ଓଡ଼ିଶା ବିଦ୍ୟୁତ ଶକ୍ତି ସଂଚାରଣ ନିଗମ ଲିଃ.
ODISHA POWER TRANSMISSION CORPORATION LIMITED
*(A Govt. of Odisha Undertaking)*
ENGINEERING & QUALITY DEPARTMENT

# Technical Specification
# For
# I. 125MVAR, 420kV Bus Shunt Reactors
# II. 80MVAR, 420kV Line Shunt Reactors
# III. 145kV Neutral Grounding Reactors

## Revision 1
## May 2025

# TECHNICAL SPECIFICATION

## 1. SCOPE :

**1.1.** This Specification provides for design, engineering, manufacture, assembly, stage inspection, final inspection and testing before despatch, packing and delivery at destination Sub-station by road transport, unloading at site and supervision of erection, testing and commissioning of 125MVAR, 420kV Bus Shunt Reactors / 80MVAR, 420kV Line Shunt Reactors with 145kV Neutral Grounding Reactors complete with all fittings, accessories, associated equipment and spares, required for its satisfactory operation in any of the sub-stations of OPTCL in the State of Odisha COMPLIANCE STANDARDS:

**1.2.** The scope of supply includes the provision of training for Purchaser's personnel in regard to principle, design, manufacture, assembly, testing, operation and maintenance of offered Reactors at his works in the event of order, free of cost to OPTCL.

**1.3.** The Reactors shall conform in all respects to high standards of engineering, design, workmanship and the latest revisions of relevant standards at the time of offer and Purchaser shall have the power to reject any work or material which, in his judgment, is not in full accordance therewith. The reactor(s), offered shall be complete with all components, necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of supply, irrespective of whether those are specifically brought out in this Specification and/or the commercial order or not.

This specification also covers following provisions for the reactor,

a) Dehydrating Breather(s) as per clause no.20
b) RIP Bushing as per Cl. No -39.1 & 58
c) Oil sampling bottles as per clause no. 66
d) Nitrogen Injection system for protection against Fire & Explosion as per clause no.63
e) On line insulating oil drying system as per clause no. 62
f) On line Dissolved Gas (Multi-gas) and Moisture Analyser as per clause no.61

**1.4.** The reactor(s), to be supplied against this specification shall be suitable for satisfactory continuous operation under the following Topographical and Meteorological conditions: -

| | | |
|---|---|---|
| a) | Maximum ambient air temperature (ºC) - | 50 |
| b) | Minimum ambient air temperature (ºC)- | 0 |
| c) | Average daily ambient air temperature (ºC)- | 32 |
| d) | Relative humidity (%) - | 100 |
| e) | Average rainfall per annum (cm)- | 150 |
| f) | Maximum altitude above mean Sea level (m)- | 1000 |
| g) | Isoceraunic level (days/year)- | 70 |
| h) | Seismic withstand factor(g) | 0.3 |
| i) | Wind Velocity-(Wind Zone to IS875) (m/sec) | 55(Zone-VI |
| j) | Pollution level to IEC815 | Heavy/Very Heavy |
| k) | Air-borne contamination, if any | Highly Polluted |
| l) | Specific Creepage Distance of insulation in air | 31mm/KV |

## 2. 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;

Bear full responsibility for any transportation-related damages or delays

### 2.1. ROUTE SURVEY AND TRANSPORTATION METHODOLOGY:

a. The Contractor shall conduct a comprehensive route survey in coordination with the appointed transporter to:
    iv. Identify the optimal transportation route for the transformer;
    v. Assess all infrastructure requirements along the selected route;
    vi. Determine the complete transportation methodology.
b. Based on the route survey findings, the Contractor 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 scope of work and at the Contractor's expense.

### 2.2. 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/RHQ upon 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

**2.3. 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

**2.4. 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

**2.5. 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 analyzed post-transportation
ii. Full impact reports shall be submitted for review
iii. Any exceedance shall be immediately reported

## 3. PRINCIPAL PARAMETERS OF RECTOR

| S. No | Description | Unit | Technical Parameters | |
|---|---|---|---|---|
| 1. | Rated Capacity at 420kV | MVAr | **80** | **125** |
| 2. | Rated Voltage (Ur) (1.0 pu) | kV | 420 | |
| 3. | Number of phases | | 3 (three) | |
| 4. | Connection | | Star | |
| 5. | Cooling type | | ONAN | |
| 6. | Frequency | Hz | 50 | |
| 7. | Reference standard | | IEC 60076-6 | |
| 8. | Service | | Outdoor | |
| 9. | Permissible unbalance current among phases | % | ±2% | |
| 10. | Crest value of third harmonic content in phase current when reactor is energised at rated voltage with sinusoidal wave form | % | ≤ 3% of the crest value of fundamental | |
| 11. | Range of constant impedance (Linearity) | | Up to 1.5 p.u voltage (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished) | |
| 12. | Tolerance on current | % | 0 to +5% | |
| 13. | Ratio of zero sequence reactance to positive reactance (X0/X1) | | Between 0.9 & 1.0. | |

| | | | |
|---|---|---|---|
| 14. | Temperature rise over 50 °C ambient temperature at 420 kV | | |
| i) | Top oil measured by thermometer | °C | 40 |
| ii) | Average winding measured by resistance method | °C | 45 |
| 15. | Winding hot spot temperature rise over yearly weighted average temperature of 32 °C | °C | 61 |
| 16. | Max. tank surface temperature | °C | 110 |
| 17. | Max design ambient temperature | °C | 50 |
| 18. | Windings | | |
| i) | Lightning Impulse withstand Voltage | | |
| | Line end | kVp | 1300 |
| | Neutral | kVp | 550 |
| ii) | | | |
| | Line end | kVp | 1430 |
| iii) | Switching Impulse withstand Voltage at Line end | kVp | 1050 |
| iv) | One Minute Power Frequency withstand Voltage | | |
| | Line end | kVrms | 570 |
| | Neutral | kVrms | 230 |
| 19. | Tan-delta of windings | | < 0.005<br>(Tan delta shall be measured at ambient temperature. No temperature correction factor shall be applied ) |
| 20. | Neutral earthing | | Solidly Earthed |
| 21. | Whether neutral brought out | | Yes (through 145kV class bushing) |
| 22. | Bushing | | |
| i) | Rated voltage | | |
| | Line bushing | kV | 420 |
| | Neutral bushing | kV | 145 |
| ii) | Rated current | | |
| | Line bushing | A | 1250 |
| | Neutral bushing | A | 1250 |
| iii) | Lightning Impulse withstand Voltage | | |
| | Line bushing | kVp | 1425 |
| | Neutral bushing | kVp | 650 |
| iv) | Switching Impulse withstand | kVp | 1050 |

| | | | | |
|---|---|---|---|---|
| | Voltage of Line bushing | | | |
| v) | 1minute power frequency withstand voltage of bushings (dry) | | | |
| | Line bushing | kV rms | 695 | |
| | Neutral bushing | kV rms | 305 | |
| vi) | Tan delta of bushing at ambient Temperature | % | ≤ 0.5(Temp. correction as pre CEA Guideline) | |
| vii) | Minimum creepage distance | | (Specific Creepage Distance: of 31mm/kV corresponding to highest line to line voltage) | |
| | Line bushing | mm | 13020 | |
| | Neutral bushing | mm | 4495 | |
| viii) | Partial discharge of bushings at Ur (line end and neutral) | pC | < 10 | |
| 23. | Maximum partial discharge level at 1.58Ur/√3 | pC | 100 | |
| 24. | Vibration and tank stress at rated voltage | | Max. amplitude ≤200microns (peak to peak) Average amplitude ≤ 60microns (peak to peak) Tank stress: ≤2.0kg/sq.mm at any point of tank | |
| 25. | Maximum noise pressure level at rated voltage & frequency | dB | 80 | |
| 26. | Minimum Knee point voltage | | 150% of rated voltage | |
| 27. | Material of winding Conductor | | Copper | |
| 28. | Polarization index i.e. ratio of IR values at 600 sec. to 60 sec | | Shall be greater than or equal to 1.7 | |
| | Type of oil preservation | | Air Cell type | |
| 29. | **Maximum Permissible Losses of Reactor at rated current and frequency and at 75°C** | | **Total loss** | **$I^2R$ Loss** |
| i) | **80 MVAr** | kW | **115** | **65** |
| il) | **125 MVAr** | kW | **160** | **90** |
| 30. | System fault level | KA | 63 | |
| 31 | Type of Mounting. | | On wheels, mounted on rails. | |
| | | | | |

**4. <u>Technical Parameters of Oil filled Neutral Grounding Reactor (NGR)</u>**

| S. No. | Description | Unit | Parameters |
|---|---|---|---|
| 1. | Rated voltage from insulation | kV | 145 |
| 2. | Connection | | Between neutral of reactor and ground |

| | | | |
|---|---|---|---|
| 3. | Cooling System | | ONAN |
| 4. | Cooling medium | | Insulating oil |
| 5. | Frequency | Hz | 50 |
| 6. | No of Phases | | 1 (Single) |
| 7. | Service | | Outdoor |
| 8. | Insulation | | Graded |
| 9. | Max. continuous current (rms) | | 10 A |
| 10. | Rated short time current (rms) | | 60 A for 10 seconds |
| 11. | Rated impedance at rated short time and continuous current | | To be specified by the utility as per requirement |
| 12. | Max. temperature rise over ambient temperature of 50°C at rated voltage | | |
| i) | Top oil measured by thermometer | °C | 45 |
| ii) | Winding measured by resistance | °C | 50 |
| 13. | Insulation level for winding | | |
| i) | Lightning Impulse withstand Voltage | | |
| | Line side | kVp | 550 |
| | Ground side | kVp | 95 |
| ii) | Chopped Wave Lightning Impulse Withstand Voltage | | |
| | Line end | kVp | 605 |
| iii) | One min Power Frequency withstand Voltage | | |
| | Line side | kVrms | 230 |
| | Ground side | kVrms | 38 |
| 14. | **Bushing** | | |
| i) | Rated Voltage | | |
| | Line side | kV | 145 |
| | Ground side | kV | 24 |
| ii) | Lightning Impulse withstand Voltage | | |
| | Line side | kVp | 650 |
| | Ground side | kVp | 125 |
| iii) | One Minute Power Frequency withstand Voltage | | |
| | Line side | kVrms | 305 |
| | Ground side | kVrms | 55 |
| iv) | Total minimum Creepage distance of bushing | | 31mm/kV |
| | Line side | mm | 4495 |
| | Ground side | mm | 744 |
| v) | Tan delta of bushing at ambient Temperature | % | ≤ 0.5(Temp. correction as pre CEA Guideline) |
| 15. | Method of grounding | | Solidly connected between neutral of shunt reactor and earth |
| 16. | Whether neutral is to be brought out | | Yes (through 24kV bushing) |

## 5. GENERAL TECHNICAL REQUIREMENTS

**5.1. The shunt reactor shall be of either gapped core type or magnetically shielded air core type (shell type) construction.**

In case of coreless construction following requirements are stipulated.

i) A magnetic shield shall be provided around the coreless coils.

ii) Non-magnetic material sheet shall form the central core to minimize the vibrations.

**5.2.** Shunt reactors will be connected to the transmission system for reactive compensation and shall be capable of controlling the over voltages occurring in the system.

**5.3.** The neutral grounding reactor is required for grounding of the neutral point of shunt reactor (for line reactor only) to limit the secondary arc current and the recovery voltage to a minimum value.

**5.4.** 420 kV and below shunt reactors shall be designed for switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient conditions which may cause additional current flow as a result of changed saturation characteristics/ slope beyond 1.5 p.u.

**5.5.** The thermal and cooling system shall be designed for maximum continuous operating voltage $U_m$ (where $U_m$= 800/√3 kV for 765/√3 kV reactor; 420 kV for 420 kV reactor & 245 kV for 245 kV reactor).

**5.6.** In addition, the reactors shall be designed to withstand the following over-voltages repeatedly without risk of failure (w.r.t. Hotspot temperature of 140 $^oC$ & core saturation):

1.05 $U_m$ Continuous (for 765 kV & 420 kV reactor)
1.10 $U_m$ Continuous (for 245 kV reactor)
1.50 $U_m$ for 5 seconds
1.25 $U_m$ for 1 minute

**5.7.** The winding hot spots shall be calculated considering the maximum localized losses, insulation thickness at the maximum loss and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

**5.8.** Tank hotspot temperature under over voltage condition specified above shall not exceed 110 deg C considering maximum ambient temperature as 50 deg C.

**5.9.** Also, the most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

**5.10.** The transformer/reactor shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth harmonics so as to minimise interference with communication circuits.

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

**6. The maximum permissible losses (No load loss, $I^2R$ loss, auxiliary loss and load loss) at rated voltage/current (at 75 deg C) have been specified in TS covered under this specification. Following penalties shall be levied on the manufacturer/contractor (as the case may be) if losses measured during routine test are found to be within +2% tolerance of the losses specified in GTP(Clause-3 & 4), 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 .**

| S. 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.** | | |

**6.1.** In case of failure of the Reactor, the supplier shall take back the faulty Reactor from its plinth for repair at their own cost (or replace the Reactor with a new Reactor) and deliver, at their own cost, unload at the destination sub-station Reactor plinth within three months period from the date of intimation of defects to the satisfaction of the owner, at free of cost. If the delivery after repair/replacement will not be completed within three months, then the supplier shall pay penalty @ 0.5% of the contract price for each calendar week of delay from the end of three months period from the date of intimation of defects. Also, the Purchaser reserves the right for forfeiture of the total Composite Bank Guarantee and all the Securities, available with OPTCL, in case the Supplier fails to pay the penalty by one month before the expiry of the guarantee period. Also, this will be taken as adverse in all future tenders**.**

**7. CLEARANCE**

**7.1.** The overall dimensions of the reactor shall allow for sufficient clearances for installation in a 420/245/145 KV switchyard with bay width of 27000/18000/10500 mm and beam height of 22/15/11 m.

**8. DESIGN REVIEW**

**8.1.** 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. Adequate safety margin w.r.t. thermal, mechanical,

dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer/reactor with least maintenance

**8.2.** 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. Purchaser may also visit the manufacturers works to inspect design, manufacturing and test facilities.

**8.3.** The design review shall be finalised before commencement of manufacturing activity and shall be conducted generally following the "CIGRE TB 529: Guidelines for conducting design reviews

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

**8.5.** The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric and vibration etc. in design to take into account the uncertainties of his design and manufacturing processes.

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

## 9. CONSTRUCTIONAL DETAILS

The features and constructional details of shunt reactor shall be in accordance with the requirements stated hereunder. The components & fittings associated with the reactors are subject to Purchaser's approval.

## 10. TANK AND TANK ACCESSORIES

a. 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 tanks, if provided, shall have joints as close as possible to the bottom of the tank.
b. The tank shall be designed in such a way that the reactor can be placed directly on the plinth and the transformer can be rested on the concrete plinth foundation directly or on the roller assembly.
c. The tank shall be fabricated from tested, quality low-carbon steel of adequate thickness. Unless otherwise approved, metal plates, bars, and sections for fabrication shall comply with IS 2062. The tank shall be designed to be mounted either directly on the plinth or on rollers, depending on the manufacturer's standard practice.
d. The base of each tank shall be so designed that it shall be possible to move the complete transformer/reactor unit by skidding in any direction without damage when using plates or rails, and the base plate shall have the 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 |

e. The 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 the site or factory. The 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.
f. All seams and joints that are not required to be opened at the 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.
g. The 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 the tank/stress relieving shall be based on the recommendation of IS 10801.
h. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld spatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.
i. 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.
j. Tank MS plates of thickness >12 mm should undergo ultrasonic testing (UT) to check for lamination defects and internal impurities in line with ASTM 435 & ASTM 577.
k. After fabrication of the tank and before painting, a non-destructive test (dye penetration test) is mandatory on the load-bearing members such as base plate joints, jacking pads, and lifting devices, etc.
l. 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.
m. The tank should be provided with adequately sized inspection covers, either circular or rectangular, 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 to the lower end of the bushings, earthing connections, 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.
n. 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.
o. It should be possible to inspect the Buchholz relay or oil surge relay while standing on the tank cover, or a suitable arrangement shall be made to access the Buchholz relay safely.
p. The tank cover shall be designed to prevent retention of rainwater. 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.

q. A minimum of 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.
r. A minimum of four jacking pads (not fouling with rails, rollers, or other accessories) shall be provided in accessible positions 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 the trailer.
s. 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 the maximum possible misalignment of the jacking force to the centre of the working surface.
t. The tank shall be provided with suitable valves as specified in Valve schedule: The location of valves shall be finalized during design review.
u. 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.
v. 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.
w. Gas venting: 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 account the slopes of the plinth (if any) on which the transformer/reactor is being mounted.

**11. LIFTING AND HAULAGE FACILITIES**

Tank shall be provided with:

a) Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete reactor when filled with oil without structural damage to any part of the reactor. The factor of safety at any one point shall not be less than 2.
b) A minimum of four jacking pads in accessible position to enable the reactor complete with oil to be raised or lowered using hydraulic jacks.
c) Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the reactor filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.
d) Suitable haulage holes shall be provided.
e) 04 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during design review.
f) Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

**12. FOUNDATIONS, CABLE DUCTING ETC.:-**

The Supplier will have to liaise with the Purchaser or its authorised contractor immediately after Design approval to finalize the detailed design of the following:-

- Reactor main tank foundations.
- Cooler bank foundations.
- Marshalling kiosk/control cabinet location and foundation.
- Cable ducting requirements.
- Adequate bunding design for the complete containment of all oil spills.
- Any other civil/electrical requirements for the installation of the reactor.

**13. AXLES AND WHEELS**

a) The reactor shall be placed directly on concrete plinth foundation. To facilitate the movement of reactor to its foundation over rail track, the reactor shall be designed with flanged bi-directional wheels and axles of a suitable size to carry the full weight of the reactor, oil and accessories. These shall be so designed as not to deflect excessively to interfere with the movement of the reactor. Wheels, axles and bearings shall be fully corrosion - resistant and complete with fittings to facilitate lubrication.

b) Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of the reactor.

c) The wheels are required to swivel and they shall be arranged so that they can be turned through an angle of 90 degrees when the tank is jacked up to clear of rails. Means shall be provided for locking the swivel movements in positions parallel to and at right angles to the longitudinal axis of the tank.

d) The rail track gauge shall be 5'6" (1676 mm) along longer axis as well as along shorter axis.

e) Foundation layout details will be furnished by the supplier during detailed Engineering

**14. ANTI-EARTHQUAKE CLAMPING DEVICE**

To prevent reactor movement during earthquake, clamping device shall be provided for fixing the reactor to the foundation. The Bidder shall supply necessary bolts for embedding in the concrete foundation. The arrangements shall be such that the reactor can be fixed to or unfastened from these bolts, as desired. The fixing of the reactor to the foundation shall be designed to withstand seismic events to the extent that a static co-efficient of 0.3g. applied in the direction of least resistance to that loading, will not cause the reactor or clamping devices as well as bolts to be over-stressed. Special steps must be taken to prevent mal-operation of Buchholz relay in such conditions.

The details of the device used and its adequacy, suitability and design calculations to withstand seismic load shall be brought out in the additional information schedule

**15. GASKET FOR TANK & COVER**

All gasketed joints shall be designed, manufactured, and assembled to ensure long-term leakproof and maintenance-free operation. All gasketed joints shall preferably be O-ring and designed with a gasket-in-groove arrangement. If a gasket/O-ring is compressible, metallic stops/other suitable means shall be provided to prevent over compression. All bolted connections shall be fitted with a weatherproof, hot oil-resistant, resilient gasket in between for complete oil tightness. All matching flanges of gasket sealing joints should be machined (except curb joints). Gaskets with intermediate stops are not acceptable. To the extent possible, the seamless gasket should be used for openings on the tank/cover, such as turrets, bushings, 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.

Foundation, Roller Assembly and Anti Earthquake Clamping Device

The transformer shall be placed on the foundation either directly or on the roller assembly. The reactor shall be placed directly on the concrete plinth foundation.

For the transformer/reactor to be placed directly on the foundation, one set of rollers shall be provided for movement within the yard. The rollers for the 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 undercarriage of a transformer/reactor to facilitate its movement on a rail track. A suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of the transformer.

The rail track gauge shall be 1676 mm. Single-phase autotransformers of the 765 kV class and 3-phase autotransformers of the 400 kV class shall have four (4) rails, and other voltage class transformers shall have two (2) rails. However, generator transformers of the 765 kV & 400 kV class (single-phase units) may have two (2) or three (3) rails.

To prevent movement during an 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, an arrangement of unidirectional rollers mounted on a channel shall be provided, and the channel shall be locked with the plinth suitably.

For the foundation of a separately mounted cooler bank of a transformer/reactor, fixing of the cooler support shall be through anchor fasteners with chemical grouting, and no pockets for bolting shall be provided.

For support of cooler pipes, Buchholz pipes (if required), and fire-fighting pipe pylon supports, Pre-fabricated metallic support from the 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 waterlogging during flooding. Suitable arrangements (ladders and platforms) shall be provided for safe access to control cubicles.

**16. CONSERVATOR:**

The conservator of the main tank shall have an air cell-type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. The conservator shall be fitted with a magnetic oil level gauge with potential-free high and low oil level alarm contacts and a prismatic oil level gauge.

The conservator shall preferably be on the left side of the tank while viewing from the HV side.

The conservator tank shall have adequate capacity with the 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°C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing 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 the air cell and clean the conservator as applicable.

The conservator shall be positioned so as not to obstruct any electrical connection to the transformer. Contact of the oil with the 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 rise up to 100°C during operation. As such, the air cell used shall be suitable for operating continuously at this temperature.

The connection of the air cell to the top of the conservator is by an airtight seal, preventing the 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 in size shall be used in such a way as to ensure clear legibility from ground level when the transformer/reactor is fully installed. To prevent oil from 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 equalizing 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.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be externally installed on the top of the conservator to give an alarm in the event of lowering of oil in the conservator due to puncture of the air cell in service

**17. PIPING WORKS FOR CONSERVATOR:**

Pipework 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 the pipe diameters from the Buchholz relay.

No metal corrugated bellow (flexible metal system) should be used in the feed pipe connecting the main tank to the conservator.

Pipework shall neither obstruct the removal of tap changers for maintenance nor the opening of inspection or manhole covers.

**18. VALVES:**

The type of valves to be used for the transformer/reactor is as per the following table. The location and size of valves for other applications shall be finalized during design review. The 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) | Valve for vacuum application on Tank | Gate |
| 8) | Conservator Drain valve | Gate |
| 9) | Aircel equalizing valve | Gate/Globe/Ball |
| 10) | Valve for Conservator vacuum (top) | Gate |
| 11) | Filter valve for Cooler Bank (Header) | Gate |
| 12) | Cooler Bank isolation valve | Butterfly |
| 13) | Pump Isolation valve | Butterfly |
| 14) | Valve for N2 injection (NIFPS) | Gate |
| 15) | Valve for NIFPS Drain | Gate |
| 16) | 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 gunmetal or may have cast iron bodies with gunmetal fittings. They shall be of the full-way type with an internal screw and shall open when turned counter clockwise when facing the hand wheel.

Suitable means shall be provided for locking the valves in the open and closed 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 an “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 pipework can be drained independently.

All valves in the oil line shall be suitable for continuous operation with transformer oil at 115°C.

After testing, the inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil-resistant paint/varnish, followed by two coats of red oxide zinc chromate primer and 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 the main tank surface. The outside surface, except for the 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 the main tank shall have two identical valves put in series. The oil sampling valve shall have a provision to fix a rubber hose of 10 mm size to facilitate oil sampling.

Valves or other suitable means shall be provided to fix various online condition monitoring systems, if specified, to facilitate continuous monitoring. The location & size of the same shall be finalized during the detail design review.

All hardware used shall be hot-dip galvanized/stainless steel.

**18.1. Flow-Sensitive Conservator Isolation Valve:**

a. In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the Buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.
b. When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

**All hardware used shall be hot-dip galvanized or made of stainless steel**

**19. PRESSURE RELIEF DEVICE(PRD):**

Conservators of the main tank 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 25 mm. 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

One PRD of 150 mm diameter is required for every 30000 Liters of oil. However, at least two numbers of PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to the bushing turret or cover. PRD operating pressure selected shall be verified during design review.

PRD shall be provided with a special shroud to direct the hot oil in case of a 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 the 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. The oil shroud should be kept away from the 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 a full internal vacuum at mean sea level. It shall be mounted directly on the tank. A suitable canopy shall be provided to prevent the ingress of rainwater. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. The 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

**20. DEHYDRATING SILICA GEL FILTER BREATHER:**

Conservators 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 25 mm. 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 the atmosphere by an oil seal.
c. Moisture absorption indicated by a change in colour of the crystals.
d. The breather is mounted approximately 1200 mm above the rail top level.
e. To minimize the ingress of moisture, three breathers (of identical size) for 220 kV and above voltage class transformer/reactor and two breathers (of identical size) for below 220 kV class transformer/reactor shall be connected in series for the main tank conservator. The manufacturer shall provide flexible connection pipes to be used during replacement of any silica gel breather.

**21. SUDDEN PRESSURE RELAY**

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

Pressurized water ingress tests for the terminal box (routine tests) shall be conducted on the sudden pressure relay/rapid pressure rise relay.

**22. BUCHHOLZ RELAY:**

A double float, reed-type Buchholz relay complying with IS:3637 shall be connected through a pipe between the oil conservator and the transformer/reactor tank with a minimum distance of five times the 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 samples. 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 is in service. A suitable canopy shall be provided to prevent the ingress of rainwater. 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 a 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 maloperation through fault conditions or be influenced by the magnetic fields around the transformer/reactor during the external fault conditions. Pressurized water ingress tests for the terminal box (routine tests) shall be conducted on the Buchholz relay**

**23. 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 an angular sweep of 270°. The range of temperature should be 0-150°C with an accuracy of ±1.5% (or better) of full-scale deflection. The instruments should be capable of withstanding a high voltage of 2.5 kV AC rms, 50 Hz 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), a maximum reading pointer and resetting device, a switch testing knob, and anti-vibration mounting grommets (for projection mounting). The type of switch (NO/NC) shall be a heavy-duty micro switch for 240V DC. The adjustable range shall be 20-90% of the full-scale range. The instrument case should be weatherproof with epoxy coating on all sides.

Instruments should meet a degree of protection of IP55 as per IS/IEC-60529. A temperature-sensing bulb located in a thermometer pocket on the 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°C. The setting of alarm and tripping contacts shall be adjustable at the site.

The OTI shall be so mounted that the dials are about 1200 mm from ground level. A 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:**

**24. TEMPERATURE TRANSDUCER WITH PT100 SENSOR (AS REQUIRED):**

The RTD shall be provided with a PT100 temperature sensor having a nominal resistance of 100 ohms at zero degrees centigrade. The PT100 temperature sensor shall have a three-wire ungrounded system. The calibration shall be as per IS 2848 or equivalent. The PT100 sensor may be placed in the pocket containing the temperature-sensing element. RTD shall include an image coil for the OTI system and shall provide dual output 4-20mA for the SCADA system. The transducer shall be installed in the individual marshalling box. Any special cable required for shielding purposes for the connection between the PT100 temperature sensor and the transducer shall be in the scope of the manufacturer. The 4-20mA signal shall be wired to the digital RTCC panel/BCU for further data transfer to SCADA through IS/IEC 61850-compliant communications

**25. 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, and tertiary (if applicable)]. It shall have an angular sweep of 270°. The range of temperature should be 0-150°C with an accuracy

of ±1.5% (or better) of full-scale deflection. The instruments should be capable of withstanding a high voltage of 2.5 kV AC rms, 50 Hz 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 those required for control of cooling equipment, if any. The instrument should be provided with a maximum reading pointer and resetting device, a switch testing knob, and anti-vibration mounting grommets (for projection mounting). The type of switch (NO/NC) shall be a heavy-duty micro switch for 240V DC. The adjustable range shall be 20-90% of the full-scale range. The instrument case should be weatherproof and epoxy-coated on all sides. Instruments should meet a degree of protection of IP55 as per IEC60529. A temperature-sensing bulb located in a thermometer pocket on the 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 an image coil and auxiliary CTs, if required to match the image coil mounted in the local control box. The setting of alarm and tripping contacts shall be adjustable at the site.

The WTI shall be so mounted that the dials are about 1200 mm from ground level. A 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:**

**26. TEMPERATURE TRANSDUCER WITH PT100 SENSOR FOR EACH WINDING (AS REQUIRED):**

The RTD shall be provided with a PT100 temperature sensor having a nominal resistance of 100 ohms at zero degrees centigrade. The PT100 temperature sensor shall have a three-wire ungrounded system. The calibration shall be as per IS 2848 or equivalent. The PT100 sensor may be placed in the pocket containing the temperature-sensing element. RTD shall include an image coil and auxiliary CTs, if required to match the image coil, for the WTI system and shall provide dual output 4-20mA for remote WTI and SCADA systems individually. The transducer and auxiliary CT shall be installed in the individual marshalling box. Any special cable required for shielding purposes for the connection between the PT100 temperature sensor and the transducer shall be in the scope of the contractor. The 4-20mA signal shall be wired to the digital RTCC/BCU panel for further data transfer to SCADA through IS/IEC 61850-compliant communications.

**27. 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 galvanized steel grounding flat shall be provided each at a 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 galvanized steel flats 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 the tank and connected through two flexible insulated copper links.

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 the tank may also be provided with an equipotential flexible copper link.

Each transformer/reactor unit should have provision for earthing and connection to a grounding mat when not in service.

**28. core**

The core shall be constructed from non-aging, cold-rolled grain-oriented (CRGO) silicon steel laminations. Indian transformer manufacturers shall use core material as per the 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 components 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 overvoltage conditions specified in the document, and they shall not exceed 125°C and 120°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 the core and winding relative to the 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 framework of the core shall be so designed as to avoid the presence of pockets that would prevent complete emptying of the tank through the drain valve or cause trapping of air during oil filling.

Adequate lifting lugs shall be provided to enable lifting of the active part (core & winding).

Core assembly shall be manufactured in such a way that lamination shall remain flat and the 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 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 nameplates/labels shall be provided for the ‘Core’ and ‘Core clamp.’ The cross section of the core earthing connection shall be a minimum size of 80 sq. mm copper, with the 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 the core to the 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 megaohms for a new transformer.

In addition to the above, the following additional provisions for reactors shall be applicable:

a. The leg magnetic packets (cheeses) shall be made from state of the state-of-the-art low-loss electrical steel CRGO (conventional/regular grade or better).
b. The "Cheeses" shall be designed to minimize losses and equalize the distribution of flux in the legs.
   The "cheeses" shall be bonded using high-temperature epoxy. resins to assure that they will remain bonded in service at the Chapter 2: Technical Specification for Transformer and Reactor, Page II-23
   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 careful 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 yolks.
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.

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.

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 500MΩ for all cases mentioned above.

**29. WINDINGS:**

The manufacturer shall ensure that windings of all transformers/reactors are made in a clean, dustproof (cleanroom class ISO 9 or better as per ISO 14644-1), humidity-controlled environment with positive atmospheric pressure.

1 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 the main winding for a rated current of 400 A or more.

The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize 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 the design review.

The insulation of transformer windings and connections shall be free from insulating compounds that 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 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 a conductor should have a density of >0.75 g/cc.

Wherever required, an electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high-voltage windings from the magnetic circuit.

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.

The aspect ratio of the selected conductor shall be chosen suitably based on manufacturer experience to result in stable winding under normal and abnormal service conditions 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 that will Distribute the clamping forces evenly over the ends of the winding.

Either brazing or crimping type of connections are permitted for joints. It shall be time-proven and safely withstand the cumulative effect of stress that may occur during handling, transportation, installation, and service, including line-to-line and line-to-ground faults/short circuits. The manufacturer shall have a system that allows only qualified personnel to make brazing or crimping joints.

**30. 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.

**31. 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.

**32. PAINT SYSTEM AND PROCEDURES**

The typical painting details for the transformer/reactor main tank, pipes, conservator tank, radiator, control cabinet/marshalling box/oil storage tank, etc., shall be as given in Clause-67. The proposed paint system shall generally be similar to or better than this. The quality of paint should be such that its colour does not fade during the drying process and it shall be able to withstand temperatures up to 120°C. The detailed painting procedure shall be finalized during the award of the contract.

**33. 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 Clause No. 53, while tested at the oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at Clause No. 53 prior to dispatch of oil from the refinery to the site. Under no circumstances shall poor-quality oil 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 the manufacturer’s works, processed oil, and oil after filtration and settling, are Clause No. 53. The oil test results shall form part of the equipment test report.

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

Oil used for the first filling, testing, and impregnation of active parts at the manufacturer's works shall be of the same type of oil that shall be supplied at the site and shall meet parameters as per specification.

**34. PARTICLES IN THE OIL (FOR 400 KV AND ABOVE TRANSFORMERS & REACTORS**

The particle analysis shall be carried out on an oil sample taken before carrying out FAT at the manufacturer's works and after completion of the oil filtration at the 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 the manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration, the oil is to be flushed and the particle count is to be measured.

Limiting values for the particle count are 1000 particles/100 ml with size ≥ 5 µm and 130 particles/100 ml with size ≥ 15 µm.

**35. PARTICLE CONTAMINATION IN OIL (APPLICABLE FOR 400 KV AND ABOVE TRANSFORMERS & REACTORS)**

Particle analysis shall be conducted on oil samples taken both prior to the Factory Acceptance Test (FAT) at the manufacturer's works and after completion of oil filtration at the installation site. The testing procedure and result interpretation shall follow the guidelines outlined in CIGRE Report WG-12.17 – "Effect of Particles on Transformer Dielectric Strength."

To ensure low contamination levels, the manufacturer shall comply with the particle limits specified in CIGRE Brochure 157, Table 8. After filtration, the oil shall be flushed, and a fresh particle count measurement shall be carried out.

The limiting values for particle count are as follows:

Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.

**36. OIL FILLING:**

Site drying, oil purification, and oil filling shall be carried out in accordance with the EMPLOYER's Field Quality Plan (FQP) and Supervision of Transformer OEM.

The adequacy of vacuum treatment shall be verified using water or dew point measurement with a cold trap or other suitable method. Vacuum shall be measured at the top of the transformer tank and must be below 1 mbar.

Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

If the minimum safe oil level differs from the Buchholz level, it shall be clearly specified in the operation manual. Oil filling under vacuum must reach at least this level.

An Ultra High Vacuum (UHV) type oil treatment plant, provided by the bidder on a returnable basis, shall be used. The plant must have a capacity of at least 6000 litres per hour and be suitable for EHV-class transformer oil treatment. It should support both new oil processing (per IS 335 / IEC 60296) and reconditioning of used oil (per IS 1866 / IEC 60422), with performance as follows:

a. Reduce moisture content from 100 ppm to a maximum of 3 ppm

b. Reduce dissolved gas content from 10% vol. to 0.1% vol.
c. Increase dielectric breakdown voltage from 20 kV to 70 kV
d. Include at least two degassing chambers with sufficient surface area to meet final specifications
e. Filter out particles larger than 0.5 microns
f. Automatically control processing temperature within an adjustable range of 40°C to 80°C

The bidder shall provide the oil filtration unit at their own expense.

**37. TRANSPORTATION OF OIL**

As per tender condition

**38. Test of oil as per approved MQP**

**39. BUSHINGS:**

For various voltage classes of transformers/reactors, the types of bushings shall be as follows:

| Voltage rating | Bushing type |
|---|---|
| 145KV,245KV and 420KV Bushing for 400KV and below voltage class transformer and Rectors | RIP/RIS |
| Bushing 36KV and below | Solid porcelain or oil-communicating type |

Bushings shall be robust and designed for adequate cantilever strength to meet the requirements of seismic conditions, substation layout, and movement along with the spare transformer/reactor with bushings 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.

**39.1. Oil-filled condenser-type bushings shall be provided with at least the following fittings:**

Oil level gauge
Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable
Oil filling plug & drain valve (if not hermetically sealed)

Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities, and other flaws or imperfections that might affect the mechanical or dielectric quality, and shall be thoroughly vitrified, tough, and impervious to moisture.

Bushing shall be provided with a tap for capacitance and tan delta tests. Test taps relying on pressure contacts against the outer earth layer of the bushing are 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 optimize the requirement of spares. The standard dimensions for the lower portion of the condenser bushings shall be as indicated in Cl-58

Polymer insulator shall be a seamless sheath of a silicone rubber compound. The housing & weather sheds should have a silicon content of a minimum of 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 molded as part of the sheath (injection molding process) and free from imperfections. The vulcanization for the extrusion process shall be at high temperature, and for injection molding shall be at high temperature & high pressure. Any seams/burrs protruding axially along the insulator resulting from the injection molding 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; the effectiveness of the sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth, with no projecting points or irregularities that 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 galvanized/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 the bushing terminal (air end) to minimize corona.

Bushings shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable wooden boxes with hinged-type covers. Without any gap between wooden planks. Packing Box opening cover with nails/screws-type packing arrangement shall not be acceptable. The manufacturer shall submit drawings/documents of packing for approval during detail engineering. Detailed methods for storage of bushings, including accessories, shall be brought out in the instruction manual.

The 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 needs 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 a routine

test before dispatch, and the result shall be compared at the site during commissioning to verify the healthiness of the bushing.

The tan δ value of the 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 the above-mentioned limit, the necessary correction factor as per IEEE shall be applicable.

If the bushing Tan Delta goes beyond 0.005 or increase is more than 0.001 within the guarantee period with respect to the pre commissioning values, the contractor shall arrange to replace the defective bushing by new one.

Bushings of identical rating of different makes shall be interchangeable to optimize the requirement of spares. The standard dimensions for the lower portion of the condenser bushings shall be as indicated in Cl-58.

**40. NEUTRAL FORMATION AND EARTHING ARRANGEMENT**

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 the 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 a connection (using a bimetallic strip of adequate size) to the grounding mat through separate earth pits using two (2) 75 x 12 mm galvanized steel flats. Aluminium clamps & connectors of suitable size shall be provided for connection with the neutral of the transformer/reactor, surge arrester, and the neutral grounding reactor (NGR).

**41. COOLING EQUIPMENT AND ITS CONTROL:**

Radiator-based cooling for power/auto transformers & reactors:

The transformer/reactor shall be designed with a cooler system as specified in GTP and with the following provisions, as applicable.

The cooler shall be designed using separately mounted radiator banks or tank-mounted radiators. The design of the cooling system shall satisfy the performance requirements.

In the case of a separately mounted radiator bank arrangement, the radiator bank shall generally be placed on the left side of the tank while watching from the 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 a minimum thickness of 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 shutoff valve
c. Drain valve and sampling valve
d. Top and bottom oil filling valves
e. Air release plug
f. Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanized steel flats.

g. Thermometer pockets 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 joints (for separately/ground-mounted cooler banks) shall be provided on the top and bottom cooler pipe connections.

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

Cooling fans shall not be directly mounted on the radiator. The supporting frames for the cooling fans shall be fixed, preferably on separate supports or to the main tank, in such a manner that the fan vibration does not affect the performance of the radiators and their valves. Fans shall be located so as to prevent the ingress of rainwater. Each fan shall be suitably protected by a galvanized wire guard. The exhaust airflow from the 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 the Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of the power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

The changeover to the standby oil pump in case of failure of the 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 the pump and oil flow indicator.

Cooling fans and oil pump motors shall be suitable for operation from a 415-volt, three-phase, 50 Hz power supply and shall be of premium efficiency class IE3, conforming to IS: 12615. Each cooling fan and oil pump motor shall be provided with a starter, thermal overload, and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have a 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 galvanized, or corrosion-resistant paint should be applied to the external surface of it.

Air release devices and oil plugs shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipework can be drained independently.

Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of the winding temperature indicator. The manufacturer shall recommend the setting of WTI for automatic changeover of cooler control over the entire operating range depending on types of cooling systems 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 differentials, does not occur.

Suitable manual control facilities for cooler fans and oil pumps shall be provided. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.

The following lamp indications shall be provided in the cooler control cabinet:

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

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of the cooler control cabinet, and for single-phase unit connections, shall be extended further to the 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/Individual Marshalling Box. All the CT secondary terminals in the Cooler Control Cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

All the necessary terminations for remote connection to the purchaser's panel shall be wired up to the common marshalling box (in the case of a 1-phase unit) or marshalling box (3-phase unit).

AC power for cooler control circuitry shall be derived from the AC feeder. In case the auxiliary power supply requirement for the cooler control mechanism is different than the station auxiliary AC supply, then all necessary converters shall be provided.

**42. AUXILIARY POWER SUPPLY FOR COOLER CONTROL AND POWER CIRCUIT**

The OEM shall provide two auxiliary power supplies, 415-volt, three-phase, four-wire, to the cooler control cabinet or marshalling box. All loads shall be powered by one of the two sources through an electrically interlocked automatic transfer scheme, which shall be housed in the cooler control cabinet or marshalling box.

For each circuit, the contractor shall provide suitably rated power contactors, MCBs/MCCBs, as required for the complete auxiliary power supply distribution scheme. This includes distribution online gas and moisture monitoring systems, online drying systems, and any other applicable systems, all housed within the cooler control cabinet or marshalling box.

The contractor shall submit the auxiliary power supply distribution scheme for approval. The contractor is also responsible for supplying and laying power, control, and special cables from the marshalling box to all accessories. **Provision shall be made to select one feeder as the normal source and the other as the standby source.**

a. In the event of failure of the normal source, the loads shall be automatically transferred to the standby source after an adjustable time delay.

b. Indications shall be provided at the cooler control cabinet, individual marshalling box, or common marshalling box for normal source failure, transfer to the standby source, and failure to transfer.
c. The system shall automatically re-transfer to the normal source without intentional time delay once the normal source is re-energized.
d. Both transfers and re-transfers shall be dead transfers, ensuring that AC feeders are never 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,NIFPES etc. as applicable. Necessary cabling in this regard shall be done by the Contractor**

**43. CABLING:**

All interconnecting control and power cables emanating from various parts of the transformer/reactor, like the turret CT, MBs, fans, pumps, Buchholz, PRD, etc., shall be routed through covered cable trays or GI conduits 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 specifications for cables are mentioned in Clause no-59& 60. 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).

Cabling of the spare unit of the transformer/reactor with isolator switching arrangement shall be in such a way that the spare unit can be brought into service in case of failure/outage of a healthy unit without physically shifting. All control, protection, and indication signals of the spare unit shall be brought to the Common Marshalling Box (CMB) of all the banks. From CMB, all the control, protection, and indication signals of R, Y, B, and spare units shall be transferred to the purchaser's control panels/SCADA. Changeover of spare unit signals with faulty units shall be done through the purchaser's C & R panels/SCADA level. Changeover of RTCC signals shall be carried out in CMB. Plug & socket arrangements shall be provided for quicker transition of faulty units to spare units to avoid interconnection errors.

**44. SCADA INTEGRATION (IF APPLICABLE):**

All the online monitoring equipment, i.e., optical temperature sensors & measuring units, online dissolved gas (multi-gas) and moisture analyzers, online insulating oil drying systems (cartridge type), etc., provided for individual transformer/reactor units, including spare units (if any), shall be IS/IEC 61850 compliant (either directly or through a gateway). This monitoring equipment is required to be integrated.

with SAS through a managed Ethernet switch conforming to IS/IEC 61850. This Ethernet switch shall be provided in IMB (for 3-Ph unit) / CMB (for 1-Ph unit). The switch shall be powered by redundant DC. supply (as per available Station DC supply). The Ethernet switch shall be suitable for operation at an ambient temperature of 50°C. All required power & control cables, including optical cable and patch cord (if any), up to IMB (for 3-Ph unit) / CMB (for 1-Ph unit), all the cables from RTCC to DM and any special cable between IMB (for 3-Ph unit) / CMB (for 1-Ph unit) to switchyard panel room/control room shall be in the scope. However, fiber optic cable, power cable, and control cables, as applicable, between IMB (for 3-Ph unit) / CMB (for 1-Ph unit) to switchyard panel room/control

room and power supply (AC & DC) to MB and integration of above-said IS/IEC-61850-compliant equipment with substation Automation systems may be a part of substation contracts.

Cooling of transformers/Reactor(as applicable) shall also be monitored and controlled from SCADA. The list of signal exchanges between the transformer and SCADA may be mutually agreed upon between the owner and manufacturer. The owner/contractor, as applicable, shall ensure the provision of an adequate number of redundant Bay Control Units (BCUs).

**45.** TERMINAL BLOCK:

a) The terminal blocks( 'ELMEX' Make, Type – OAT 6 or its equivalent), to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with block and barriers, moulded integrally. Such block shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring.

b) All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. The terminal blocks shall be 1100 V grade and have 10 Amps continuous rating moulded piece, complete with insulated barriers, non-disconnecting stud type terminals, washers, nuts and lock nuts. Terminal block design shall include a white fibre-marking strip with clear plastic, slipon/clipon terminal cover. Markings on the terminal strips shall correspond to wire number and terminal numbers on the wiring diagrams.

c) Terminal blocks for current reactor's secondary leads shall be provided with test links and isolating facilities. Also current reactor secondary leads shall be provided with short-circuiting and earthing facilities.

d) At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

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

(i) For all circuits except current reactor circuits, minimum of two nos. 2.5 sq.mm copper.

(ii) For all CT circuits, minimum of two nos. 4 sq. mm. copper.

f) There shall be a minimum edge-to-edge clearance of 250 mm. between the first row of terminal block and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be minimum of 150 mm.

g) Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run parallel and in close proximity long each side of the wiring duct to be provided for convenient attachment of internal panel wiring. The side of the terminal block, opposite the wiring duct shall be reserved for the owner's external cable connection. All adjacent terminal blocks shall also share this field-wiring corridor. A steel strip shall be connected between adjacent terminal block rows at 450 mm intervals for support of incoming cables.

h) The number and sizes of the purchaser's multi-core incoming cable will be furnished to the Bidder after placement of the order.

**46. CONSTRUCTIONAL FEATURES OF COOLER CONTROL CABINET/ INDIVIDUAL MARSHALLING BOX**

Each transformer /Reactor unit shall be equipped with a local OLTC Drive Mechanism Box, cooler control cabinet/ marshalling box, Digital RTCC panel (where applicable), and a common marshalling box The individual marshalling box and cooler control box shall be ground-mounted. For ground-mounted panels, the gland plate shall be at least 450mm above ground level.

The cooler control cabinet, individual marshalling box, junction box, and all other outdoor cubicles (except the OLTC Drive Mechanism box) shall be constructed from stainless steel sheet with a minimum grade of SS304 and a minimum thickness of 1.6mm (SS316 for coastal areas).

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

All doors, removable covers, and plates shall be fully gasketed around the edges with suitably profiled gaskets. All gasketed surfaces shall be smooth, straight, and reinforced if necessary to minimize distortion and ensure a tight seal. For outdoor control cubicles, marshalling boxes, etc., the sealing gaskets shall be made of EPDM rubber or any other approved high-quality material. For indoor control cabinets and the Digital RTCC panel, the sealing gaskets shall be made of neoprene rubber or any other approved high-quality material. The gaskets shall be tested in accordance with the approved quality plan, IS: 1149, and IS: 3400.

Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. Thermostat controlled space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

**47. TERMINAL CONNECTORS:**

a) Bushing terminals shall be provided with terminal connectors of approved type and size for connection to external parts. Terminal connectors, offered must have been successfully type tested as per IS: 5561.
b) All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off. The aluminium alloy castings, if used, shall conform to designation A6 of IS: 617.
c) No part of clamp shall be less than 10 mm. thick.
d) All ferrous parts shall be hot dip galvanized conforming to IS: 2633. Spring washers and H.T. bolts shall be electro galvanised conforming to IS: 1573.
e) For bimetallic clamp, copper alloy linear of minimum thickness of 2 mm. shall be cast integral with aluminium body.
f) Flexible connectors shall be made from tinned copper sheets.
g) Size of terminal/conductor for which the clamp is suitable and rated current under site conditions shall be embossed/punched on each component of the clamp, except hardware.
h) All current carrying parts shall be designed and manufactured to have minimum contact resistance.
i) The short time rating of terminal connector shall not be less than the short time rating of respective bushing.

j) **Terminal connectors shall be subject to all type, routine and acceptance tests as per IS: 5561 (latest).**

k) Malleable cast iron for terminal connectors or any of its parts and accessories shall not be acceptable.

l) Bolts and Nuts used shall be of stainless steel or galvanized/passivated mild steel.

**48. CURRENT TRANSFORMER:**

Current transformers shall conform to the standards outlined in IS 16227 (Part 1 & 2) and IEC 61869 (Part 1 & 2).

The turret-mounted current transformers shall be removable from the transformer tank without the need to remove the tank cover. Appropriate measures shall be taken to minimize eddy currents and the local heat generated within the turret.

The secondary leads of the current transformers shall be routed to a weatherproof terminal box located near each bushing. These terminals shall be connected to the common marshalling box using separate cables for each core.

The technical parameters of the bushing CTs and neutral CTs are provided in Clause-54. The CTs used for Restricted Earth Fault (REF) protection must have identical parameters to minimize circulating current under normal conditions and ensure the stability of the protection. The bushing current transformer parameters listed in this specification are tentative and may be subject to change within reasonable limits. The contractor must obtain the purchaser's approval before proceeding with the design of the bushing current transformers.

**49. FITTINGS & ACCESSORIES:**

The following fittings and accessories (as applicable) shall be provided with each transformer/Rector as outlined in this specification. The list below is not exhaustive, and any other fittings necessary for the satisfactory operation of the transformer are included in the scope.

a. Conservator for the main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge (with canopy) including high and low oil level alarm contacts, prismatic oil level gauge, and a dehydrating silica gel filter breather with flexible connection pipes for replacement of the silica gel breather.
   Conservator for OLTC with drain valve, oil surge relay, filling hole with cap, prismatic oil level gauge, and dehydrating silica gel filter breather with flexible connection pipes for replacement of the silica gel breather.
b. Pressure relief devices including a canopy with a special shroud to direct oil.
c. Sudden pressure relief relay (for 400kV Transformer only) including canopy.
d. Buchholz relay (double float, reed type) with canopy, isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases, and alarm/trip contacts (gas collecting device).
e. Air release plug.
f. Conservator air cell rupture detection relay.
g. Inspection openings and covers.
h. Bushings of each type with metal parts and gaskets to suit the termination arrangement.
i. Winding & oil temperature indicators.

j. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, and core and winding lifting lugs.
k. Protected type mercury or alcohol-in-glass thermometer, or magnetic or micro-switch type dial temperature indicator as applicable.
l. Rating and diagram plates (in Hindi & English) on transformers and auxiliary apparatus.
m. Roller assembly
n. On-load tap-changing gear, OLTC DM Box, off-circuit tap changer (OCTC), individual marshalling box/cooler control cabinet, common marshalling box, and digital RTCC panel, as applicable for transformer.
o. Cooling equipment.
p. Bushing current transformers, neutral CT .
q. Oil flow indicators (if applicable).
r. Terminal marking plates.
s. Valve schedule plate.
t. All the valves.
u. Ladder(s) suitably placed to avoid fouling with bushings or piping, allowing access to the transformer tank cover, with suitable locking arrangements to prevent climbing during charged conditions. Additional ladder for conservator if it is not tank-mounted.
v. Suitable platform for safe access to the flow-sensitive non-return valve and Buchholz relay, in case these are not accessible from the transformer top.
w. Haulage lugs.
x. Neutral bus connection arrangement (3-phase transformer).
y. Brass/tinned copper grounding bar supported from the tank by using porcelain insulator and flexible conductor for earthing the neutral and line terminals.
z. Online insulating oil drying system as applicable
aa. Online dissolved gas (multi-gas) and moisture measuring equipment (if specified) as applicable.
bb. Online dissolved hydrogen and moisture measuring equipment (if specified) as applicable.
cc. Nitrogen injection type fire prevention and extinguishing system (if specified in) as per Clause No.-63.
dd. 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 RTCC panel/employer's C&R panel.

**50. 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.

**Pre-Shipment Checks at Manufacturer's Works (Proof to be submitted by OEM)**

Verify the interchangeability of components from similar transformers, ensuring consistency in mounting dimensions.

Inspect the proper packing and preservation of accessories such as radiators, bushings, dehydrating breather, rollers, Buchholz relay, fans, control cubicles, connecting pipes, conservator, etc.

Prior to dispatch from the factory, the following impact recorder settings must be implemented for graphical analysis:

a. 1g: Start recording
b. 2g: Warning
c. 3g: Alarm

Additionally, the drop-out setting should be 1g, and the threshold setting must be within the range of 3g to 10g.

Ensure proper bracing is provided to prevent movement of the core and winding assembly inside the transformer tank.

Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity

**51. RATING & DIAGRAM PLATE**

AS per CEA Guideline & Clause No-68 &69

**52. GUARANTED AND OTHER TECHNICAL PARTICULAR FOR SUBMISSION BY BIDDER**

AS per CEA Guideline & Clause no.55

**53. INSULATING OIL:-**

| 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<br>a) for bulk supply<br>b) for delivery in drums | IEC 60814 | (Max.)<br>30 mg/kg<br>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<br>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.<br>Aromatic:<br>4 to12 %<br>Paraffins: <50%<br>& 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.)<br>(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.)<br>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<br>each individual compound |
| 11. | Stray gassing under thermos oxidative stress | Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper | Non stray gassing:<br>< 50 µl/l of hydrogen (H2) and < 50 µl/l methane (CH4)<br>and < 50 µl/l ethane (C2H6) |
| **C** | **Performance** | | |
| 1. | Oxidation stability | IEC 61125 (method c)<br>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 energization 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) |

**54. Technical Parameters of Current Transformers for 125 MVAR (3-ph), 80 MVAR (3-ph) 420 kV Shunt Reactor & Neutral Grounding Reactor (NGR)**

| **Description** | **Shunt Reactor** | | | NGR |
|---|---|---|---|---|
| | Line Side | Neutral Side | Common Neutral side | Earth Side |

| | | | | |
|---|---|---|---|---|
| **Ratio** | | | | |
| CORE 1 | 200/1A | 200/1A | 200/1 | 200/1A |
| CORE 2 | 200/1A | To be decided by manufacturer for WTI | | - |
| CORE 3 | 200/1A | 3000-2000-500/1A | | - |
| CORE 4 | 200/1A | 3000-2000-500/1A | | - |
| **Minimum knee point voltage or burden and accuracy class** | | | | |
| CORE 1 | 200V, PX/PS Class | 200V, PX/PS Class | 200V, PX/PS Class | 200V, PX/PS Class |
| CORE 2 | 200V, PX/PS Class | To be decided by manufacturer for WTI | | - |
| CORE 3 | 200V, PX/PS Class | 3000-2000-500V, PX/PS Class | | - |
| CORE 4 | 10VA, Class 1.0 | 3000-2000-500V, PX/PS Class | | - |
| **Maximum CT Secondary Resistance** | | | | |
| CORE 1 | 1 Ohm | 1 Ohm | 1 Ohm | 1 Ohm |
| CORE 2 | 1 Ohm | - | - | - |
| CORE 3 | 1 Ohm | 15-10-2.5 Ohm | - | - |
| CORE 4 | - | 15-10-2.5 Ohm | - | - |
| **Exciting current (max.) @$V_K/4$** | | | | |
| CORE 1 | 250mA | 250mA | | - |
| CORE 2 | 250mA | - | | - |
| CORE 3 | 250mA | 20mA @3000/1<br>30mA @ 2000/1<br>120mA @ 500/1 | | - |



**Notes:**

1. For PX/PS Class CTs, dimension parameter "K", secondary VA shall be considered 1.5 and 20 respectively.
2. Rated continuous thermal current rating shall be 200% of rated primary current.
3. Parameters of WTI CT for each winding shall be provided by the manufacturer / contractor.
4. 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.
5. In case of 1-phase reactor, common Neutral side shall be out door type.

**55. GUARANTEED AND OTHER TECHNICAL PARTICULARS FOR REACTORS**

**(To be filled in by the manufacturer)**

**General**

| Sl. No. | Description | Unit | Specified by Buyer | Offered by manufacturer |
|---|---|---|---|---|
| 1. | General Information<br><br>i) Supplier<br>ii) Name of Manufacturer<br>iii) Place of Manufacture (Country & City)<br>iv) Type of Reactor (Shunt reactor/ Bus reactor)<br>v) Type of NGR (oil filled/air core) | | | |
| 2. | Applications (Indoor/Outdoor) | | | |
| 3. | Corrosion Level at Site<br>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 (IEC: 60076/IS : 2026/Any other, please specify) | | | |
| 8. | Rated Capcity / Power | MVAR | | |
| 9. | Single Phase / 3-Phase | | | |
| 10. | Rated Voltages | kV | | |
| 11. | Maximum Operating Voltage | kV | | |
| 12. | Rated Current | Amp | | |
| 13. | Rated Continuous current (For NGR) | Amp | | |
| 14. | Rated short time current (10 sec / 60 sec) (For NGR) | Amp | | |
| 15. | Permissible unbalance current among phases | % | | |
| 16. | Crest value of third harmonic content in phase current at rated voltage with sinusoidal wave form | % | | |
| 17. | Vibration and tank stress at rated voltage | | | |
| 18. | Rated Frequency | Hz | | |
| 19. | Winding Connection | | | |
| 20. | 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 | | |
| | iv) Total weight | kg | | |
| | v) Transportation Weight | kg | | |
| | vi) Overall dimensions L x B x H | mm | | |

| | | | | |
|---|---|---|---|---|
| | vii) Size of heaviest package L x B x H | mm | | |
| | viii) Weight of heaviest package | kg | | |
| | ix) Weight of 5% extra oil | kg | | |
| | x) Weight of core | Kg | | |
| | xi) Weight of copper | kg | | |
| | xii) Insulating Oil volume (excluding 5% extra oil) | Ltrs | | |
| 21. | Transport limitation | | | |
| 22. | Impedance and Losses | | | |
| | i) Guaranteed Max. Total loss at rated current and frequency (at 750C) | kW | | |
| | Tolerance | % | | |
| | ii) Guaranteed I2R Loss at rated current & frequency (at 750C) | kW | | |
| | iii) Tolerance | % | | |
| | iv) Reactance at rated voltage & frequency | ohms | | |
| | v) Range of constant impedance | | | |
| | vi) Ratio of zero sequence reactance to positive reactance (X0/X1) | | | |
| 23. | Any limitations in carrying out the required test? If Yes, State limitations | | | |
| 24. | Over voltagewithstand time (without exceeding winding hotspot temperature of 1400C):<br>105% (foe 420 kV and above reactor) 110% (for 245 kV reactor)<br>125%<br>150% | msec | | |
| 25. | Maximum partial discharge level at 1.58Ur/√3 | | | |
| 26. | Free space required above the tank top for removal of core | mm | | |

**Magnetic System**

| Sl. No. | Description | Unit | Specified by Buyer | Offered by manufacturer |
|---|---|---|---|---|
| 1. | Core Type:<br>i) 3Phase 3 Limb( 3 wound limbs)<br>ii) 3Phase 5 Limb(3 wound limbs)<br>iii) 1Phase 2 Limb(2 wound limbs)<br>iv) 1Phase 3 Limb( 1 wound limb)<br>v) 1Phase 4Limb( 2 wound limbs)<br>vi) 1Phase 5Limb( 3wound Limbs) | | | |
| 2. | Type of Core Joint:<br>i) Mitred<br>ii) Step Lap | | | |
| 3. | Gapped core | Yes/No | | |

| | | | | |
|---|---|---|---|---|
| 4. | CRGO :<br>i) Make & Country of Origin<br>ii) Thickness, mm<br>iii) Max. Specific loss at 1.7 T, 50Hz, in Watts/kg<br>iv) Grade of core as per BIS<br>v) Insulation between core lamination<br>vi) BIS certified (Yes/No) | | | |
| 5. | Minimum Gross Area of:<br>i) Core<br>ii) Limb<br>iii) Yoke<br>iv) Unwound limb<br>(May be verified during manufacturing stage – at the discretion of buyer) | cm2 | | |
| 6. | Stacking Factor | % | | |
| 7. | Voltage per turn | V | | |
| 8. | Apparent Core Density for Weight Calculation | | | |
| 9. | Minimum Net Weight of Silicon Steel Lamination CRGO (may be verified during manufacturing stage by calculation) | kg | | |
| 10. | W/kg at working flux density | | | |
| 11. | Building Factor Considered | | | |
| 12. | Magnetizing inrush current | Amp | | |
| 13. | Core Isolation test | kV | | |
| 14. | Core bolt in limb / yoke | Yes/No | | |
| 15. | Core bolt insulation withstand voltage for one minute | kV | | |
| 16. | Maximum temperature rise of any part of core or its support structure in contact with oil | 0C | | |

**Conducting System**

| **Sl. No.** | **Description** | **Unit** | **Offered by manufacturer** |
|---|---|---|---|
| 1. | Type of Winding<br>Helical/Disc/Layer<br>/inter wound | | |

| | | | |
|---|---|---|---|
| 2. | Type of Conductor PICC/CTC/CTCE/C TCEN/BPICC | | |
| 3. | Minimum Yield Strength of Conductor for 0.2% elongation | $N/mm^2$ | |
| 4. | Maximum Current density at CMR and conductor area: | $A/mm^2$ &sq.mm | |
| 5. | Maximum current density under short circuit | $A/mm^2$ | |
| 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 winding | | |
| 10. | Insulating material used between winding and core | | |
| 11. | Details of special arrangement provided to improve surge voltage distribution in the winding | | |
| 12. | Dielectric Shielding used:<br>i) Interleaved winding<br>ii) Wound in Shield<br>iii) Others | | |
| 13. | Magnetic Shielding used:<br>i) Yoke Shunt on core clamp<br>ii) Magnetic shunt on tank<br>iii) Electromagnetic shield on tank (Copper/Aluminum)<br>iv) Others | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 14. | Noise level when energized at normal voltage and frequency without load | dB | |
| 15. | Vibration level | | |

**Cooling System**

| Sl. No. | Description | Unit | Specified by Buyer | Offered by manufacturer |
|---|---|---|---|---|
| 1. | Type of Cooling | | | |
| 2. | No. of Cooler banks (2x50% / 2x100% / 1x100% etc.) | | | |
| 3. | Temperature gradient between windings and oil | | | |

| | | | | |
|---|---|---|---|---|
| 4. | Guaranteed Maximum Temperature rise at 1000 mts. altitude and at actual altitude at site at ambient temperature for cooling specified at sl. No. 1:<br><br>i) Top Oil by thermometer<br>ii) Average Winding by resistance<br>iii) Winding hot spot | $^0$C | | |
| 5. | Type of Cooler | | | |
| | | | | |
| 6. | Radiators:<br><br>i) Width of elements (mm)<br>ii) Thickness (mm)<br>iii) Length (mm)<br>iv) Numbers | | | |

**Dielectric System**

| **Sl. No.** | **Description** | **Unit** | **Offered by manufacturer** | |
|---|---|---|---|---|
| 1 | Insulation Levels of windings | | HV end | Neutral end / ground end |
| | i) Lightning Impulse withstand voltage (1.2/50µs) | kVp | | |
| | ii) Chopped wave Lightning Impulse withstand voltage | kVp | | |
| | iii) Switching Impulse withstand voltage (250/2500µs) | kVp | | |
| | iv) Power frequency withstand voltage (one minute / 5 minutes) | $kV_{rms}$ | | |
| 2 | Tan delta of windings at ambient Temperature | % | | |

**Accessories**

| Sl. No. | Description | Unit | Offered by manufacturer | Specified by Buyer |
|---|---|---|---|---|
| 1. | 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<br>(a) Tank<br>(b) Radiators/Conservator/Accessories | mm of Hg | | |
| | viii) High Pressure withstand Capability | mm of | | |

| | | | | | |
|---|---|---|---|---|---|
| | (a) Tank<br>(b) Radiators/Conservator/Accessories | Hg | | | |
| | ix) Radiator fins / conservator plate thickness | mm | | | |
| | x) Tank Hot spot temperature | O C | | | |
| | xi) Tank suitable for plinth mounting | Yes/No | | | |
| 2. | Bushings: | | HV side | Neutral end / ground end | |
| | i) Termination Type<br>a- Outdoor<br>b- Cable Box (oil/Air/$SF_6$)<br>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) | kVp | | | |
| | vii)Switching Impulse withstand voltage (250/2500µs) | kVp | | | |
| | v) One minute Power frequency withstand voltage (dry & wet) | kVrms | | | |
| | viii) Minimum Creepage Distance | mm | | | |
| | ix) Quantity of oil in bushing and specification of oil used | | | | |
| | x) Make and Model | | | | |
| | xi) Tan delta of bushings | | | | |
| | xii)Terminal Pad details | | | | |
| | xiii) Weight of assembled bushings | kg | | | |
| | xiv) Whether terminal connector for all bushings included in the scope of supply | | | | |
| | xv) Max Partial discharge level at Um | pC | | | |
| 3. | Minimum clearances between bushings<br>(a) Phase to phase<br>(b) Phase to ground | | | | |
| 4. | 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: | | | | |
| | vi) Oil Sight Window: | | | | |
| 5. | Conservator: | | | | |

| | | | | |
|---|---|---|---|---|
| | i) Total volume<br>ii) Volume between highest and lowest visible oil levels | | | |
| 6. | Conservator Bag (air cell)<br>i) Material of air cell<br>ii) Continuous temperature withstand capacity of air cell | | | |
| 7. | Air cell rupture relay provided | Yes / No | | |
| 8. | Pressure Relief Device:<br>i) Number of PRDs provided<br>ii) Location on tank<br>iii) Operating pressure of relief device | | | |
| 9. | Sudden Pressure Relay / Rapid Pressure rise relay provided; if yes,<br>i) Location on the tank<br>ii) Operating pressure | Y/N | | |
| 10. | Dehydrating Breathers(Type & No. of breathers) | | | |
| 11. | Flow sensitive Conservator Isolation Valve Provided | Y/N | | |
| 12. | Sudden Pressure Relay / Rapid Pressure rise relay provided | Y/N | | |
| 13. | Type and material of gaskets used at gasketed joints | | | |
| 14. | Bushing CTs:<br>i) Voltage class<br>ii) No. of cores<br>iii) Ratio<br>iv) Accuracy class<br>v) Burden<br>vi) Accuracy limit factor<br>vii) Maximum resistance of secondary winding<br>viii) Knee point voltage<br>ix) Current rating of secondaries | kV<br><br>VA<br><br>Ω V<br>A | | |
| 15. | Neutral CTs:<br>i) Voltage class<br>ii) No. of cores<br>iii) Ratio<br>iv) Accuracy class<br>v) Burden<br>vi) Accuracy limit factor<br>vii) Maximum resistance of secondary winding<br>viii) Knee point voltage<br>ix) Current rating of secondaries | kV<br><br><br>VA<br><br>Ω<br>V A | | |
| 16. | Transformer Oil<br>i) IS 335 / IEC60296 / as per specification<br>ii) Inhibited/ un-inhibited<br>iii) Mineral / Natural Ester / Synthetic Ester<br>iv) Spare oil as percentage of first filling<br>v) Manufacturer<br>vi) Quantity of oil (before filling and | | | |

| | | | | |
|---|---|---|---|---|
| | before commissioning) vii)Moisture content (mg/L or ppm) | | | |
| | viii) Tan delta (Dielectric Dissipation Factor) at 90oC<br>ix) Resistivity (Ω-cm))<br>x) Breakdown Voltage (before and after treatment) (kV)<br>xi) Interfacial tension at 20 oC (N/m)<br>xii) Pour point (oC)<br>xiii) Flash point(oC)<br>xiv) Acidity (mg KOH/gm)<br>xv) Inhibitors (for inhibited oil) (%)<br>xvi) Oxidation Stability | | | |
| 17. | Press Board:<br><br>i) Make<br>ii) type | | | |
| 18. | Conductor Insulating Paper<br>i) Kraft paper<br>ii) Thermally upgraded Kraft paper<br>iii) Nomex | | | |
| 19. | Provision for fire protection system (as per spec), if yes, provide details | Y/N | | |
| 20. | Insulation of core bolts, washers, end plates etc. | | | |
| 21. | Weights and Dimensions:<br><br>i) Weights:<br>a. Core<br>b. Windings<br>c. Tank<br>d. Fittings<br>e. Oil<br>f. Total weights of complete transformers with oil and fittings<br><br>ii) Dimensions; | | | |
| | a. Overall Height above track<br>b. Overall length<br>c. Overall breadth<br><br>iii) Minimum bay width required for installation of the transformer<br><br>iv) Weight of the heaviest package of the transformer arranged for transportation | | | |
| 22. | Lifting Jacks<br><br>i) Number of jacks included<br>ii) Type and Make<br>iii) Capacity<br>iv) Pitch | | | |

| | | | | |
|---|---|---|---|---|
| | v) Lift<br>vi) Height in close position | | | |
| 23. | Rail Track gauges<br><br>i) 2 Rails or 3 rails or 4 rails<br>ii) Distance between adjacent rails on shorter axis<br>iii) Distance between adjacent rails on longer axis | | | |

**56. <u>Tests for Reactors</u>**

| S. No. | Test | Test Category |
|---|---|---|
| 1. | Measurement of winding resistance | Routine |
| 2. | Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units ) | Routine |
| 3. | Measurement of insulation resistance & Polarization Index | Routine |
| 4. | Measurement of insulation power factor and capacitance between winding and earth | Routine |
| 5. | Measurement of insulation power factor and capacitance of bushings | Routine |
| 6. | Tan delta of bushing at variable frequency (Frequency Domain Spectroscopy) | Routine |
| 7. | Core assembly dielectric and earthing continuity test | Routine |
| 8. | High voltage with stand test on auxiliary equipment and wiring after assembly | Routine |
| 9. | Chopped wave lightning impulse test for the line terminals (LIC) | Routine |
| 10. | Lightning impulse test on Neutral (LIN) | Routine |
| 11. | Switching impulse test | Routine |
| 12. | Separate source voltage withstand test | Routine |
| 13. | Short time over voltage Test (830kVrms) (applicable for 765 kV Reactor only) | Routine |
| 14. | Induced over voltage test with Partial Discharge measurement (IVPD) | Routine |
| 15. | Measurement of dissolved gasses in dielectric liquid | Routine |
| 16. | 2-Hour excitation test except type tested unit | Routine |
| 17. | Vibration & stress measurement at Um/√3 level Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units. (Measurement shall also be carried out at 1.05Um/√3 level for reference purpose) | Routine |

| | | |
|---|---|---|
| 18. | Temperature rise test | Type |
| 19. | Measurement of harmonic content of current ( Measured in Cold state) | Type |
| 20 | Measurement of acoustic sound/noise level (Measured in Cold and Hot state of temperature rise test) | Type |
| 21. | Knee point voltage measurement of reactor (Measured in Cold and Hot state of temperature rise test ) | Type |
| 22. | Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports ) | Routine |
| 23. | Oil leakage test on Reactor tank | Routine |
| 24. | Appearance, construction and dimension check | Routine |
| 25. | Measurement of mutual reactance on 3-phase reactor | Routine |
| 26. | Measurement of zero-sequence reactance on 3-phase reactor | Routine |
| 27. | Tank vacuum test | Routine |
| 28. | Tank pressure test | Routine |

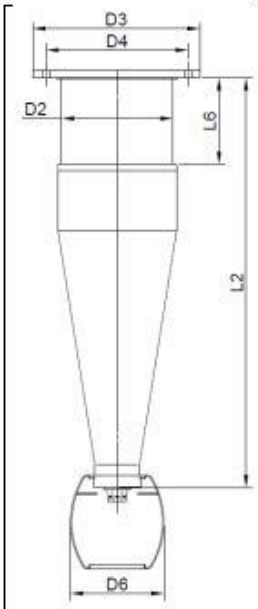
**57. <u>Tests for Oil Filled Neutral grounding Reactors (NGR</u>)**

| | | |
|---|---|---|
| 1. | Measurement of winding resistance | Routine |
| 2. | Measurement of Impedance at rated continuous current | Routine |
| 3. | Measurement of insulation resistance | Routine |
| 4. | Measurement of Capacitance & Tan delta of winding insulation to earth and bushing | Routine |
| 5. | Lightning impulse test | Routine |
| 6. | Separate source voltage withstand test | Routine |
| 7. | Isolation Test | Routine |
| 8. | Oil leakage test | Routine |
| 9. | Appearance, construction and dimension check | Routine |
| 10. | High voltage with stand test on auxiliary equipment and wiring after assembly | Routine |
| 11. | Tank vacuum test | Routine |
| 12. | Tank pressure test | Routine |
| 13. | Temperature rise test | Type Test |
| 14. | Measurement of vibration at rated continuous current | Routine |
| 15. | Measurement of loss | Routine |

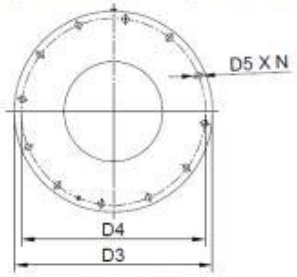
| | | |
|---|---|---|
| 16. | Short time current test and measurement of impedance at short time current | Type Test |
| 17. | Measurement of acoustic sound / noise level | Type Test |

**58. Standard dimension for lower portion of condenser Bushing.**

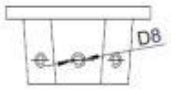
**STANDARD DIMENSIONS FOR LOWER PORTION OF CONDENSER BUSHINGS**
**(For 2500 A, 800 kV and 420 kV voltage class Bushings)**




Bushing Mounting Flange Details



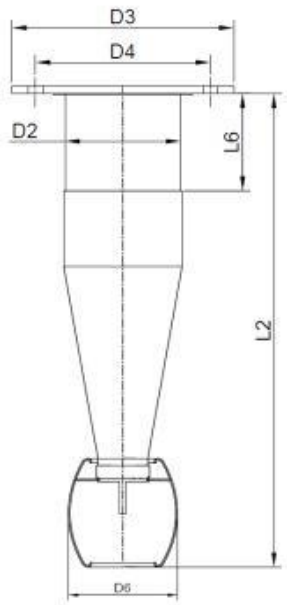

Bottom Connection Details



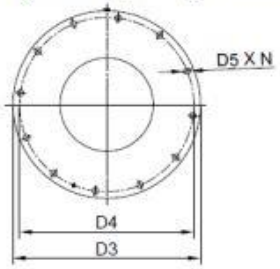

| Symbol | Description |
|---|---|
| L2 | Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest |
| L6 | Length for accommodating Bushing Current Transformer (BCT) |
| D2 | Maximum diameter of oil immersed end |
| 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<br>1550 (for GT) |
| **Creepage Distance (mm) (min.)** | 24800 | 13020 |
| **Current Rating (A)** | **2500** | **2500** |
| **Type of lead** | Solid Stem (SS) | SS |
| **L2 ±5** | 1955<br>(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 |

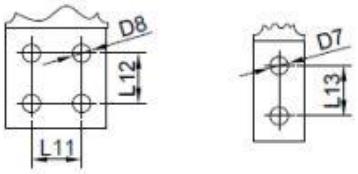
## STANDARD DIMENSION FOR LOWER PORTION OF CONDENSER BUSHINGS
### (For 420 kV and below voltage class Bushings)




Bushing Mounting Flange Details




Bottom Connection Details




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

| **Voltage Rating (kV)** | **420** | **245** | | **145** | | **72.5** | | **52** |
|---|---|---|---|---|---|---|---|---|
| **BIL kVp** | 1425<br>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/<br>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 |

**59. 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

**60. 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).

**61. Online Dissolved Gas (Multi-gas) and Moisture Analyser**

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 have facility 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.

| | |
|---|---|
| Accuracy | $\pm$ 10% |
| Repeatability | $\pm$3% to 10% depending upon gases |
| Oil temperature range | - 20$^{0}$ C to + 120$^{0}$ C |

| | |
|---|---|
| External Temp. Range | - $20^0$ C to + $55^0$ C<br>(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 |

The technical features of the equipment shall be as under:

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/Rector.

**62. 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 /Rector shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The

bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

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

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

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

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

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

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

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

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

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.

**63. 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 up to 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 /Rector 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** |
|---|---|---|---|---|---|---|
| Oil Storage Tank | Shot Blast cleaning Sa 2 ½* | Epoxy base Zinc primer (30-40μm) | Epoxy high build Micaceous iron oxide (HB MIO) (75μm) | Aliphatic polyuret hane (PU) (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 marshalling 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 / marshalling 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 / marshalling 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 enamelled 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/Rector:-**

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.

The guaranteed technical particulars for the offered system are indicated in Ann-IV. 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, as per the format given in Tender specification.

**64. 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 AN IN-HOUSE NABL-ACCREDITED LAB IS AVAILABLE, THE SAMPLE CAN BE TESTED THERE. IF NOT, THE SAMPLE SHOULD BE SENT TO A THIRD-PARTY NABL-ACCREDITED LAB |
| 2 | BUSHING | FAT AT OEM PERMISES AS PER IEC &TS | FAT AT TRANSFORMER MANUFACTURER | SHOULD BE EQUIPPED WITH A NABL-ACCREDITED LABORATORY |
| 3 | INSULATING OIL | TEST AT OIL MANUFACTURER PERMISES AS PER IS/IEC. (FOR TOTAL QUANTY OF OIL) | AS PER FAT | SHOULD BE EQUIPPED WITH A NABL-ACCREDITED LABORATORY |
| 4 | MARSHALLING BOX, DM, RTCC PANEL | IP55 TEST FOR ONE OF EACH FOR A LOT | FUNCTIONAL & OTHER TEST | FROM NABL LAB |
| 5 | TANK | VACCUM, PRESSURE TEST & OTHER TEST | | |
| 6 | WINDING | AS PER MQP | | |
| 7 | CORE BUILDING AND FRAME ASSEMBLY | AS PER MQP | | |
| 8 | CORE COIL ASSEMBLY | AS PER MQP | | |
| 9 | NIFPES | FUNCTIONAL TEST AT OEM PERMISES | | |
| 10 | TRANSFORMER | | FAT TEST AS PER QAP AND TS | SHOULD BE EQUIPPED WITH A NABL-ACCREDITED LABORATORY |

**65. Sub Vender list for Transformer/Reactor 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 |

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|---|---|---|
| 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 | CBS Tech. Pvt Ltd. |
| | ON LINE INSULATING OIL DRYING SYSTEM | TRANSEC LTD – UK |
| 20 | OIL FILTERATION MACHINE | CEE DEE VACUUM EQUIPMENT PVT.LTD |
| | OIL FILTERATION MACHINE | CBS Tech. 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 |

Manufacturer should purchase materials as per sub-vendor list provided.

**66. Oil sampling bottles**

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Transformers and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

**67. 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 40µm (min)** | | | | | |
| Radiator and pipes up to 80 NB (Internal surfaces) | Chemical cleaning, if required | Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint | -- | -- | -- | -- |
| Control cabinet / Marshalling Box - No painting is required. | | | | | | |

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

**68. RATING AND DIAGRAM PLATE(REACTOR)**

| | | | | | |
|---|---|---|---|---|---|
| **Manufacturer's name, country and city where the reactor was assembled** | | | | | |
| **MVAR Rating, Voltage & Type of Reactor (for example 80MVAR, 420kV Line reactor with NGR / bus reactor)** | | | | | |
| Type of Cooling | | | Applicable Standard | | |
| Rated Power at rated voltage | MVAR | | Rated frequency | Hz | |
| Rated Voltage | kV | | Number of phases | | |

| | | | | | |
|---|---|---|---|---|---|
| Maximum operating Voltage | kV | | % Impedance | % | |
| Rated Current | A | | Zero sequence reactance | Ohm | |
| Winding connection | | | Ratio of zero sequence reactance to positive sequence reactance (X0/X1) | | |
| Reactance at rated voltage & frequency | ohms | | Vibration and tank stress | Micron & kg/sq. mm | |
| Basic Insulation Level (Lightening Impulse/Switching Impulse/Power | | | Core mass | Kg | |
| Frequency Withstand Voltage) | | | | | |
| HV end/ terminal | kVp/ kVp/ kVrms | | Copper Mass | 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 tank | mm of Hg | | Total mass | Kg | |
| Noise level | | | Reactor oil Quantity | Ltrs | |
| Tan delta of winding | | | Paint Shade | | |

| | | | | | |
|---|---|---|---|---|---|
| Moisture content | ppm | | Total loss at rated current & frequency (at $75^0$C) | KW | |
| Manufacturer's Serial number | | | $I^2R$ loss at rated current & frequency (at $75^0$C) | KW | |
| Year of manufacture | | | | | |
| Work Order No. | | | | | |
| Purchaser's Order No. & Date | | | | | |
| OGA Drg. No. | | | | | |

**69. RATING AND DIAGRAM PLATE(NGR)**

| **Manufacturer's name, country and city where the NGR was assembled** | | | | | |
|---|---|---|---|---|---|
| **Voltage & Type of NGR (for example 145kV Oil-filled /Air Core NGR)** | | | | | |
| Type of Cooling | | | Applicable Standard | | |
| Connection | | | Rated frequency | Hz | |
| Rated Voltage | kV | | Number of phases | | |
| Rated Current | A | | Core mass | Kg | |
| Rated Short time current | kA (for –sec) | | Copper Mass | Kg | |
| Rated impedance | ohms | | Core & Coil Mass | Kg | |
| Basic Insulation Level (Lightening Impulse/Switchin g Impulse/Power Frequency Withstand Voltage) | | | Transportation Mass | Kg | |
| HV end/ terminal | kVp/ kVp/ | | Tank & Fitting mass | | |
| | kVrms | | | | |
| Ground side | kVp/ kVp/ kVrms | | Type & total mass of insulating oil | Kg | |

| | | | | | |
|---|---|---|---|---|---|
| Guaranteed Temperature rise<br>over ambient temperature of 50 Deg. C | | | Total mass | Kg | |
| (c) Top Oil | $^0$ C | | NGR oil Quantity (if applicable) | Ltrs | |
| (d) Winding | $^0$ C | | Paint Shade | | |
| Manufacturer's Serial number | | | Vacuum withstand Capability of tank | mm of Hg | |
| Year of manufacture | | | Tan delta of winding | | |
| Work Order No. | | | Moisture content | ppm | |
| Purchaser's Order No. & Date | | | | | |
| OGA Drg. No. | | | | | |
| **Purchaser's Name** | | | | | |

**70. DESIGN DOCUMENTS TO BE SUBMITTED BY OEM**

| Sr. No. | Description |
|---|---|
| 1. | Core and Magnetic Design |
| 2. | Over-fluxing characteristics up to 1.7 Um (for transformer) and Linear characteristics (for reactor) |
| 3. | Characteristics of the leg magnetic packets (cheeses) (For reactor) |
| 4. | Inrush-current characteristics while charging |
| 5. | Winding and winding clamping arrangements |
| 6. | Characteristics of insulation paper |
| 7. | Typical data and parameters mentioned in GTP |
| 8. | Short-circuit withstand capability including thermal stress / withstand capability for 2 seconds (3 seconds for generator transformers & associated auxiliary transformer). |
| 9. | Thermal design including review of localized potentially hot area |
| 10. | Structural design |
| 11. | Overvoltage withstand capability of reactor |
| 12. | Cooling design |
| 13. | Overload capability |

| | |
|---|---|
| 14. | Calculations of losses, flux density, core quantity etc. |
| 15. | Calculations of hot spot temperature |
| 16. | Eddy current losses |
| 17. | Seismic design, as applicable |
| 18. | Insulation co-ordination |
| 19. | Tank and accessories |
| 20. | Bushings |
| 21. | Mechanical layout design including lead routing and bushing termination |
| 22. | Tapping design (as applicable) |
| 23. | Protective devices |
| 24. | Number, locations and operating pressure of PRD |
| 25. | Location, Operating features and size of Sudden Pressure Relay/ Rapid Pressure Rise Relay |
| 26. | Radiators ,Fans and Pumps (as applicable) |
| 27. | Sensors and protective devices– its location, fitment, securing and level of redundancy |
| 28. | Oil and oil preservation system |
| 29. | Corrosion protection |
| 30. | Electrical and physical Interfaces with substation |
| 31. | Earthing (Internal & External) |
| 32. | Processing and assembly |
| 33. | Testing capabilities |
| 34. | Inspection and test plan |
| 35. | Transport and storage |
| 36. | Sensitivity of design to specified parameters |
| 37. | Acoustic Noise |
| 38. | Spares, inter-changeability and standardization |
| 39. | Maintainability |
| 40. | Conservator capacity calculation |
| 41. | Winding Clamping arrangement details with provisions for taking it “in or out of tank” |
| 42. | Conductor insulation paper details |
| 43. | Location and numbers of Optical temperature sensors (if provided) |
| 44. | The design of all current connections |
| 45. | Location & size of the Valves |
| 46. | Manufacturing facilities and manufacturing environment (clean, dust free, humidity controlled environment) as per Annexure G |

**NB- 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.**