINAL	LAB STATUS
1	CRGO	Mother coil verification, Samling for CRGO testing from NABL lab, slitting, cutting & packing.		If having own NABL lab ,sample can be tested .if not having NABL lab send to third party NABL lab.
2	BUSHING	Fat at OEM premises as per IEC &TS	FAT at transformer manufacturer	Should have NABL LAB
3	INSULATING OIL	Test at oil manufacturer premises as per IS/IEC.(for total quantity of oil)	As per FAT	Should have NABL LAB
4	Marshalling box, DM,RTCC panel	IP55 test for one sample for a lot	Functional & other test	FROM NABL LAB
5	TANK	Vacuum ,pressure test & other test		
6	OLTC	FAT at OEM premises as per IEC &TS	Functional & other test	SHOULD HAVE NABL LAB
7	WINDING	AS PER MQP		SHOULD HAVE NABL LAB
8	CORE BUILDING AND FRAME ASSEMBLY	AS PER MQP		SHOULD HAVE NABL LAB
9	CORE COIL ASSEMBLY	AS PER MQP		SHOULD HAVE NABL LAB
10	NIFPES		Functional test	
11	TRANSFORMER		FAT TEST	SHOULD HAVE NABL LAB

QAP will be issued after Design review.

Annexure-P (Sub Vendor list for Transformer components)

1	CTC/PICC	ASTA,AUSTRIA
	CTC/PICC	RATIONAL ENGINEERS LTD, PALGHAR
	CTC/PICC	SHREE CABLES & CONDUCTORS BHOPAL
	CTC/PICC	KSH INTERNATIONAL, CHAKAN
	CTC/PICC	PRECISION WIRES INDIA LTD, SILVASSA
	CTC/PICC	SAMDONG, KOREA
	CTC/PICC	APAR INDUSTRIES LTD
	CTC/PICC	TOSHIBA TRANSMISSION AND DISTRIBUTION
	CTC/PICC	ASTA INDIA, VADODARA
	CTC/PICC	BHANDARY POWER LINE, MANIPAL
	CTC/PICC	BCPL, MANDIDEEP
	CTC/PICC	MP ELECTRICALS, BHOPAL
	CTC/PICC	SHAKTI INSULATED WIRES PVT LTD
	CTC/PICC	SIGNET CONDUCTORS PVT. LTD., REWA
	CTC/PICC	RATIONAL ENGINEERS LIMITED,
2	KRAFT INSULATING PAPER	AHLSTROM MUNKSJO, SWEDEN
	KRAFT INSULATING PAPER	KAMMERER GERMANY
	KRAFT INSULATING PAPER	NORDIC PAPER AMOTFORS AB
	KRAFT INSULATING PAPER	WIEDMAN ELECTRICAL, SWITZERLAND
	KRAFT INSULATING PAPER	TERVAKOSKI OY, FINLAND
	KRAFT INSULATING PAPER	WIEDMAN ELECTRICAL, SWITZERLAND
	KRAFT INSULATING PAPER	CINDUS CORPORATION, USA
	KRAFT INSULATING PAPER	TOMOEGAWA CO. LTD, JAPAN
	PRECOMPRESSED PRESS BOARD	ABB FIGEHOLMS , SWEDEN

3	PRECOMPRESSED PRESS BOARD	ABB AB, SWEDEN
	PRECOMPRESSED PRESS BOARD	SENAPATHY WHITELEY – BANGALORE
	PRECOMPRESSED PRESS BOARD	OJI F-TEX CO LTD. JAPAN
	PRECOMPRESSED PRESS BOARD	ABB POWER PRODUCTS & SYSTEMS INDIA LTD
	PRECOMPRESSED PRESS BOARD	ENPAY , TURKEY
	PRECOMPRESSED PRESS BOARD	H WEIDMANN SWITZERLAND
4	CRGO STEEL	THYSSENKRUPP ELECTRICAL STEEL INDIA PVT
	CRGO STEEL	TKES GERMANY
	CRGO STEEL	POSCO, KOREA
	CRGO STEEL	NOVOLIPETSK STEEL (NLMK), RUSSIA
	CRGO STEEL	NIPPON STEE,JAPAN
	CRGO STEEL	FE STEEL CORP. , JAPAN
	CRGO STEEL	AST ITALY
	CRGO STEEL	AK STEEL, USA
	CRGO STEEL	ACESITA, BRAZIL
5	CRGO CUTTING AND SLITTING	AMOD STAMPING PVT. LTD, VADODARA
	CRGO CUTTING AND SLITTING	MAHINDRA STEEL SERVICE CENTRE (MANDIDEEP)
	CRGO CUTTING AND SLITTING	KRYFS POWER COMPONENTS LTD, SILVASSA
	CRGO CUTTING AND SLITTING	MAHINDRA INTERTRADE LTD. (SAVLI-VADODARA
	CRGO CUTTING AND SLITTING	MAHINDRA STEEL SERVICE CENTRE (PUNE)
	CRGO CUTTING AND SLITTING	NEXUS ELECTRO STEEL LTD., THANE
	CRGO CUTTING AND SLITTING	NLMK INDIA SERVICE CENTRE PVT. LTD., DAMAN
	CRGO CUTTING AND SLITTING	JFE SHOJI STEEL INDIA PVT. LTD., PUNE
	CRGO CUTTING AND SLITTING	POSCO POGGENAMP ELECTRIC STEEL PVT LTD., KHEDA

	CRGO CUTTING AND SLITTING	POSCO-TMC INDIA PVT LTD., PUNE.
6	NITRILE RUBBER SHEET, GASKETS,O-RINGS	BANDO CHEMICALS CO. LTD., SOUTH KOREA
	NITRILE RUBBER SHEET, GASKETS,O-RINGS	BANDO CHEMICALS CO. LTD., SOUTH KOREA
	NITRILE RUBBER SHEET, GASKETS,O-RINGS	NU CORK PRODUCTS PVT LTD, BHIWADI
	NITRILE RUBBER SHEET, GASKETS,O-RINGS	MA-GUMI KFT, KIRALY HUNGARY
	NITRILE RUBBER SHEET, GASKETS,O-RINGS	BOMBAY OIL SEAL MFG CO MUMBAI
7	CONDENSOR BUSHING(OIP)(UP TO 400KV)	ABB AB, SWEDEN
	CONDENSOR BUSHING(OIP)(UP TO 400KV)	MASA LLC, RUSSIA
	CONDENSOR BUSHING(OIP)(UP TO 400KV)	CGL NASIK
	CONDENSOR BUSHING(OIP)(UP TO 400KV)	GE T&D INDIA LIMITED, HOSUR
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	ABB AB , SWEDEN
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	MASSA IZOLYTOR MEHRU PVT LTD (MIM)
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	MASA LLC, RUSSIA
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	MGC MOSER-GLASER AG, SWITZERLAND
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	HSP, GERMANY
	RIP-CONDENSOR BUSHINGS (UPTO 400 KV)	GE GRID SOLUTIONS
8	RIP-CONDENSOR BUSHINGS (UPTO 245KV)	YASH HIGHVOLTAGE LTD, VADODARA

9	RIP-CONDENSOR BUSHINGS (UPTO 145KV)	CG,NASIK(CONDITIONAL)
10	BUSHING CURRENT TRANSFORMER	MAHENDRA ELECTRICALS, MUMBAI
	BUSHING CURRENT TRANSFORMER	ENPAY, TURKEY
	BUSHING CURRENT TRANSFORMER	NARAYAN POWERTECH, VADODARA
	BUSHING CURRENT TRANSFORMER	PRAGATI ELECTRICALS PVT. LTD., THANE
	BUSHING CURRENT TRANSFORMER	SAMDONG CO. LTD., SOUTH KOREA
	BUSHING CURRENT TRANSFORMER	T & R INDIA LTD
	BUSHING CURRENT TRANSFORMER	AGARWAL INDUSTRIES, BHOPAL
11	BUCHLOZ RELAY	SUKRUT ELECTRIC CO. PVT. LTD., PUNE
	BUCHLOZ RELAY	VIAT INSTRUMENTS PVT. LTD., AHMEDABAD
	BUCHLOZ RELAY	CEDESPE, ITLAY
	BUCHLOZ RELAY	ETI CEDASPE MR, ITALY
12	TERMINAL CONNECTOR	KLEMMEN ENGG. CORP. , CHENNAI
	TERMINAL CONNECTOR	NOOTAN ENGINEERING VADODARA
	TERMINAL CONNECTOR	MILIND ENGG MUMBAI
	TERMINAL CONNECTOR	PEEVEE ENGG. BANGALORE
	TERMINAL CONNECTOR	VINAYAK TRANSMISSION PRODUCTS PVT. LTD., MUMBAI
	TERMINAL CONNECTOR	HYOSUNG
13	DIGITAL RTCC (AVR)	PRADEEP SALES & SERVICES PVT LTD, MUMBAI
	DIGITAL RTCC (AVR)	MR, GERMANY
	DIGITAL RTCC (AVR)	E-BERLE,
14	OTI / WTI	QUALITROL AKM, SWEDEN

	OTI / WTI	PERFECT CONTROL, CHENNAI
15	PRV/PRD	SUKRUT UDYOG
	PRV/PRD	VIAT INSTRUMENTS PVT. LTD
16	RADIATORS	BHEL, BHOPAL
	RADIATORS	CTR MANUFACTURING INDUSTRIES PVT LTD,
	RADIATORS	FRESCO RADIATORS PVT. LTD, THANE
	RADIATORS	GURURAJ RADIATORS PVT LTD, NAINI
	RADIATORS	HI-TECH RADIATOR PVT LTD., MUMBAI,
	RADIATORS	MENK, GERMANY
	RADIATORS	TARANG ENGINEERING PVT LTD, NAGPUR
	RADIATORS	THERMAL TRANSFER BANGALORE
	RADIATORS	TRIVENI ELECTROPLAST PVT LTD., ALLAHABAD
	RADIATORS	TTP TECHNOLOGIES PVT LTD
17	CRCA SHEETS	JSW STEELS LTD
	CRCA SHEETS	SAIL
	CRCA SHEETS	TISCO
	CRCA SHEETS	BHUSAN STEEL
18	INSULATING OIL	APAR LTD SILVASA
	INSULATING OIL	APAR LTD,THANE
	INSULATING OIL	SAVITA OIL TECHNOLOGIES LTD, SILVASSA
	INSULATING OIL	SAVITA OIL TECHNOLOGIES LTD, NAVI MUMBAI
	INSULATING OIL	RAJ PETRO, SILVASA
	INSULATING OIL	RAJ PETRO, CHENNAI
19	ON LINE DGA MULTIGAS & MOISTURE MONITORING SYSTEM	A-EBERLE, GERMANY
	ON LINE DGA MULTIGAS & MOISTURE MONITORING SYSTEM	GRID SOLUTION LTD

	ON LINE DGA MULTIGAS & MOISTURE MONITORING SYSTEM	KELMAN – UK
	ON LINE DGA MULTIGAS & MOISTURE MONITORING SYSTEM	MORGAN SHAFFER
	ON LINE DGA MULTIGAS & MOISTURE MONITORING SYSTEM	SERVERON CORPORATION, USA
	ON LINE INSULATING OIL DRYING SYSTEM	CEE DEE
	ON LINE INSULATING OIL DRYING SYSTEM	PTSS-VELCON SYSTEMS
	ON LINE INSULATING OIL DRYING SYSTEM	TRANSEC LTD – UK
20	OIL FILTERATION MACHINE	CEE DEE VACUUM EQUIPMENT PVT.LTD
	OIL FILTERATION MACHINE	OWLER WESTRUP
	OIL FILTERATION MACHINE	SUMESH PETROLEUM, VADODARA
	OIL FILTERATION MACHINE	VACUUM PLANT & INSTRUMENTS MANUFACTURING COMPANY
21	NIFPES	CTR MANUFACTURING INDUSTRIES LIMITED, PUNE
	NIFPES	EASUN-MR TAP CHANGERS (P) LTD., PONDICHERRY
	NIFPES	VENDRE SALES SERVICES (INDIA) PVT LTD, AURANGABAD

NB-Any deviation from the approved vendor list requires prior approval from OPTCL.

Annexure-Q (Guaranteed and other technical particulars)

To be submitted by bidder

Sl. No.	Description	Unit	Specified by Buyer	Offered by manufacturer
1.	General Information i) Supplier ii) Name of Manufacturer iii) Place of Manufacture (Country & City) iv) Type of transformer (Core/Shell)			
2.	Applications i) Indoor/Outdoor ii) 2wdg/3wdg/Auto iii) GT/Step-down/ICT/Station Start-up/ Auxiliary/ Rail Trackside Supply			
3.	Corrosion Level at Site i) Light ii) Medium iii) Heavy iv) Very Heavy			
4.	Site altitude above mean sea level	m		--
5.	Seismic zone and ground acceleration at site (both in horizontal & vertical direction)			--
6.	Maximum and minimum ambient temperature at site			
7.	Applicable Standards i) IEC: 60076 ii) IS : 2026 iii) Any other, please specify			
8.	Rated Capcity / Full load rating (HV/IV/LV)	MVA		
9.	3-Phase/Bank of Three Single Phase (A,B,C)			
10.	Rated No Load Voltages (HV/IV/LV)	kV		

11.	Currents at normal tap (HV/IV/LV)	Amp		
12.	Rated Frequency	Hz		
13.	Connections and phase displacement symbols (Vector Group)			
14.	Weight Schedules (Minimum with no negative tolerance)			
	i) Active part (Core + coil)	kg		
	ii) Insulating Oil (excluding mass of extra oil)	kg		
	iii) Tank and Fittings	kg		
	iii) Total weight	kg		
	iv) Transportaion Weight	kg		
	v) Overall dimensions L x B x H	mm		
	vi) Size of heaviest package L x B x H	mm		
	vii) Weight of heaviest package	kg		
	viii) Weight of 5% extra oil	kg		
	ix) Weight of core	Kg		
	x) Weight of copper (HV/IV/LV/ Regulating)	kg		
	xi) Insulating Oil volume (excluding 5% extra oil)	Ltrs		
	xii) Quantity of oil in OLTC	Ltrs		

15.	Transport limitation			
16.	LV Winding i) Stabilizing tertiary (Yes/No) ii) Loaded (Yes/No)			
17.	Tappings i)Type (OLTC/OCTC) and make of tap changer ii)Position of Tapping on the winding iii)Variation on iv) Range of variation v) No. of Steps vi) Whether control suitable for : • Remote/local operation • Auto/manual operation v) Parallel Operation Requirements	%		
18.	Impedance and Losses			
	i) Guaranteed No load loss at rated voltage and frequency	kW		
	Tolerance (to be considered for loss evaluation)	%		
	ii) Guranteed I2R Loss at rated current & frequency (at 750C) at principal tap	kW		

	Tolerance (to be considered for loss evaluation)	%		
	iii) Eddy current and stray loss at rated current & frequency (at 750C) at principal tap	kW		
	iv) Load Loss(I2R+Eddy and Stray) at rated current & frequency (at 750C) at principal tap	kW		
	v) Guaranteed Auxiliary loss at rated voltage and frequency	kW		
	Tolerance (to be considered for loss evaluation)	%		
	vi) Calculated Fan Loss	kW		
	vii) Calculated Pump Loss	kW		
	viii) Air core reactance of HV winding	%		
	ix) Guaranteed Impedance (at Highest MVA base)	%		
	(a) HV-IV (at Pricipal tap) (b) HV-LV(at Pricipal tap) (c) IV-LV(at Pricipal tap)			
	Tolerance			
	x) Impedance at extreme tappings at Highest MVA base [for HV-IV for 3 winding transformer (or) HV-LV for two winding transformer] a) Max. Voltage tap b) Min. Voltage tap	%		
	Tolerance	%		
	xi) Zero sequence impedance at principal tap (for 3-phase transformers)			

19.	Capacitance to earth for HV/IV/LV	pF		
20.	Regulation at full load at 75 0C winding temperature at: a) upf b) 0.8 pf			
21.	Guaranteed maximum Magnetizing Current at rated Voltage	%		
22.	Efficiency : At 100% load upf 0.8 lead 0.8 lag At 75% load upf 0.8 lead 0.8 lag At 50% load upf 0.8 lead 0.8 lag	%		
23.	Load at Maximum efficiency	%		
24.	Any limitations in carrying out the required test? If Yes, State limitations			
25.	Fault level of system (in kA) and its duration (in sec)	kA (sec)		
26.	Calculated short Circuit current (in kA) withstand capability for 2 seconds (3 seconds for generator transformers) without exceeding temperature limit (i.e. Thermal ability to withstand SC current)	kA		
27.	Test current (in kA) and duration (in ms) for short Circuit current test (i.e. Dynamic ability to withstand SC)	kA & msec		
28.	Over fluxing withstand time (due to combined voltage & frequency fluctuations): 110% 125%	msec		

	140% 150% 170%			
29.	Free space required above the tank top for removal of core			
30.	Maximum Partial discharge level at 1.58 Ur/√3	pC		
Sl. No.	Description	Unit	Specified by Buyer	Offered by manufa-cturer
1.	Core Type: i) 3 Phase 3 Limb (3 wound limbs) ii) 3 Phase 5 Limb (3 wound limbs) iii) 1 Phase 2 Limb (2 wound limbs) iv) 1 Phase 3 Limb (1 wound limb) v) 1 Phase 4 Limb (2 wound limbs) vi) 1 Phase 5 Limb (3 wound Limbs)			
2.	Type of Core Joint: i) Mitred ii) Step Lap			
3.	CRGO : i) Make & Country of Origin ii) Thickness, mm iii) Max. Specific loss at 1.7 T, 50Hz, in Watts/kg iv) Grade of core as per BIS v) Insulation between core lamination vi) BIS certified (Yes/No)			
4.	Minimum Gross & Net Area of: i) Core ii) Limb iii) Yoke iv) Unwound limb (May be verified during manufacturing stage – at the discretion of buyer)	cm2		
5.	Stacking Factor	%		

6.	Voltage per turn	V		
7.	Apparent Core Density for Weight Calculation			
8.	Minimum Net Weight of Silicon Steel Lamination CRGO (may be verified during manufacturing stage by calculation)	kg		
9.	Maximum Flux density at 90%, 100% and 110% voltage and frequency (may be verified during manufacturing stage by calculation)	T		
10.	W/kg at working flux density			
11.	Building Factor Considered			
12.	Calculated No Load Loss at rated voltage and Frequency (Net Weight x W/kg x Building factor)	kW		
13.	Magnetizing inrush current	Amp		
14.	No load current at normal ratio and frequency for : 85% of rated voltage 100% of rated voltage 105% of rated voltage	Amp		
15.	Core Isolation test	kV		
16.	Core bolt in limb / yoke	Yes/ No		
17.	Core bolt insulation withstand voltage for one minute	kV		
18.	Maximum temperature rise of any part of core or its support structure in contact with oil	0C		

Sl. No.	Description	Unit	Offered by manufacturer			
			HV	IV	LV	Regulating
1.	Type of Winding Helical/Disc/Layer/inter wound					
2.	Type of Conductor PICC/CTC/CTCE/CTCEN/BPICC					
3.	Minimum Yield Strength of Conductor for 0.2% elongation	N/mm2				
4.	Maximum Current density at CMR and conductor area at any tap: i) HV ii) IV iii) LV	A/mm2 & sq. mm				
5.	Maximum current density under short circuit: i) HV ii) IV iii) LV	A/mm2				
6.	Bare Weight of copper without paper insulation and lead (Minimum)	Kg				
7.	Per Phase Maximum resistance of winding at rated tap at 75 OC	ohm				

8.	Number of Turns/Phase					
9.	Insulating material used for HV/IV/LV winding					
10.	Insulating material used between : i) HV and IV winding ii) IV and LV winding iii) LV winding and core iv) Regulating winding and adjacent winding/core					
11.	Details of special arrangement provided to improve surge voltage distribution in the winding					
12.	Dielectric Shielding used: i) Interleaved winding ii) Wound in Shield iii) Others					
13.	Magnetic Shielding used: i) Yoke Shunt on core clamp ii) Magnetic shunt on tank iii) Electromagnetic (Copper/Aluminum) shield on tank iv) Others					
14.	Noise level when energized at normal voltage and frequency without load	dB				

Sl. No.	**Description**	**Unit**	**Specified by Buyer**	**Offered by manufacturer**
1.	Type of Cooling [ONAN (or) ONAN/ONAF (or) ONAN / ONAF / OFAF (or) ONAN / ONAF/ ODAF (or) ONAN / ONAF1 / ONAF2 etc.]			
2.	Percentage Rating Corresponding to Cooling Stages (HV/IV/LV)			
3.	No. of Cooler banks (2x50% / 2x100% / 1x100% etc.)			
4.	Temperature gradient between windings and oil			
5.	Time in minutes for which the transformer can run at full load without exceeding maximum permissible temperature at reference ambient temperature when supply to fans and / or	min		

	pumps is cut off			
6.	Guaranteed Maximum Temperature rise at 1000 mts. altitude and at actual altitude at site at ambient temperature at cooling specified at sl. No. 1: i) Top Oil by thermometer ii) Average Winding by resistance iii) Winding hot spot	0C		
7.	Type of Cooler: i) Radiator Bank ii) Unit Cooler (Oil to Air Heat Exchanger) iii) Single tube oil to water cooler; iv) double tube oil to water cooler; v) tank mounted; vi) header mounted; vii) separately mounted; viii) terminal box protection degree			
8.	Cooling Fans: i) Type ii) Size iii) Rating (kW) iv) Supply voltage v) Quantity (Running + Standby) per cooler bank vi) Whether fans are suitable for continuous operation at 85% of their rated voltage calculated time constant: • natural cooling • forced air cooling vii) Degree of Protection of terminal box			
9.	Oil Pumps: i) Type ii) Size iii) Rating (lpm and kW) iv) Supply voltage v) Quantity (Running + Standby) per cooler bank vi) Efficiency of motor at full load vii) Temperature rise of motor at full load viii) BHP of driven equipment			
10.	Coolers (Oil to Air): i) Quantity (Running + Standby) ii) Type and Rating			

11.	Coolers (Oil to Water): i) Quantity (Running + Standby) ii) Type and Rating iii) Oil flow rate (lpm) iv) Water flow rate (lpm) v) Nominal Cooling rate (kW) vi) Material of tube						
12.	Radiators: i) Width of elements (mm) ii) Thickness (mm) iii) Length (mm) iv) Numbers						
13.	Cooler loss at rated output, normal ratio, rated voltage, rated frequency at ambient temperature of 50oC	kW					
Sl. No.	**Description**	**Unit**	**Offered by manufacturer**				
1.	Geometric Arrangement of winding with respect to core e.g: Core-LV-IV-HV-Reg Coarse-Reg Fine						
2.	Regulating Winding: i) Body Tap ii) Separate						
3.	HV Line Exit point in winding: i) Top ii) Center						
4.	Varistors used across Windings If yes, Details	Yes/ No					
5.	Insulation Levels of windings		HV	IV	LV	HV-N	IV-N
	i) Lightning Impulse withstand voltage (1.2/50µs)	kV_p					
	ii) Chopped wave Lightning Impulse withstand voltage	kV_p					
	iii) Switching Impulse withstand voltage (250/2500µs)	kV_p					
	iv) Power frequency withstand voltage	kV_{rms}					
6.	Tan delta of windings at ambient temperature	%					

Sl. No.	Description	Unit	Offered by manufacturer	Specified by Buyer
1.	Tap Changers			
	i) Control a-Manual b-Automatic c-Remote d-Local			
	ii) Voltage Class and Current Rating of Tap Changers			
	iii) Make and Model			
	iv) Make and Type of Automatic Voltage Regulator (AVR)			
	v) Tie-in resistor requirement (to limit the recovery voltage to a safe value) and its value			
	vi) OLTC control and monitoring to be carried out through Substation Automation System	Y/N		
	vii) Power Supply for control motor (No. of Phases/Voltage/Frequency)			
	viii) Rated Voltage for control circuit (No. of Phases/Voltage/Frequency)	V		
2.	Tank			
	i) Tank Cover: Conventional/Bell/Bottom Plate			
	ii) Material of plate for tank			
	iii) Plate thickness : side, bottom, cover	mm		
	iv) Rail Gauge	mm		
	v) Minimum Clearance height from rail for lifting Active Part	mm		
	vi) Wheels : Numbers/Plane/Flanged/Uni-Directional/Bi-Directional/Locking Details			
	vii) Vacuum withstand Capability (a) Tank (b) Radiators/Conservator/Accessories	mm of Hg		
	viii) High Pressure withstand Capability (a) Tank (b) Radiators/Conservator/Accessories	mm of Hg		
	ix) Radiator fins/ conservator plate thickness	mm		
	x) Tank Hot spot temperature	O C		

3.	Bushings:		HV	IV	LV	HV-N LV-N	
	i) Termination Type a- Outdoor b- Cable Box (oil/Air/SF_6) c- Plug in Type						
	ii) Type of Bushing: OIP/RIP/RIS/oil communicating						
	iii) Bushing housing - Porcelain / polymer						
	iv) Rated Voltage Class	kV					
	v) Rated Current	A					
	vi) Lightning Impulse withstand voltage (1.2/50µs)	kV_p					
	vii) Switching Impulse withstand voltage (250/2500µs)	kVp					
	viii) One minute Power frequency withstand voltage (dry & wet)	kVrms					
	ix) Minimum Creepage Distance	mm					
	x) Quantity of oil in bushing and specification of oil used						
	xi) Make and Model						
	xii) Tan delta of bushings	%					
	xiii) Max Partial discharge level at Um	pC					
	xiv) Terminal Pad details						
	xv) Weight of assembled bushings	kg					
	xvi) Whether terminal connector for all bushings included in the scope of supply						
4.	Minimum clearances between bushings (for HV, IV and LV) (a) Phase to phase (b) Phase to ground						
5.	Indicator / Relay						
	i) Winding temperature thermometer / indicator: Range Accuracy						
	ii) Oil temperature thermometer / indicator: Range Accuracy						
	iii) Temperature sensors by fiber optic (if						

	provided)			
	iv) Oil actuated/gas operated relay			
	v) Oil level Indicators: Main Conservator OLTC Conservator			
	vi) Oil Sight Window: Main Tank Main Conservator OLTC Conservator			
6.	Conservator: i) Total volume ii) Volume between highest and lowest visible oil levels			
7.	Conservator Bag (air cell) i) Material of air cell ii) Continuous temperature withstand capacity of air cell			
8.	Air cell rupture relay provided	Yes / No		
9.	Pressure Relief Device: i) Number of PRDs provided ii) Location on the tank iii) Operating pressure of relief device			
10.	Sudden Pressure Relay / Rapid Pressure rise relay provided; if yes, i) Location on the tank ii) Operating pressure	Y/N		
11.	Dehydrating Breathers(Type & No. of breathers) (a) For main Conservator tank (b) For OLTC conservator			
12.	Flow sensitive Conservator Isolation Vlave Provided	Y/N		
13.	Tap Changer protective device			
14.	Type and material of gaskets used at gasketed joints			
15.	Bushing CTs: (HV side and IV/LV side) i) Voltage class ii) No. of cores iii) Ratio iv) Accuracy class v) Burden vi) Accuracy limit factor vii) Maximum resistance of secondary winding viii) Knee point voltage ix) Current rating of secondaries	 kV VA Ω V A		

16.	Neutral CTs: i) Voltage class ii) No. of cores iii) Ratio iv) Accuracy class v) Burden vi) Accuracy limit factor vii) Maximum resistance of secondary winding viii) Knee point voltage ix) Current rating of secondaries	 kV VA Ω V A		
17.	Transformer Oil i) IS 335 / IEC60296 / as per specification ii) Inhibited/ un-inhibited iii) Mineral / Natural Ester / Synthetic Ester iv) Spare oil as percentage of first filling v) Manufacturer vi) Quantity of oil (before filling and before commissioning) vii) Moisture content (mg/L or ppm) viii) Tan delta (Dielectric Dissipation Factor) at 90oC ix) Resistivity (Ω-cm))			
	x) Breakdown Voltage (before and after treatment) (kV) xi) Interfacial tension at 20 oC (N/m) xi) Pour point (oC) xii) Flash point(oC) xiii) Acidity (mg KOH/gm) xiv) Inhibitors (for inhibited oil) (%) xv) Oxidation Stability			
18.	Press Board: i) Make ii) type			
19.	Conductor Insulating Paper i) Kraft paper ii) Thermally upgraded Kraft paper iii) Nomex			
20.	Provision for fire protection system (as per spec), if yes, provide details	Y/N		
21.	Insulation of core bolts, washers, end plates etc.			

22.	Weights and Dimensions: i) Weights: a. Core b. Windings c. Tank d. Fittings e. Oil f. Total weights of complete transformers with oil and fittings ii) Dimensions; a. Overall Height above track b. Overall length			
	c. Overall breadth iii) Minimum bay width required for installation of the transformer iv) Weight of the heaviest package of the transformer arranged for transportation			
23.	Lifting Jacks i) Number of jacks included ii) Type and Make iii) Capacity iv) Pitch v) Lift vi) Height in close position			
24.	Rail Track gauges i) 2 Rails or 3 rails or 4 rails ii) Distance between adjacent rails on shorter axis iii) Distance between adjacent rails on longer axis			
24.	Rail Track gauges iv)2 Rails or 3 rails or 4 rails v) Distance between adjacent rails on shorter axis vi) Distance between adjacent rails on longer axis			