

Section - 3 (Transformers)

**TECHNICAL SPECIFICATIONS FOR 100MVA, 160MVA, 200MVA
220/110/11KV AND 100MVA, 150MVA, 220/66/11KV, 31.5MVA, 66/11KV
POWER TRANSFORMERS FOR 220KV STATIONS.**

1.0 SCOPE

1.01 This specification covers design, manufacture, shop testing, supply, delivery, supervision of erection, testing and commissioning of 100MVA,160MVA,200MVA 220/110/11KV Auto Transformer with tertiary, 220/66/11KV, 100MVA/150MVA three winding transformer with tertiary, air forced, Oil forced (OFAF) cooling 31.5MVA, 66/11KV two winding Transformer with air forced cooling complete and with all fittings and accessories, Nitrogen Fire Protection System, OLTC, RTCC, FCC, parallel operating equipments, first filling of oil and 10% spare oil in non-returnable drums at 220KV stations .The power transformers thus offered shall be designed for satisfactory parallel operation with the power transformers to be installed in future, the transformer/s sharing the load in proportion to the rating of the winding.

The power transformer shall be SCADA compatible.

1.02 It is not the intent to specify completely herein all details of the design and construction of equipments. However, the equipment shall conform in all respects to standards of engineering, design and workmanship listed in clause No. 2 and shall be capable of performing in continuous commercial operation up to the supplier's guarantee in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment, is not in accordance therewith. The equipments offered shall be complete with all components necessary for effective and trouble free operation such component shall be deemed to be within the scope of supplier's supply, irrespective of whether those are specifically brought out in this specification and or / the commercial order or not.

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

2.0 STANDARDS:

2.01 The transformers, accessories and associated equipment shall generally conform to the latest revision and amendments of standards as given below, except to the extent explicitly modified in the Specifications,

Indian Standard	Title	International and Internationally recognized Standard
IS-325	Three Phase Induction Motors	IEC – 60034
IS-335	Insulating oils for Transformers and Switchgear	IEC-60296, BS-148
IS-778	Gun metal gate, globe and check-valves for general purpose.	
IS-1866 - 2000	Code of practice for Electrical maintenance and supervision of mineral insulating oil in equipment.	
IS-1886	Code of practice for installation and maintenance of transformers	
IS-2026	Power Transformers	IEC-60076
IS-2099	Bushings for alternating or AC voltage above 1000V	IEC-60137,BS-223
IS-2147	Degrees of Protection provided by enclosures for low voltage switchgear and control gear	
IS-2705	Current Transformers	IEC-61869
IS-3203	Code of practice of climatic proofing of electrical equipments.	
IS-3347	Dimension for porcelain Transformer Bushings	
IS-3401	Silica gel	
IS-3637	Gas operated relays	
IS-3639	Fittings & Accessories for Power transformers	
IS-4253	Cork and rubber	
IS-5561	Electric Power connector	
IS-5578	Marking and arrangements for switchgear	
IS-11353	:bus bars, Main connections and auxiliary wiring.	
IS-6272	Industrial cooling fans	
IS-6600	Guide for loading of oil immersed transformers	IEC-354
IS-8468	On load tap changer	IEC-60214
IS-8478	Application guide for OLTC	IEC-60542
IS-9434	Guide for sampling and analysis of dissolved gas in oil filled equipments.	
IS-12676	Oil impregnated paper-insulated condenser Bushing Dimension and requirements.	
	Insulation Co-ordination, Indian Electricity Rules 1956	IEC-60071
	High voltage test techniques IEMA Standard Publication- Transformer-I CBIP Manual on power transformers	IEC-60060

2. 02. The standards mentioned above are available from:

Standard	Name and Address
IS	BUREAU OF INDIAN STANDARDS, Manak Bhawan, No. 9 Bahadur Shah Zafar Marg, New Delhi-110 001, INDIA
IEC	INTERNATIONAL ELECTRO-TECHNICAL COMMISSION, bureaucentral de la Commission Electro Technique Internationale, 1, Rue deVerembe, Geneva, SWITZERLAND.

2.03 Equipment meeting with the requirements of other authoritative international standards which ensure equal or better Performance than the standards mentioned above shall also be considered. When the equipment offered by the supplier conforms to other standards, salient points of difference between standards adopted and the standards specified in this specification shall be clearly brought out in the offer. Two copies of such standards with authentic translation in English shall be furnished along with the offer.

3.0 CLIMATIC CONDITIONS :

The equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

- a) Maximum ambient air temperature [Deg. C] - 50
- b) Minimum ambient air temperature [Deg. C] - 5
- c) Average daily ambient air temperature [Deg. C] - 30
- d) Relative humidity [%] - 10-100
- e) Average rainfall per annum [mm] - 3000 max.
- f) Maximum altitude above mean sea level [Mtrs] - 1000
- g) Maximum wind pressure [Kg. / Sq. M] - 150
- h) Isoceraunic level [days / year] - 46
- i] Seismic level [horizontal acceleration] - 0.3g

Moderately hot and humid tropical climate, conducive to rust and fungus growth.

4.0 CLEARANCES :

4.01 The over all dimensions of the transformer shall allow for sufficient clearances for installation :

- a) In 220KV switchyard, with bay width of 14000mm and boom height of 11000mm, the phase to phase and phase to earth clearance of 220KV bay is 3650mm and 3350 mm. However the overall length of transformer is to be limited to 12000mm and the maximum length of the Transformer from centre line of Transformer to the longest side shall be less than 6700mm.
- b) In 66KV Yard with bay width of 7600mm /8200mm and boom height of 8500mm, the phase to phase and phase to earth clearance of 66KV Bay is 2000 mm and 1800/2100mm. However the overall length of transformer is to be limited to 6500mm and the maximum length of the transformer from centre line of transformer to the longest side shall be less than 3500mm.

4.02 RAIL GAUGE :

Rail gauges to be available at the station are indicated below :

For 100MVA/150MVA/160MVA/200MVA Transformer

- a) In the direction parallel to the line of 220KV and 110/66 KV Bushing - 1676 mm

- b) In the direction perpendicular to the line of 220KV and 110/66KV Bushing - 2982 mm

For 31.5MVA Transformer:

- a) In the direction parallel to the line of 66KV bushing - 1676mm.
 b) In the direction perpendicular to the line of 66KV bushing - 1676mm.

5.00 AUXILIARY POWER SUPPLY

Auxiliary electrical equipment shall be suitable for operation on the following supply system:-

a) Power Devices like drive motors etc.	415V, 3Ph, 4Wire, 50Hz, neutral grounded AC supply
b) AC Control & Protective devices	240V, Single Phase, 50 Hz, neutral ground AC supply
c) DC for Alarm, Control & protective devices	220V, DC, 2Wire un-grounded DC supply from batteries and battery charger. The ripple content in the DC supply from the charger will be less than 2%

Each of the foregoing supplies shall be made available by the purchaser at the terminal point for each transformer for operation of accessories and auxiliary equipment. Supplier's scope includes supply of interconnecting cables, terminal boxes etc. the above supply voltage may vary as below and all devices shall be suitable for continuous operation over entire range of voltages.

- i) AC Supply : Voltage +10% to -20%, Frequency + or -5%
 ii) DC Supply : +10% to - 20%

6.00 PRINCIPAL PARAMETERS:

6.01 The transformer shall be of core type construction, 3 Ph oil immersed, oil natural, forced air cooled and forced oil cooled with external radiator and shall be suitable for outdoor service. The transformer shall conform to the principal technical parameters indicated in Annexure - A.

6.02 CURRENT TRANSFORMER FOR TERTIARY WINDING:

Three CT's of ratio 1010/1 Amps for 100MVA Transformer, 1515/1 Amps for 150MVA, 1616 Amps for 160MVA Transformer & 2020/1 Amps for 200MVA Transformer should be mounted one in each phase inside the Delta winding of the tertiary for protection of the tertiary winding. All CT secondary leads (six leads) should be brought out to the Marshaling Box mounted on the Transformer.

7.00 A DUTY REQUIREMENTS:

7.01 The interconnecting transformers would be used for Bi-directional flow of rated power.

- 7.02 The 220/110/11 KV & 220/ 66/11 KV and 66/11KV Transformer shall operate satisfactorily in parallel with each other of similar voltage between HV and IV Bus bars.
- 7.03 The transformer and all its accessories like bushing CT's (only for 100/150/160/200MVA Transformer) etc., shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 sec. The short circuit level of the HV system to which the subject transformer will be connected is 50kA for 220kV and 40kA for 66kV [Sym, rms, 3 phase fault]. The accessories of the transformer like bushings CTs etc., shall be designed to withstand short time current rating of 50kA/40kA.
- 7.04 The transformer shall be capable of being loaded in accordance with IS : 6600 / IEC-354 upto loads of 150%. There shall be no limitation imposed by bushings, tap changer etc. or any other associated equipments.
- 7.05 The transformer shall be capable of being operated without danger on any tapping at the rated KVA with voltage variation of $\pm 10\%$ corresponding to the voltage of that tapping.
- 7.06 Noise Level
i) The noise level of Transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed 75db.
- 7.07 Transformer shall be capable of withstanding thermal and mechanical stress caused by symmetrical or asymmetrical faults on any winding.

The thermal ability to withstand short circuit for duration of 3 secs. shall be demonstrated by theoretical evaluation of the ability to withstand a short circuit event by manufacturer's experiences supported by IEC guidelines as per IEC 60076-5, 2006 (3rd edition or the latest version)/ IS 2026-5, 2011(or latest version). **The calculation of dynamic ability to withstand short circuit shall be submitted before drawing approval along with thermal stability calculations.**

The windings shall be capable of withstanding axial and radial forces during fault conditions. **The detailed calculation towards the above should be furnished before drawing approval.**

The short circuit temperature rise should not exceed the limits, fixed as per IS: 2026. **The calculation towards the above for 220kV, 110kV, 66kV & 11kV windings shall be furnished before drawing approval.**

- 7.08 Transformer shall withstand, without injurious heating, combined voltage and frequency fluctuation, which produces the following over fluxing condition:
- | | | |
|-----------------------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------|
| i) 110% continuously :
125% for 1 minute :
140% for 5 seconds : | } | for all transformers where base voltage &
frequency refers to those mentioned in 3 & 4
of Annexure - A. |
|-----------------------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------|

ii) The Bidder shall indicate 150% and 170% over voltage withstand time.

But the normal flux density should be limited to 1.60 Tesla. Suitable over flux relay will be provided by the purchaser for protection with adjustable setting taking into account the above capability of the transformer.

iii) Over fluxing withstand characteristics up to 170% of V/f shall be submitted along with the tender where base voltage and frequency refers to those mentioned in 3 & 4 of Annexure – A.

7.09 Transformer shall be capable of operating under the natural cooled ONAN condition up to the specified load. The forced cooling equipment shall come into operation by preset contacts of winding temperature indicator and the transformer shall operate as a forced cooled unit, initially as ONAF up to specified load and then as OFAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140° C, also stopping up to one cooling fans in each bank should not have any effect on the cooling system, Transformers fitted with two cooler banks, each capable of dissipating 50 per cent of the heat loss at continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler, without the calculated winding hot spot temperature exceeding 140°C at continuous maximum rating.

7.10 DGA of oil shall be periodically monitored by the employer and the interpretation of DGA results will be as per IEC 599.

7.00 B Design review (for 220/110/11kV & 220/66/11kV Transformer):

The transformers 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 with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc so that the transformer provide long life with least maintenance.

Owner may visit to the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under scope of this specification.

The design review shall be conducted generally following the “CIGRE TB 529: Guidelines for conducting Design Review for Power Transformers”.

The manufacturer shall provide all necessary information and calculations during design review to demonstrate that the transformer meets the requirements for short

circuit strength and durability. The latest recommendations of IEC 60076-5/2006/ IS 2026-5/2011 and Cigre SC 12 shall be applied for short circuit withstand evaluation. .

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

The scope of such a design review shall at least include the following:

1. Core and magnetic design
2. Winding, tapping and insulation design
3. Short-circuit withstand capability
4. Thermal design including review of localized potentially hot area.
5. Cooling design
6. Overload capability
7. Eddy current losses
8. Seismic design, as applicable
9. Insulation co-ordination
10. Tank and accessories
- 10.1 Bushings and barrier design
- 10.2 Tap changers
- 10.3 Protective devices
- 10.4 Fans, pumps and radiators
- 10.5 Sensors and protective devices – its location, fitment, securing
and
level of redundancy
- 10.6 Oil and oil preservation system
11. Corrosion protection
12. Electrical and physical Interfaces with substation
13. Earthing
14. Processing and assembly
15. Testing capabilities
16. Inspection and test plan
17. Transport and storage
18. Sensitivity of design to specified parameters
19. Acoustic Noise
20. Spares, inter-changeability and standardization
21. Maintainability
22. Electrical clearances between windings to core (both axially & radially) between windings, outer windings and tank, etc.
23. Any other design aspect, as deal necessary.

8.00 GUARANTEED LOSS:

- i) The bidder while quoting should clearly indicate the guaranteed value of the losses which **shall be firm and without any tolerance limit**

in respect of under mentioned losses at normal tap, as required in GTP.

- (a) No load loss at rated voltage and rated frequency.
 - (b) Load losses at rated output, rated voltage and rated frequency.
 - (c) I²R Loss at rated output, rated voltage and rated frequency.
 - (d) Auxiliary losses at rated output.
- ii) Void.
 - iii) Void.
 - iv) The Maximum permissible losses (No load loss, I²R loss, auxiliary loss and load loss) at rated voltage/current (at 75 deg C) have been specified in Technical particulars/parameters. Following penalties shall be levied on the manufacturer/contractor/bidder (as the case may be) if losses measured during routine test are found to be within +2% tolerance of the Guaranteed losses declared by the manufacturer/contractor/bidder (as the case may be), beyond which the transformer shall be liable for rejection. No benefit shall be given for supply of transformer, with losses (measured during routine tests) less than the Guaranteed losses declared by the manufacturer/contractor/bidder (as the case may be).

Sl. No.	Differential of specified losses vs Measured losses	RATE (in INR per KW)
1	No Load Loss	Rs. 10,00,000/KW
2	I ² R 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.		

9.00.00 CONSTRUCTION DETAILS:

The features and construction details of power transformer shall be in accordance with the requirements stated here under.

9.01.01 CORE

- 9.01.02 (a) The cores shall be built up with high grade non aging cold rolled super grain oriented silicon steel laminations specially suitable for transformer cores. The conventional grain oriented (CGO) core of grade M4 or better shall be used.
- (b) The manufacturer of transformer shall directly import CRGO either from the manufacturer or through their accredited marketing organization of repute or through authorized dealer. In support of this requirement the manufacturer of transformer should submit an undertaking in the form of an affidavit on Rs.100/- stamp paper, duly notarized, in the specified format.

- 9.01.03 After being sheared, the lamination shall be treated to remove all burrs and shall be re-annealed to remove all residual stresses. At least one side of each lamination shall be coated with a durable carlite Lamination coating, which shall, be inert to the action of hot transformer oil. Paper and varnish insulation will not be accepted. The nature of insulation shall be inorganic coating.
- 9.01.04 The core shall be provided with adequate lugs suitable for lifting the complete core and coil assembly of the transformer.
- 9.01.05 The design of the magnetic circuit shall be such as to avoid static, discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.
- 9.01.06 Core and winding shall be capable of withstanding the shock during transport, installation, service (during short circuit) and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions. Necessary cooling ducts shall be provided.
- 9.01.07 Each of the core bolts and parts of the core clamping frame work which are likely to form a closed circulation path shall be insulated from the core laminations and tested after completion of the core assembly to withstand, a voltage of 2500V, rms 50Hz, for a duration of one minute.
- 9.01.08 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.
- 9.01.09 When bell type tank construction is offered, suitable projecting guides shall be provided on core-assembly to facilitate removal of tank.*
- 9.01.10 The supporting frame work of core shall be so designed as to avoid presence of pockets which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.
- 9.01.11 The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency at any tap shall not exceed 1.60 tesla.
- 9.01.11 Bidder should have in house core cutting facility for proper monitoring and control on quality and also to avoid any possibility of mixing of prime material with defective / second grade material.

9.02.01 WINDINGS:

- 9.02.02 The tenderer shall ensure that winding of all EHV class transformers are made in dust proof, atmosphere, preferably in an enclosure or room where higher air pressure is maintained so that no dust can enter the premises. The Bidder shall furnish the facilities available in this regard at their works along with the tender.
- 9.02.03 The conductors shall be of electrolytic grade copper free from scales and burrs.

- 9.02.04 The windings shall be so designed that all coil assemblies of identical voltage rating shall be interchangeable and field repairs to the windings can be made readily, without special equipments. The coil shall be supported between adjacent sections by insulating spacers and barriers, Bracing's and other insulating materials used in the assembly of the windings shall be so arranged to ensure a free circulation of the oil and to reduce hot spots in the windings. The high, medium and tertiary windings on each leg shall be so assembled as to admit their being placed on or removed from core leg as complete units.
- 9.02.05 The insulation of the coils shall be treated with suitable insulating varnish or equivalent compound to develop the full electrical strength of the windings. All materials used in the insulation and assembly of the windings shall be insoluble non-catalytic and chemically inactive with the hot transformer oil, and shall not soften or otherwise be adversely affected under the operating conditions. Class 'A' insulation shall be used throughout.
- 9.02.06 All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal Board and bushings shall be rigidly supported to prevent injury from vibration. Guide shall be used where practicable.
- 9.02.07 The winding shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled cores and windings shall be vacuum dried and suitably impregnated before removal from the treating tank. The copper conductors, used in the coil structure shall be best suited to the requirements and all permanent current carrying joints in the windings and leads shall be welded or brazed.
- 9.02.08 All star connected windings of 66KV and above shall have graded insulation as per relevant India or International Standard. The Power Transformer shall withstand the power frequency and impulse test voltage specified. The windings shall be designed to reduce to minimum out of balance forces in the transformer at all voltage variations. The conductor shall be transposed at intervals to reduce eddy currents and equalize currents and temperature distribution along the windings.
- 9.02.09 The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices if necessary shall be provided for taking up possible shrinkage of coils if any, in service, The provision made in this respect shall be clearly brought out in the Tender.
- 9.02.10 Power transformer should be designed for the short circuit current of $100/Z$ times the rated primary current of transformer for 3 secs where 'Z' is the percentage impedance of transformer, The high voltage and medium voltage winding shall be capable of withstanding this fault current. The supplier would furnish the detailed calculation to prove the short circuit strength of power transformer.
- 9.02.11 The tertiary winding which is meant for stabilizing purpose shall be capable of withstanding the over currents resulting from different forms of system faults that can arise in service, associated with system earthing conditions which is

solidly grounded system, Suitable cross section and current density of tertiary winding may be provided, taking in to account, the source impedance specified. The duration of the fault current shall be as per IS depending upon the inter winding impedance. The excess section provided shall take care of the mechanical stresses also during system short circuit. In the tender the calculation to prove the short circuit strength of the winding should be furnished.

The short circuit MVA capacity of the tertiary winding shall be 25% extra over the calculated and designed short circuit MVA. Detailed short circuit calculations of the transformer shall be furnished along with the offer.

9.02.12 The maximum current density in any winding shall not exceed 3 Amps / sq. mm at all taps.

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

9.02.14 *Fiber optic Sensors shall be embedded in each phase of the winding. The sensors shall be located where the Temperature is the highest.*

9.02.15 **SUPPRESSION OF HARMONICS:**

The transformer shall be designed with particular attention to the suppression of harmonic voltages, especially the 3rd and 5th so as to eliminate wave form distortion and any possibility of high frequency disturbances, inductive effected or of circulating currents between neutral points of different transformer stations reaching such a magnitude as to cause interference with communication circuits.

9.03.00 **TANK AND TANK ACCESSORIES:**

9.03.01 **TANK:**

- a) The transformer tank and cover shall be fabricated from tested grade low carbon steel suitable for welding. For 31.5 MVA transformer, the thickness shall be not less than 8mm for sides, 10mm for bottom and top cover and for 150 MVA transformer, the thickness shall be not less than 10mm for sides, 20mm for bottom and top cover. The tank shall be of welded construction.
- b) All seams and those joints not required to be opened at site shall be factory welded and wherever possible they shall be double welded. After completion of tank construction and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment for tank / stress relieving parts shall be based on recommendation of BS 5500 table 4.4.3.1
- c) The completely fabricated tank shall be subjected to oil leakage test, vacuum test and pressure test as specified in the clause 17.3.1 and 17.3.2 section A of revised 1987 CBIP manual. The tank cover shall be bolted to the tank and the transformer design shall be such that the tank will not be split between lower and upper cooler

connection for un-tanking. The tank shall also be designed to withstand (a) Mechanical shocks during transportation (b) short circuit forces (c) Vacuum filling of oil *d). Continuous internal pressure of 35kN/m² over normal hydrostatic pressure of oil.*

- d) Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.
- e) The transformer of rating 100 MVA and above shall be of bell type tank construction with the joint at about 500 mm above the bottom of the tank. In case the joint is welded it should be provided with flanges suitable for repeated welding. The joint shall be provided with suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.
In bell tank construction, suitable projecting guides shall be provided on core assembly to facilitate removal of tank.
- f) Suitable guides shall be provided for positioning the various parts (core and coil assembly) during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.
- g) Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantling. In addition the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the transformer either by crane or by jacks. Suitable haulage holes shall also be provided.
- h) The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be lifted with the use of these lugs without any damage or distortions.
- i) The tank shall be provided with two suitable copper alloy lugs for the purpose of grounding.
- j) Each tank shall be equipped with the following valves with standard screw connection for external pipings.
 - 1) One drain valve - 100 mm (4") flanged at the bottom of the tank to completely drain the tank. At the option of the purchaser, a large valve may be furnished with an eccentric reducer. This valve shall be equipped with a small sampling cock. Also another sampling cock shall be provided at the top of the tank.
 - 2) One filter valve located at the bottom of the tank. The filter valve shall be 50 mm (2") flanged to seat 40 mm (1½ ") male threaded adopter, for the filter pipe connection.
 - 3) One filter valve located at the top of the tank. The filter valve shall be 50mm (2") flanged to seat 40 min (1 ½ ") male threaded adopter, for the

filter pipe. The opening of the valve shall be baffled to prevent aeration of the oil.

- k) Wherever possible the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets can not be avoided, pipes shall be provided to vent the gas into the main expansion pipes.
- l) The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in any direction without injury when using plates or rails.
- m) Tank shields shall be such that no magnetic/ fields shall exist outside the tank. They shall be of magnetically permeable material. If required impermeable shields shall be provided at the coil ends. Tank shield shall not resonate when excited at the natural frequency of the equipment. Bidder may confirm use of tank shields in the schedule of additional information.

9.03.02 **TANK COVER :**

- a) The tank cover shall preferably be sloped to prevent retention of rain water and shall not distort when lifted.
- b) At least two adequately sized inspection openings, one at each end of the tank shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 Kg. The inspection covers shall be provided with two handles to facilitate shifting/lifting.
- c) The tank covers shall be fitted with pockets at the position of Maximum oil temperature of MCR (Maximum Continuous Rating) for *RTD sensor* /thermometer and bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. Protection shall be provided where ever necessary for each capillary tube.
- d) Bushings, turrets, covers of inspection Openings, thermometer, pockets etc., shall be designed to prevent ingress of water into or leakage of oil from the tank,
- e) All bolted connections shall be fitted with weather proof, hot oil resistant gasket in between, for complete oil tightness. Special attention shall be given to the methods of marking the hot oil tight joints between the tank and cover as also between the cover and the bushings and other outlets to ensure that the joints can be remade satisfactorily and with ease, with the help of semi skilled labour. If gasket is compressible, metallic stops shall be provided to prevent over-compression.

9.03.04 **AXLES AND WHEELS:**

- a) The transformer tank shall be supported on a structural steel base equipped with forged steel or cast steel, flanged bi- directional wheels and axles suitable for moving the transformer completely fitted with oil. These

shall be so designed as not to deflect excessively to interfere with the movement of the transformer. Wheels shall be provided with suitable bearings which shall be rust and corrosion resistant. Fittings for lubrication shall also be provided.

- b) Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.
- c) The wheels are required to swivel and they shall be arranged so that they can be turned through an angle of 90° when 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 gauge of the wheels when the transformer is moved on the common track shall be 1676 mm. The gauge of wheels when the transformer is moved on its own foundation plinth which will be at right angles to the direction of the common track shall be 2982 mm for 100MVA and above transformer and 1676 mm for 31.5MVA Transformer.
- e) A minimum of four jacking pads in accessible position at 500 mm height to enable the transformer complete with oil, to be raised or lowered using hydraulic or screw jacks.
- g) Suitable haulage holes shall be provided to facilitate moving the transformers and they shall be suitably braced in a vertical direction so that bending does not occur when the pull has a vertical component. Suitable jacks for lifting the transformer for changing the plane of rotation of the wheels shall be supplied.

9.03.05 ANTI- EARTHQUAKE CLAMPING DEVICE:

To prevent transformer movement during earthquake, clamping device shall be provided for fixing transformer to the foundation. The supplier shall supply necessary bolts for embedding in the concrete foundation. The arrangements shall be such that the transformer can be fixed to or - unfastened from these bolts as desired. The fixing of the transformers to the foundation shall be designed to withstand seismic events to the extent that a static coefficient of 0.3g, applied in the direction of least resistance to that loading will not cause the transformer or clamping devices as well as bolts to be over stressed.

The details of the device used and its adequacy shall be brought out in the additional information schedule.

9.03.06 CONSERVATOR TANK :

- a) The conservator tank shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100° C.

Conservator shall be with volumetric capacity at least 7 ½ % of a total volume of oil in the main tank of the transformer. The conservator tank shall be above the level of the bushing flanges.

- b) The conservator tank shall be bolted into position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell wherever applicable.
- c) Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high & low oil level alarm contacts & prismatic oil level guage.
- d) Conservator shall be provided in such a position as not to obstruct the electrical connections to the transformer.
- e) OLTC shall have separate conventional type conservator (without air cell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.
- f) The conservator tank shall have two filter valves one at the bottom at one end, the other at the top, opposite end, in addition to the valve specified in the accessories for the main tank. The conservator shall also have shut-off valve and a sump with a small drain valve and sampling cock, the latter so arranged as not to interfere with oil lines.
- g) Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be externally installed on the top of conservator to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service

9.03.07 PRESSURE RELIEF DEVICE:

Adequate number of pressure relief devices shall be provided at suitable locations which shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure of transformer tank. It shall be mounted direct on the tank. One set of electrically insulated contacts shall be provided for instantaneous tripping along with the recommended settings. If required discharge of PRD shall be properly taken through pipes and directed away from the Transformer / other equipments and this shall be prevented from spraying on the tank. Following routine test shall be conducted on PRD:

- a) Air pressure test
- b) Liquid pressure test
- c) Leakage Test
- d) Contact Test
- e) Dielectric Test

9.03.08 BUCHHOLZ RELAY:

A DOUBLE FLOAT TYPE Buchholz relay shall be provided. All the gases evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper or stainless steel tube, shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling, with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. It shall be provided with shut off valves and flange coupling to permit easy removal without lowering oil level in the main tank.

9.03.09 TEMPERATURE INDICATORS:

A) OIL TEMPERATURE INDICATOR (OTI):

- i. All transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent un-grounded alarm and trip contacts, maximum reading pointer and resetting device mounted in the cooler control cabinet. Temperature sensing element suitably located in a pocket of top oil to read the hottest part of the oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be 1.5% or better.
- ii. Remote Oil temperature indicator. It shall be suitable for flush mounting on RTCC panel. The difference between local and remote OTI indication at any given time shall not exceed 1 degree C.

B) WINDING TEMPERATURE INDICATOR (WTI)

A device for measuring the hot spot temperature of each of the (HV, IV & LV) windings shall be provided. It shall comprise of the following :

- i. Temperature sensing element with three hot spot winding temperature elements one each located in the HV windings, IV windings and LV windings.
- ii. Image coil.
- iii. Auxiliary CTs, if required to match the image coil, shall be furnished and mounted in the cooler control cabinet,
- iv. 150mm diameter local indicating instrument with maximum reading pointer mounted in cooler control cabinet and with two adjustable electrically independent ungrounded contacts (besides that required for control of cooling equipment), one for high winding temperature alarm and one for trip. The cooling equipments (Fan / Pump Motor) shall be switched on when the winding attains respective present high temperature

and switch it off when the temperature drops by an established differential (so as to avoid too frequent on and off operation of the switch).

- v. Calibration device.
- vi. In addition to the above, the following indication equipment shall be provided for each winding.
 - a) Remote winding temperature indicator. It shall be suitable for flush mounting on RTCC panel. The difference between local and remote WTI indication at any given time shall not exceed 1 degree C. One RWTI shall be provided for each winding in the middle phase (HV, IV / LV).
 - vii) The winding temperature detector relay shall be indicating and responsive to the combination of top oil temperature and winding current, calibrated to follow the hottest spot temperature of the transformer winding. The winding temperature detector shall operate remote alarm in the event of the hottest spot temperature approaching a dangerous value and it shall automatically actuate.
 - viii) Auxiliary supply if required, at owner's panel, for RWTI, shall be 220 V DC only.
 - ix) Accuracy class of WTI shall be 1.5% or better.
 - x) Any special cables required for shielding purpose for connection between cooler control cabinet and remote winding Temperature Indicator control circuit shall be in supplier's scope of work.
 - xi) Suppliers should supply reputed make winding temperature indicator. The make shall be indicated in his offer and the purchaser reserves the right to suggest different make in the event of an order. The earlier performance shall be indicated in the offer.

C) SIGNAL TRANSMITTER FOR EACH WINDING:

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Owners data acquisition system, for which a duplex platinum RTD with nominal resistance of 100 Ohms at zero degree centigrade shall be supplied. The RTD shall be suitable for 3 wire under grounded system . The calibration shall be as per SAMA (USA) standard. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided in lieu, separate RTD for each of the functions shall be provided.

D) REMOTE WINDING TEMPERATURE INDICATOR

It shall be suitable for flush mounting on Owner's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter.

Any special cable required for shielding purpose for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of

contractor. One RWTI shall be provided for each winding of HV, IV and LV. Auxiliary supply for RWTI, if required, will be 220DC only. Drawing showing dimensional details of RWTI shall be submitted to the Owner within two months from the date of award of contract.

E) *Temperature Indicator:*

Temperature measurement of Oil and windings shall be done using Fiber optic sensors, meeting following criteria:

- 1. System shall be of proven and rugged technology. The temperature sensing tip along with the fibre optic cable shall be of an already type tested design. Details of the relevant tests conducted shall be submitted along with the offer. The probes shall be directly installed in each phase/winding of power transformer to measure the winding hot spot and at the top (inside) of the transformer to measure top oil temperature. There shall be minimum eight probes inside the transformer, out of which one probe should be installed in top of the transformer for detection of top oil temperature.*
- 2. The remaining Fiber optic probes shall be installed in core and each phase / winding at the hottest spots of each of the phase windings. The locations of the probes shall be proposed by the Manufacturer by identifying the hot spots with necessary supporting calculations/documents and shall be finalized by agreement of the Purchaser.*
- 3. Probes shall be able to be completely immersed in hot transformer oil; they shall withstand exposure to hot Kerosene vapor during the transformer insulation drying process (VPD). The probes shall meet the requirement to eliminate the possibility of partial discharge in high electrical stress areas in the transformer.*
- 4. Temperature range of the system should be -30°C to 200°C & accuracy of $\pm 2^\circ\text{C}$ with no recalibration required. The probes shall not get damaged/affected during filtration of the transformer.*
- 5. Probes shall be all Silica, Double Teflon jacketed fibre with perforations/slits in the outer jacket to allow complete oil filling.*

The fibre with Teflon jacket shall be strong enough to withstand the severe conditions prevailing inside an EHV transformer.

- 6. The microprocessor based Fibre optic temperature monitoring system using Fibre optic probes shall confirm the following features:*
 - i. The Microprocessor based Fibre optic TMS shall read & display temperature of each Fibre optic sensor measurement channel. The system shall work in independent mode and failure of one channel should not affect the performance of the other healthy channels.*
 - ii. The logic for each relay should not consider the temperature channels for which probe error is detected and the out-put should return to normal state immediately after the probe error is detected.*
- 7. A Microprocessor based monitoring & recording unit shall be a part of the system. System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be $\pm 0.1^\circ\text{C}$ and the systems shall offer a user programmable temperature alarm outputs with 8 relays, alarm lamps (LED) and*

controller system status indicators. All inputs and outputs of the system shall meet the requirements of surge test of IEEE C37.90.1-2002 in which a 4000 V surge is applied to all the inputs and outputs without permanent damage to the instrument. The microprocessor based unit shall be of an already type tested design & details of type tests conducted shall be submitted with the offer. The device shall be communicable type & the protocol shall be IEC 61850 compliant. Provision for Time Synchronization with GPS shall be made.

The temperature monitoring system shall be direct measurement non-calibrating type. It shall read & display temperature of each Fibre Optic sensor measurement channel. The system shall work in independent mode and failure of one channel should not affect the performance of the other healthy channels.

- 8. The system shall be capable of retaining temperature data of 90 days at one (1) reading/ minute and should retain maximum temperature of each channel until reset.*
- 9. The manufacturer should submit data showing that the probes are located in the hottest point of the winding, while submitting drawings for approval.*
- 10. The fiber optic cables are to be brought out of the main tank through the tank wall penetrator feed through plate. The Feed through plate shall be welded on the Tank such that no oil leakage/moisture ingress will occur. The external fiber optic extension cable shall then be run to main control cabinet, routed inside the conduits with large bend radiuses.*
- 11. The controller shall be housed in the cooler control cubicle or in a separate box of IP56 class mounted on the transformer tank. The position shall be clearly indicated in the GA drawings.*
- 12. Temperature rise test measurements shall be made with the FO Thermometers. The equipment shall be operational during temperature rise tests and demonstrated during these tests. During probe verification, the hottest spot for each phase shall be identified, and temperature data for all probes recorded and reported in the test report.*
- 13. For remote indications on RTCC panel output of 4 to 20 mA shall be made available*

9.03.10 EARTHING TERMINALS:

- i) Two (2) earthing pads of size 100x100mm[each complete with two (2) Nos. tapped holes, M 12 bolts, plain and spring washers] suitable for connection to 50 x 8mm/75x12mm galvanized steel flat shall be provided each at position close to the two (2) diagonally bottom corners of tank. Earthing strip up to the ground level shall be provided by the Bidder.
- ii) Two earthing terminals suitable connection to 50x8mm/75x12mm galvanized steel flat also be provided on cooler, marshalling box and any other equipment mounted separately.

9.04.00 INTERNAL EARTHING ARRANGEMENTS:

9.04.01 GENERAL:

All metal parts of the transformer with the exception of the individual core- laminations, core bolts and associated individual clamping plates shall be maintained at some fixed potential.

9.04.02 EARTHING OF CORE CLAMPING STRUCTURE:

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods.

- a) By connection through vertical tie rods to the top structure.
- b) By direct metal - to - metal contact with the tank base maintained by the weight of the core and windings.
- c) By a connection to the top structure on the same side of the core as the main earth connection to the tank.

9.04.03 EARTHING OF MAGNETIC CIRCUIT:

The magnetic circuit shall be earthed to the clamping structure at one point only through a link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection.

9.04.04 Magnetic circuit having an insulated sectional construction shall be provided with a separate link for each individual section. Where oil ducts or insulating barriers parallel to the plane of the laminations divide the magnetic circuit into two or more electrically separate parts, the ducts or barriers shall be bridged (where the magnetic circuit is divided into pockets by cooling ducts parallel to the plane of the laminations or by insulating material above 0.25 mm thick tinned copper strips bridging pieces shall be inserted to maintain electrical continuity between pockets) and the magnetic circuit shall not be regarded as being of sectional construction.

9.04.05 EARTHING OF CLAMPING RINGS:

Where coil clamping rings are of metal at earth potential, earth ring shall be connected to the adjacent core clamping structure on the same side of transformer as the main earth connections.

9.04.06 SIZE OF EARTHING CONNECTIONS:

All earthing connections with the exception of those from the individual coil clamping rings shall have a cross sectional area of not less than 0.8

sq. cm. Connections inserted between laminations of different sections of core as per Clause 9.04.04 shall have a cross sectional area of not less than 0.2 sq. cm.

9.05.00 INSULATING OIL:

9.05.01

- a) Uninhibited Mineral insulating oil shall be used & shall comply with IEC-60296- 2012 (Latest version).

Supplier shall furnish type test certificate complying to IEC-60296-2012 (latest version) from any NABL accredited oil testing laboratory.

- b) Sufficient quantity of oil necessary for first filling of all tanks, coolers and radiator at the proper level along with 10% extra oil for topping up shall be supplied in non-returnable containers suitable for outdoor storage.
- c) For 100MVA and above transformer rating, the supplier shall dispatch the transformer filled with an atmosphere of Nitrogen. The Bidder shall take care of the weight limitation on transport and handling facility at site. Necessary arrangement shall be ensured by the supplier to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A gas pressure testing valve with necessary pressure gauge and adapter valve shall be provided.

9.05.02 At manufacturers works oil sample shall be drawn before and after heat run test and shall be tested for following:

- a) BDV-60KV (min)
- b) Moisture content – 10 PPM (Max.)
- c) Dissolved gas analysis - samples for DGA shall be taken from sampling device with 24 hrs prior to commencement of temperature test and immediately after this test. The acceptance norms with reference to various gas generation rates during the temperature rise test shall be as per IS 10593(based on IEC 599) Values of DGA test conducted before & after heat run test shall be furnished, as base value for future test

9.05.03

VOID

9.06.00 OIL PRESERVING EQUIPMENT:

9.06.01. For 245 KV class transformers Bidder shall offer diaphragm type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with atmospheric air. In this type of oil preservation system

conservator shall be fitted with a dehydrating filter breather
(Maintenance Free Type Breather).

Condition Controlled Maintenance Free Type Breather

A. The main Transformer tank conservator shall be fitted with a Maintenance-Free type silica gel Breather which shall be equipped with a microprocessor control unit and LED status indication.

B. Dehydrating breather's operating principle:

When the oil conservator breaths-in (e.g. at reduced load), the air flows through a filter made of high-grade steel wire mesh. The equipment fitted with filter & the dust cap, filters the dust, sand and other dirt particles from the air. The filtered air flows through the desiccant chamber filled with colourless, moisture adsorbing pellets and are dehydrated. The dehydrated air rises further via the pipe in the oil conservator. The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200mm approximately from transformer rail top level.

C. Technical Features:

C.1 Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0°C to +80°C.

C.2 Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

- a) Led for Power of control unit – ON
- b) LED for Filter heater – ON
- c) LED for Anti-condensation heater (of control unit) – ON
- d) LED & relay contact for “Device Error”
- e) LED & relay contact for Regeneration active (De-humidification in process)
- f) Analogue output signal (4-20mA) for the Temperature of air (in filter unit/pipe).

C.3 The Breather shall be equipped with test button which should allow to carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.

C.4 Control unit shall be equipped with communication port for downloading the operational data logged by the unit. All necessary software required for downloading and analyzing the logger data shall also be provided by the supplier. Supply of Laptop/PC for above software is not envisaged.

C.5 The moisture and temperature measurement system (Sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

C.6 The process dehydration has to be carried out only on a transformer exhale cycle in order to prevent any moisture entering into the conservator piping without blocking any parts of the breather units.

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

C.7 Degree of Protection shall be at least IP55 for which type Test report shall be submitted. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.

C.8 The control unit shall be equipped with suitable heater to prevent moisture condensation.

C.9 The size of condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.

C.10 The equipment shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over. During this period, if the equipment needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of spares, software, transportation etc. of this equipment for repair at test lab/works. Further supplier shall make alternate arrangement for smooth operation of the transformer.

C.11 Further, provision shall also be made to fix conventional dehydrating breather. The piping and flange arrangement shall be made such that it is possible to fix both the maintenance free type breather and conventional dehydrating filter breather. Such an arrangement is envisaged for smooth operation of the transformer incase of exigencies i.e., withdrawal /removable of maintenance free type breather for repair/service.

Also, the required capacity and number of conventional dehydrating filter breather shall be supplied as spare for the main tank conservator.

9.06.02 DIAPHRAGM SEAL TYPE CONSTANT OIL PRESSURE SYSTEM: (Air Cell System)

The bidder shall furnish his experience list for diaphragm type oil sealing system. The requirement of the system are given below:

- a) In this system contact of the oil with atmosphere shall be prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.

- b) Diaphragm used shall be suitable for continuous operation in an atmosphere of 100deg.C to which transformer oil is likely to rise.
- c) The connection of the air cell to the top of the reservoir shall be by an air proof seal permitting entrance of air into the cell only.
- d) The diaphragm of the conservator shall withstand the vacuum during installation and maintenance period. Otherwise provision shall be made to isolate the conservator from main tank during vacuum by providing vacuum scaling valve in the pipe connecting main tank with the conservator.

9.07.00 BUSHINGS:

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

Voltage Rating	Bushing Type
72.5kV, 145kV & 245 kV bushings	RIP/RIS
Bushings of 36 kV and below	Solid porcelain (oil communicating type)
Bushings of other rating	OIP/RIP/RIS

*OIP: Oil Impregnated Paper (with porcelain/polymer housing);
 RIP: Resin Impregnated Paper (with polymer housing); RIS: Resin Impregnated Synthetic (with polymer housing)*

9.07.02 Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IS/IEC: 60137. All details of the bushing shall be submitted for approval and design review.

9.07.03 Oil filled condenser type bushing shall be provided with at least following fittings:

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

9.07.04 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.

- 9.07.05 Bushing shall be provided **with tap for capacitance and tan delta test**. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.
- 9.07.06 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.
- 9.07.07 Bushings of **identical rating of different makes shall be interchangeable** to optimise the requirement of spares.
- 9.07.08 Polymer insulator** shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have **silicon content of minimum 30% by weight**. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP. The weather sheds of the insulators shall be of alternate shed profile as per IS 16683-3/IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IS 9947. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. **The polymer insulator shall be capable of high pressure washing.**
- 9.07.09 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- 9.07.10 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).

- 9.07.11 Clamps and fittings shall be of hot dip galvanised/stainless steel.
- 9.07.12 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- 9.07.13 **No arcing horns** shall be provided on the bushings.
- 9.07.14 **Corona shield, wherever required, shall be provided** at bushing terminal (air end) to minimize corona.
- 9.07.15 Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.
- 9.07.16 Oil end portion of RIP/RIS type bushings shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. The pressure of dry air need to be maintained in case of leakage.
- 9.07.17 The terminal marking and their physical position shall be as per IS 2026.
- 9.07.18 **Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP/ RIS) at Transformer manufacturing works as routine test before despatch** and the result shall be compared at site during commissioning to verify the healthiness of the bushing.
- 9.07.19 Tan δ value of OIP/RIP/RIS condenser bushing shall be 0.005 (max.) in the temperature range of 10°C to 40°C. If tan delta is measured at a temperature beyond above mentioned limit, necessary correction factor as per IEEE shall be applicable.

9.08.00 TERMINAL CONNECTORS:

9.08.01

- a) The 245kV, 145kV and 72.5 KV bushing shall be provided with bimetallic type connectors and of universal type. The connectors shall be suitable for Single ACSR conductor for 220kV and Twin ACSR conductor for 110KV and 66KV side. For 31.5MVA Transformer the connector on 66KV side shall be suitable for Single ACSR conductor. The connector shall be designed to prevent corrosion due to bimetallic action.

The 36KV bushings shall be provided with terminal connectors.

The neutral bushings on 220, 110 & 66 KV side shall be provided with suitable connectors for connection to strip type copper bus bars for ground connections.

- b) In case of 11 KV bushing side of 31.5 MVA, 66/11kV transformer, the transformer shall be provided with connectors to which copper flat of size suitable for continuous current of 2000A are to be connected. The copper flat is to be extended up to Aluminium U.G. Cable of 12 runs (4 runs/ph) of 1000 Sq.mm Aluminium U.G. Cable. The copper flats to be provided with suitable spaces between lams aeration.

The bus bars shall be coated with non-inflammable bus bar paints. The material of bus bars shall be EC grade copper conforming to VDE 0201 Code-ECUF30, IS-8084. The support insulators shall be suitable for voltage class of 33 KV.

- c) Terminal connectors must have been successfully type tested strictly as per IS : 5561.
- d) No part of a clamp shall be less than 12.5mm thick.
- e) Non-magnetic, hot dip galvanized / electro-galvanized nuts, bolts and washers shall be used. Nuts and bolts shall have hexagonal head with threads as per IS and shall be fully threaded type. Also instead of spring washers, check / lock nuts shall be provided.
- f) The connectors shall be designed for minimum 120% of the maximum current carrying capacity of the ACSR conductor and the temperature rise under these conditions shall not be more than 50% of that of the main conductor.

9.08.02 -A BUSHING CURRENT TRANSFORMERS:

- a). *Current transformers shall comply with IS: 2705, IEC: 61869*
- b). *It shall be possible to remove turret mounted CTs from the transformer tank without removing the tank cover. Necessary precaution shall be taken to minimize the eddy currents and local heat generated in the turret.*
- c). *All secondary leads shall be brought to a terminal box near each bushing. These terminals shall be wired up to the Cooler Control Cabinet using separate cables for each core/phase.*
- d). *Bushing CT parameters indicated in the specification are tentative and liable to change within reasonable limits. The Bidder shall obtain the Purchaser's approval before proceeding with design of Bushing CTs.*

9.08.02-B TERMINAL MARKING:

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

9.09.00 EARTHING ARRANGEMENTS:

9.09.01 TERTIARY WINDING EARTHING ARRANGEMENT:

- a) The open delta terminals of the tertiary windings shall be brought out and shorted by using a copper link of adequate size and connected to earth. The earthing of the open delta terminals shall be brought to the ground level by a copper flat of minimum size 100 x 12 mm which shall be supported from the tank by porcelain insulators *of highest system voltage of 36kV*.
- b) The end of the copper flat bar shall be brought to the ground level, at a convenient point, for connection to purchaser's ground network through 50 x 8 mm galvanised steel flats. The connection shall be made by using two (2) bolted grounding terminals with necessary accessories.

9.09.02 NEUTRAL EARTHING ARRANGEMENT:

- a) The neutral terminal of the star connected winding shall be brought to the ground through externally installed NCT (which is in the purchasers scope) by a copper flat of size minimum 2x75x10 mm which shall be supported on mounting structure of NCT, by porcelain insulators *of highest system voltage of 36kV*. The NCT will be installed at a distance of about 2Mtrs. from the transformer and the live point of the NCT will be the same as that of Neutral bushing.
- b) The end of the copper flat bar shall be brought to the ground level, at a convenient point, for connection to purchasers ground network through 50 x 8 mm galvanised steel flats. The connection shall be made by using two (2) bolted grounding terminals with necessary accessories.
- c) Suitable flexible copper strip connection of adequate size shall be provided for connecting to Neutral Bushing terminals to avoid tensile load on the Bushings.

9.10.00-A AUXILIARY POWER SUPPLY FOR OLTC, COOLER CONTROL AND POWER CIRCUIT

9.10.00-A.1 Auxiliary Power Supplies shall be as indicated in clause 3.0 and will be provided by the purchaser at any one place for OLTC Control and Cooler Control.

9.10.00.A.2 All loads shall be fed by one of the two feeders through an electrically interlocked automatic changeover scheme housed in any one of the local control cabinets for tap changer control and cooler circuits.

9.10.00.A.3 *Design features of the changeover scheme shall include the following:*

- i) *Provision for the selection of one of the feeders as normal source and the other as standby.*
- ii) *Upon failure of the normal source, the loads shall be automatically transferred, after an adjustable time delay, to the standby source.*
- ii) *Indication for 'failure of normal source' and for 'transfer to standby source' and also for 'failure to transfer' shall be provided in the local cubicle as well as in RTCC panel.*
- iii) *Automatic re-transfers to normal source with an adjustable time delay following re-energization of the normal source.*
- iv) *Both the transfer and the re-transfer shall be 'dead transfers' and AC feeders shall not be paralalled at any time.*
- v) *Necessary isolating switches, MCCB's and other components for the above power supply transfer arrangement shall be provided by the supplier.*
- vi) *MCCB's shall be provided for Incoming AC supply ie., both Main & Standby AC supply.*

9.10.00-B TAP CHANGING EQUIPMENT

9.10.01 TAP CHANGE SWITCH (GENERAL REQUIREMENT)

- a) The on load tap changer shall be *of the In Tank ,Hi speed ,Transient resistance type and same shall be* provided neutral end of the HV winding and shall permit constant voltage on IV side, in respect of 245 KV interconnecting transformer.
- b) OLTC gear shall be motor operated for local as well as remote operation. An external hand wheel / handle shall be provided for local manual operation. The OLTC shall be suitable for power flow on either direction. The transformer shall give full load out put on taps.
- c) Arrangement shall be made for securing and padlocking the tap changer wheel in any of the working positions and it shall not be possible for setting or padlocking the wheel in any intermediate position. The arrangement shall be such that no padlock key can be inserted unless all contacts are correctly engaged and switch set in a position where no open or short circuit is possible. An indicating device shall be provided to show the tap in use.
- d) *On load tap changer shall be sourced from reputed manufacturer and it should be type tested as per relevant IEC 60214 including switching and transient resistance test of the relevant switch and test methods shall be in full conformance to the procedures indicated in IEC 60214.*

9.10.02 ON LOAD TAP CHANGING GEAR (OLTC) SHALL BE SCADA COMPATIBLE

The details of the method of diversion of the load current during tap changing, the mechanical construction of the gear and the control features for OLTC gear shall be submitted with the bid. Information regarding the service experience on the gear and a list of important users shall be furnished, The tap changer shall change the effective transformation ratio without producing phase displacement.

- a) The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The chamber shall be provided with a means of releasing the gas produced by the arcing.
- b) The contacts shall be accessible for inspection without lowering oil level in the main tank and the contact tips shall be replaceable.
- c) For reduction of make and break arcing voltage due to overloads and short circuits, the arcing switch or arc suppressing tap selector shall be provided with reactors or resistors. Necessary tools and tackles shall be furnished for maintenance of OLTC gear.

OR

The supplier shall indicate the safeguards provided in order to avoid arcing at the current diverting contacts in the event of operation of the OLTC gear under over-load conditions of the transformer.

- d) The OLTC oil chamber shall have oil filling and drain plug, oil sampling valve, relief vent and level glass, It shall also be fitted with a Buchholtz relay the outlet of which shall be connected to a separate conservator tank. A dial type indicating thermometer of rolrest pattern shall be provided for OLTC and mounted in the side of transformer at convenient height to read the temperature in the hottest part of the oil fitted with alarm and trip contacts.
- e) The diverter switch or arcing switch shall be so designed as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipments.
- f) Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

- g)
 - i) Drive mechanism chamber shall be mounted on the tank in accessible position, It should be adequately ventilated and provided with anti-condensation metal clad heaters. All contactors, relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi. Pad locking arrangement for hinged door of the cubicle and cable glands for all incoming cables, etc shall be provided.
 - ii) The tap change driving motor shall be suitable for operation with 415 V, 3 phase, 50 Hz external power supply.
- h) Each transformer unit shall be provided with a local OLTC control cabinet and a remote OLTC control panel. The control feature shall provide following.
 - i) Local remote selector switch mounted in the local control cubicle shall switch control of OLTC in the following manner:
 1. When the selector switch is in LOCAL position, it shall be possible to operate the RAISE-LOWER control switches specified in section (ii) below. Remote control of RAISE-LOWER functions shall be prevented.
 2. When the selector switch is in REMOTE the local control cubicle mounted RAISE - LOWER switches specified in section (ii) shall be inoperative, Remote control of the raise - lower function shall be possible from the remote control panel. The LOCAL - REMOTE selector switch shall have at least two spare contacts per position which are closed in that position but open in the other position.
 - ii). A RAISE-LOWER CONTROL SWITCH shall be provided in the Local Control Cubicle. The switch shall be spring loaded to return to the center 'OFF' position and shall require movement to the RIGHT to raise the voltage of the transformer. Movement to the left shall lower the voltage.

This switch shall be operative only when 'local remote', selector switch is in local position.
 - iii).
 - a. 'Step by step' operation to ensure only one tap change takes place even if the tap change control switch is stuck or held in the operated position. Seal in circuits to ensure positive completion of a tap change impulse once initiated.

Interlock to prevent an impulse being give to reverse the tap change direction while a tap change operation is already under progress, until the mechanism comes to rest and resets the circuits for fresh operation .
 - b. *Operating mechanism for on load tap changer shall be designed to go through one step or tap change per command. Subsequent tap changes shall*

be initiated only on receipt of a new or repeat command. This should be ensured through Snap Action Mechanism in the Drive Mechanism

- iv). On load tap changer shall be equipped with a time delay for 'INCOMPLETE STEP' in alarm consisting of a normally open contact which closes, if the tap changer fails to make a complete tap change. The alarm shall not operate for momentary loss of auxiliary power.
- v). The OLTC load tap changer shall be equipped with a fixed resistor network capable of providing discrete voltage steps for input to the supervisory system.
- vi). *The resistor based potentiometric unit shall be installed in the local OLTC control cabinet to provide tap position indication for the transformer. The supplier shall also provide a spare set of instruments as per clause for tap position indication on the RTCC panel in the control room. Complete mounting details shall be included with approved diagram.*
- i) Limit switches shall be provided to prevent over running of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop shall be provided to prevent over - running of the mechanism under any condition. Limit switches may be connected in the control circuit of the operating motor provided that a mechanism-de-clutching mechanism is incorporated.
- j). Thermal device or other means shall be provided to protect the motor and control circuit. All relays, switches, MCCB / MCB etc. shall be mounted in the drive mechanism chamber and shall be clearly marked for the purpose of identification.
- k) A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.
- l) A five digit counter shall be fitted to the tap changing equipment to indicate the number of operations completed.
- m) All relays and operating devices shall operate correctly at any voltage between the limits specified.
- n) It shall not be possible to operate the electric drive when the manual operating gear is in use.
- o) It shall not be possible for any two controls to (i.e., manual, local electrical and remote) be in operation at the same time.
- p) The equipment shall be suitable for supervisory control & indication with make before break multi-way switch, having one potential free contact for

each tap position. This switch shall be provided in addition to any other switch/ switches, which may be required for remote tap position.

- q) All electrical control switches and the local operating gear shall be clearly labeled in a suitable manner to indicate the direction of tap changing.
- r) *OLTC Shall have a mechanical fuse incorporated in the design to ensure the protection of divertor switch in the event of an undue mechanical stress on Tap Changer.*
- s) *The Tap Selector Contacts shall not be of the threaded type to ensure positive, full face and firm contact from Transformer leads to Tap Changer.*
- t) *No continuity break shall be allowed during changeover between any two taps. The OLTC shall be tested for the same by ensuring that there is no open circuit showing while changing two taps.*
- u) **OLTC Routine Tests:**

OLTC manufacturer shall conduct the following routine tests fully in compliance with IEC 60214 on every unit as given below before dispatch to assure the quality of the product.

Sl. No.	IEC Reference	Test description	Acceptance level
1	60214 Cl No. 5.3.1	Mechanical Endurance Test	Minimum 1000 operations
2	60214 Cl No. 5.3.2	Sequence Test	Switching operation with timing less than 50m sec.
3	60214 Cl No. 5.3.4	Pressure Test	10 PSI (0.7kg per Sq.cm.) for 8 hrs. at room temp.
4	60214 Cl No. 5.3.4	Vacuum (Helium) Test	Vacuum level of 6×10^{-5}
5	60214 Cl No. 5.3.3	Auxiliary circuit insulation tests	Should withstand 2KV relative to earth for 1 min
6	Special Test	Gas Tightness Test	Helium based or any other mutually agreed method
7	Special Test	Contact resistance Test	<2 miliohms
8	Special Test	Physical & Dimensional Checks	As per approved drawing

- w) *The Tap Changer shall be suitably protected through Oil Surge Relay and it shall be of reed magnetic switch type. This surge relay shall be tested for an Oil flow velocity of 1.20 +/- 0.20 m/s.*

9.10.03 MANUAL CONTROL:

The cranking device for manual operation of the OLTC gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:

- i) Mechanical tap position indicator which shall be clearly visible from near the transformer.
- ii) A mechanical operation counter.
- iii) Mechanical stops to prevent over cranking of the mechanism beyond the extreme tap positions.
- iv) The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor - start-up during manual operation. The manual operating mechanism shall be labeled to show the direction of operation for raising the primary and vice-versa.

9.10.04 a) ELECTRICAL CONTROL:

This includes the following

- i) Local Electrical control.
- ii) Electrical remote control from remote control panel.

b) REMOTE ELECTRICAL GROUP CONTROL:

The OLTC control scheme offered shall have provision of remote electrical group control during parallel operation of transformers. This is in addition to independent control of OLTC. It shall be possible to operate 4 No. of transformers by group control of OLTC. For this, a flexible circuit arrangement shall be provided for addition of transformers at a later date.

- i. A four position selector switch having MASTER, FOLLOWER, INDEPENDENT and OFF position shall be provided in the remote OLTC control panel for each transformer. This shall be wired to enable operator to select operation of OLTC in either Master, follower or independent mode.
- ii. Out of step relays with timer contacts shall also be provided to give alarm and indication in case of tap positions in all the transformers under group control being not in identical position. There should be an automatic lock out of the combined control when any one of the units fails to fall in steps, due to mal operation of its gear.
- iii. Under abnormal condition such as may occur if the contactor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units.

iv. **Master position :**

If the selector switch is in MASTER position, it shall be possible to control the OLTC units in the FOLLOWER MODE by operating the controls of the MASTER UNIT. Independent operation of the units under FOLLOWER mode shall have to be prevented. However, the units under independent mode will be controlled independently.

v. **FOLLOWER POSITION.**

If the selector switch is in follower mode, control of OLTC shall be possible only from MASTER panel.

vi. **INDEPENDENT POSITION:**

In this position of selector switch, control of OLTC of individual unit only shall be possible.

vii. **PARALLELING INTERLOCK:**

An interlock shall be incorporated in the electrical control circuit of the ON load tap change gear to prevent electrical closing of the circuit breaker on the low voltage side of non-operation transformer with those already in operation, when :

- a) Its ON load tap change gear is not in the same position as those already in operation.
- b) The auxiliary AC supply to its on load tap change motor is not switched before hand.

9.11.00 COOLING EQUIPMENT AND ITS CONTROLS:

9.11.01 COOLING EQUIPMENT:

- a (i) 220/110/11KV and 220/66/11KV Transformer shall be provided with separately mounted radiator Bank.

Each cooler unit shall consist of a totally enclosed immersed motor pump and a forced air cooler, heat exchanger. The cooler shall be designed using 2 x 50 % radiator bank and cooler bank should be on one side of the transformer i.e., on left side of the transformer while facing the 220KV bushings. The end of the radiator bank from the center of the transformer, should be restricted to 7 M.(i.e., half the bay width of 14 M. Refer clause No. 4.01). Cooler shall be designed to withstand vacuum and pressure condition specified for the tank.

- (ii) Tank mounted radiator Bank shall be provided for 31.5MVA, 66/11KV Transformer.

- b) Each radiator bank shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves, lifting lugs, top and bottom oil filling valves, air release plug, a drain valve, grounding terminals and thermometer pocket fitted with captive screw cap on the inlet and outlet. Heat exchangers, fans and oil pumps shall be completely interchangeable.
- c) Cooler unit shall be connected to the tank by machined steel flanges welded to the cooler unit and to the tank and provided with gaskets. At each cooler unit connection, there shall be provided on the tank an indicating shut off valve which can be fastened in either open or closed position. A separate oil tight blank flange shall be provided for each tank connection for use when the cooler is detached.
- d) One stand by fan for at least 20% capacity shall also be provided and identified with each radiator bank.
- e) Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration. Fans shall be so located that they are readily accessible for inspection and repair.
- f) The Exhaust air flow from cooling fan shall not be directed towards the main tank in any case.
- g)
 - i) Cooling fans for each radiator bank shall be located so as to prevent ingress of rainwater. Each fan shall be suitably protected by galvanised wire guard.
 - ii) *The cooler and its accessories shall be hot painted with corrosion resistant paint*
- h)
 - (i) Two (2), 100% centrifugal oil pumps (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil. Under failure of main oil pump, the changeover from main to standby oil pump shall be automatic.
 - (ii) Motor and oil pump shall be enclosed in an oil tight container with motor leads brought through a hermetically sealed bushing. Each cooler unit shall be arranged for detaching from the transformer without disturbing the oil in the transformer tank. Moving parts of the motor and pump shall be readily removable with dismantling the cooler and with minimum spillage of oil.

- i) Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50Hz power supply and shall conform to IS : 325.
- j) (i) An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. A provision shall be made in the flow indicator to indicate reverse flow of oil/loss of oil flow.

(ii) Suitable mechanical interlock should be provided for proper mounting of the pump and motor, so that oil flow is ensured in the required direction only.
- k) Cooler shall be so designed as to be accessible for cleaning and painting, to prevent accumulation of water on the outer surface, to completely drain oil the tank and to ensure against formation of gas pockets when the tank is being filled. The cooler and its accessories shall be hot painted with corrosion resistant paint.
- l) Each cooling fan and oil pump motor shall be provided with starter, thermal overload and short circuit protection.
- m) Each radiator shall be provided with :
 - One shut-off valve at the top (80 mm size)
 - One shut -off valve at the bottom (80 mm size)
 - Air release device at the top.
 - Main and sampling device at the bottom.
 - Lifting lugs.
 - Expansion joints, one each on top and bottom cooler pipe connections.
 - Air release device and oil plug on oil pipe connections,
- n) The radiator bank and cooler pipe arrangement should be such that it does not hinder the movement of the transformer.

9.11.02 COOLING EQUIPMENT CONTROL (ONAN/ONAF/OFAF) :

- a) Cooler units shall be suitable for operating with a 415 volts, 3 phase, 50 Hz, 4 wire external AC power supply.
- b) Control equipment for oil pump and fan motors shall be mounted in a weather and vermin proof marshalling cabinet adjacent to the transformer and shall include the necessary contactors with automatic control and annunciator equipment and provision for manual control.
- c) Automatic operation control (Switching in and out) of fans/ pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The supplier shall recommend the setting of WTI

for automatic change over of cooler control from ONAN to ONAF to OFAF. The setting shall be such that hunting i.e., frequent start stop operations for small temperature differential do not occur.

- d) Suitable manual control facility for cooler fans and oil pumps with manual / automatic selector switches and push buttons shall be provided.
- e) Each motor or group of motors, shall be provided with a three pole electrically operated contactor and with control gear of suitable design both for starting and stopping the motor manually and also automatically from the Contacts on the winding temperature indicating device. Additional terminal for remote/manual electrical control of motors shall be provided.
- f) Where small motors are connected in groups the group protection shall be arranged so that it operates satisfactorily in the event of a fault occurring on single motor.
- g) Where blowers and oil pumps are provided the connections shall be arranged as to allow the motors or group of motors to be started up and shut down, either collectively or individually.
- h) All motor contactors and their associated apparatus shall be capable of holding in and operating satisfactorily and without over heating for a period of 10 minutes if the supply voltage falls for a small period to 75% of normal voltage at normal frequency. The motor contactors and associated apparatus shall be capable of normal operation with supply voltage at 85% of normal values and at normal frequency.
- i) All contacts and other parts, which may require renewal, adjusting or inspection, shall be readily accessible.
- j) The contact arrangements are to be designed as to prevent the simultaneous starting of motors of a total rating of more than 20 HP.
- k) Alarm indication for failure of group of fans and oil pump shall be provided. Alarm indication for failure of power supply shall also be furnished.
- l) The Bidder shall specify the loading of the transformer in case of failure of one or more set of fans.

NOTE: In addition to the above details, the clause No. 9.18 -Specification for control cabinet for tap change driving motor unit is applicable, wherever necessary.

9.11.03 COOLER CONTROL CABINET:

- a) Each transformer unit shall be provided with a cooler control cabinet.
- b) Control equipment for oil pump and fan motors shall be mounted in a weather and vermin proof marshalling cabinet adjacent to the transformer and shall include the necessary contactors with automatic control and annunciator equipment and provision for manual control.
- c) The cooler control cabinet shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer shall also be wired up to the terminal board in the cooler control cabinet. All the secondary terminals of the CT's shall also be wired up to the terminal board at the cooler control cabinet.
- d) The cooler control cabinet shall have two (2) sections. One section shall have the control equipment exclusively meant for cooler control The other section shall house the temperature indicators, auxiliary CT's and the terminal boards meant for termination of various alarm and trip contacts as well as various CT secondaries. The initiating device and contacts for alarm and trip function for the following shall be terminated to the terminal block which will be wired up to the purchaser's control and relay panel. Buchholtz trip / alarm, oil temperature high alarm, oil temperature very high trip, oil low level (MOG) alarm, winding temperature high alarm, winding temperature very high trip, OLTC surge relay trip, pressure relief device trip main and OLTC. Alternatively the two sections may be provided as two separate panels depending on the standard practices of the supplier.
- e) The temperature indicators shall be so mounted that the deals are not more than 1600 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

9.11.04 VALVES:

- 1). *All valves upto and including 100 mm size shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.*
- 2). *Suitable means shall be provided for locking the valves in the open and close position. Provision is not required for locking individual radiator valves*
- 3). *Each valve shall be provided with the indicator to show clearly the position of the valve.*

- 4) *All valve flanges shall have machined faces.*
- 5) *All valves in oil line shall be suitable for continuous operation with transformer oil at 100°C*
- 6) *The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10mm size to facilitate oil sampling.*
- 7) *A valve or other suitable means shall be provided to fix the on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location and size of the same shall be finalized during detail engineering stage.*
- 8) *Suitable valves shall be provided to take sample of oil from the OLTC chamber during operation of the transformer.*
- 9) *After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS:2932 and of a shade (preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS:2074 followed by two coats of fully glossy finishing paint.*
- 10) *All hardware used shall be cadmium plated/electro galvanized.*

9.11.05-A REMOTE OLTC / COOLER CONTROL PANEL (RTCC PANEL):

The auxiliary devices for remote electrical control of the OLTC and cooler shall be housed in a separate panel to be placed in the control room. The panel shall be made of sheet steel of not less than 3mm and it shall be duly finished with stove enamel paint. The size of the panel to be supplied by the supplier shall be 2313mm(H) x 610mm(D) x 800mm (W). The colour of the finishing paint shall be Siemens grey corresponding to shade No. RAL 7032, for panel exterior.

Control and signal devices required to be mounted in the RTCC Panel shall comprise of the following :

1. Local - Remote maintained contact selector switch for OLTC
2. Actuating switch/push button for electrical raise / lower control,
3. Remote tap position indicator with tap nos. and corresponding rated voltage marked on the instrument. The tap position indicators shall be digital type.
4. One potential free contact per tap for tele- transmission of tap position from switchyard and control room to load dispatch center shall be provided.

5. A four position selector switch having master follower, independent and off position.
6. Repeater dial of transformer winding temperature indicator.
7. Name plate for each component.
8. Initiating devices and contacts for alarm as well as for indications for discordance in the tap changer in any of the parallel operating transformers
9. Cubicle lamp actuated by door switch, space heater, power sockets etc shall be provided inside RTCC panel.
10. The OLTC shall be suitable for supervisory control and indication with make before break multiway switch having one potential free contact for each tap position. This switch shall be provided in addition to any other switch/switches which may be required for remote tap position indication.
11. Annunciator (facia type) scheme complete with accessories for the following:
 - i) Tap change incomplete/Motor stuck up.
 - ii). Tap changer out of step
 - iii) Tap changer motor trip.
 - iv) Failure of AC supply to the OLTC local control Kiosk.
 - v) OLTC control supply failure
 - vi) Running Fan failure of each group
 - vii) Stand by fan failure of each group.
 - viii) Running Pump failure of each group.
 - ix) Stand by pump failure of each group.
 - x) 415V cooler control supply failure.
 - xi) No flow / reverse flow of oil in oil pump of each group.
 - xii) 415V Cooler Main Supply fail.
 - xiii) 415V Cooler Stand by Supply fail.
12. Signal lamps for:
 - i) Fan 'ON' for each group / each fan.
 - ii) Pump 'ON' for each pump.
 - iii) Standby fan 'ON' for each group.
 - iv) Cooling system on Local manual / local auto
 - v) Cooling system on Remote manual/ Remote auto
 - vi) 415 Volts cooler Supply 'ON',
 - vii) 415 volts cooler supply auto change over from Main to Stand by.
 - viii) 415 Volts cooler supply-A 'ON'
 - ix) 415 volts cooler supply-B 'ON'
 - x) Cooler control supply 'ON'
 - xi) 415 Volts OLTC supply ' ON '.
 - xii) Tap changer upper limit reached.

- xiii) Tap changer lower limit reached
- xiv) Tap changer in local mode
- xv) Tap changer in Remote RTCC/ITCS/SAS mode
- xvi) Tap change in progress
- xvii) Tap changer in Independent/Master/follower mode

9.11.05-B *Microprocessor based Numerical RTCC Unit for Tap changer Control & Transformer Monitoring*

Microprocessor based technology has been envisaged for the control of forced cooling equipment, condition monitoring and OLTC control of transformers.

Tenderers shall provide full description of the control system offered and details of deviations from specified requirement shall be brought out in the offer along with necessary justifications.

The intent of this section is to describe the desired functional and environmental requirements in respect of microprocessor based Intelligent Transformer Control System (ITCS) without limiting the additional features that the tenderer may be able to include in the offer. The TCS should provide facilities such as SCADA/SAS links, transformer cooler control and data logging, control of the OLTC, remote OLTC tap position indication in digital form at local and the remote temperature indications for windings and top oil, temperature alarms and trip, marshalling of other control and alarm functions, emergency overload control, recording of accumulated “use of life” local display of status of control and alarm functions and selection of local and remote control etc.

The TCS equipment (other than HMI and microprocessor unit) shall be located within the auxiliary marshalling cubicle and the Man Machine Interfacing (MMI) unit in the transformer RTC control panel in the control room.

a) *FUNCTIONS:*

i) *Monitoring:*

The TCS shall be capable of monitoring the analog data and status signals of the following:

Transformer LV load, voltage, tap changer status including tap position, tap changing in progress, Tap changer control supply fail, 415V OLTC supply fail, Tap changer incomplete, Tap changer out of step, OLTC upper limit reached, OLTC lower limit reached, status of control switches with respect to OLTC and cooling, OLTC motor current, OLTC motor trip, temperature difference between OLTC compartment and main tank. Temperature and condition of the transformer cooler status including top oil temperature, ambient temperature, winding hot spot temperature, run status of cooler fans and / or pumps, fan and / or pump trip, Alarm and Trip status of all the

transformer mounted relays, Interface with the fibre optic thermometer where fibre optics probe have been specified. This data shall be available for display, data logging and remote communication. For each analog value the TCS shall display the present and minimum and maximum value reached since the last time that the minima and maxima were reset to the current values. Sufficient number of Binary Inputs (Min. 48 Nos.), Binary outputs (Min. 10 Nos.) and Analog inputs (Min. 14 Nos.) shall be provided for monitoring the analog data & status signal.

ii) Cooling Control:

The TCS shall be capable of controlling all cooling systems of the transformer including pumps, fans. The control function shall operate in such a way as to keep the transformer temperature within the limit set by the Purchaser.

The TCS shall be capable of :

Predictive mode to turn on the cooling system based on predicted top oil and winding hot spot temperatures in addition to normal control based on actual temperatures. This should work in the event of a sudden sustained increase in load current, before the temperatures had risen to normal control settings, so as to keep the transformer cooler longer. Predicted temperature shall be based on a thermal model of each specific transformer (based on actual heat run tests), ambient temperature and load.

Periodic automatic testing :

It shall be possible to automatically exercise testing of the cooler system at preset intervals to ensure that they are still functional, with an alarm if the test fails.

x) OLTC Control:

The control shall include selection of the following operating modes and features as

applicable, by push buttons or keys at the controller or from SCADA/ SAS.

Manual OLTC control by pushbuttons or keys at the controller or from SCADA/ SAS.

AVR (automatic voltage regulation)

Independent mode

Master or follower parallel mode

Circulating current parallel mode

VAR sharing parallel mode

Reverse reactance parallel mode

AVR time delay shall be settable with definite time, fast – tap – down and inverse-time modes.

AVR shall have the option of Line Drop Compensation (“LDC”).

AVR shall be blocked, if the voltage drops below the under voltage set points, to prevent false operation in the event of supply line faults, VT fuse failure etc.

OLTC operations shall be blocked if the current through the OLTC exceeds a preset value.

xi) Performance Calculations and Prediction:

The TCS shall be capable of calculating –

Watts and VARs

Accumulated number of tap changers from each tap position (discrete counter for each position) and total number of tap changers.

Winding hot spot temperatures for each winding and maximum achieved.

Winding hot spot insulation ageing rate (per unit)

Accumulated insulation ageing (use of life) based on the winding hot spot (years) as per the loading guide for oil immersed power transformer. The use of life calculations shall also convey to the operator the amount of time available at the present over load rating and the amount of overload available for two hours duration from the time in question.

Accumulated operating hours for each fan and pump group.

Accumulated number of starts for each fan and pump group.

xii) Alarms:

Alarms shall be extended to the SCADA/ SAS system for :

Voltage out of range for too long (AVR mode only)

Voltage exceeds over-voltage alarm setting or is less than under-voltage alarm

setting.

OLTC auxiliary power failure

OLTC fail (tap changed in progress too long or OLTC motor trip)

Temperature abnormalities such as high oil temperature and high winding

temperature.

Top oil or winding hot spot temperature exceeds alarm settings.

Top oil or winding hot spot temperature exceeds trip or stage to alarm settings

Cooler auxiliary power failure

Cooler fail (contactor failed to close when switched on, or motor trip, or oil flow failed)

All OLTC and temperature trip signals shall be provided by means of voltage free contacts where the contacts have a rating of not less than 0.4A at 125 VDC resistive. All other trip signals such as Buchholz, pressure relief and OLTC surge shall be provided directly from the voltage free contacts of the respective device, not via the TCS. The alarms can however be wired via the TCS.

xiii) Data Logging and Event Recording:

Monitored data shall be time and date stamped and logged in a format, which can be easily imported to data analysis software such as MS Excel/Access. The local data storage capability which can store all data at one minute intervals shall be stated by the tenderer.

A separate event record is required to record the date and time (to nearest second) when the status of any alarm changes. The number of events that can be stored shall be stated by the tenderer.

xiv) Communication:

The TCS shall accept all Analogue / Digital quantities relevant to the control of the transformer or as required by the purchaser. These quantities shall be able to be interfaced to the purchaser's SCADA/ SAS equipment. The ITCS shall be capable of downloading data files via telephone line and GSM System. The protocol for communication shall be as per IEC 60870-5-103 and IEC 61850.

xv) Other capabilities:

Tenderers may also offer TCS which performs both Dissolved Gas Analysis and moisture in oil condition monitoring.

b) MAN MACHINE INTERFACE:

Access to control variables within the TCS shall be available to the personnel as required by the purchaser. The form of these interface should preferably be via a permanent front panel that contains a display and keypad. The menu facilities shall be as simple and intuitive as possible. Facilities to access the TCS via local RS-232 port and software running on a laptop PC under the latest version of Windows shall also be provided. A sample of the PC software shall be supplied to the purchaser for evaluation before proceeding with that method. Software supplied to the purchaser is not returnable and becomes the property of the purchaser.

c) ELECTRICAL ISOLATION AND TRANSIENT PERFORMANCE:

All equipment shall be type tested, tested during manufacture and after completion in accordance with latest IEC 60255 and IEC 60068.

d) POWER SUPPLIES:

The TCS should be powered directly from the Sub-station battery bank.

e) INPUTS / OUTPUTS

f) DIGITAL INPUT AND OUTPUT MODULES

The “on” state of all digital inputs and outputs shall be indicated by Light Emitting Diodes (LED) on the front of the modules. These LEDs shall be visible from the front panel on which the TCS equipment is mounted. All inputs shall be electrically isolated from the external circuit and capable of being driven from 42 V dc to 240 V dc.

All output shall be electrically isolated from external circuit and rated for switching 42 V dc to 240 V dc and 0.5 Amp.

Sufficient number of DI and DO modules shall be provided to suit the scheme requirement during drawing approval and during commissioning as per field condition. Additional 20% spare DI's and DO's shall be provided for future use.

4-20mA analog inputs shall be provide for the following: Oil temperature, Core temperature, HV- R phase, Y phase & B phase winding temperature, IV- R phase, Y phase & B phase winding temperature, OLTC oil temperature, OLTC motor current, Ambient temperature, all Dissolved gases 9Nos. in PPM, Water content in PPM in case on-line DGA is provided. Additional 20% spare 4-20mA analog inputs shall be provided for future use.

g) COMMUNICATION PORTS:

Communication ports shall be provided for the following –

Connection to a local computer for down loading data files, uploading settings, software upgrade etc.

Communication with SCADA RTU/ SAS.

Connection to a dial-in modem for down loading data files uploading settings, software upgrade etc.

Communication with sensors and other auxiliary equipment.

Serial communication with remote via a fibre optic links

Connection to LAN to WAN or Intranet.

h) SELF-MONITORING:

The TCS shall have a self-check of power on and shall continually monitor all functions and the validity of all input values to make sure the control system is in a healthy condition. In the event that the unit is unable to control the transformer, the device is to revert to a fail-safe condition. Any monitoring system problem shall initiate an alarm.

i) MEMORY RETENTION:

The TCS shall be capable of retaining its information in the event of a power failure.

j) REAL TIME CLOCK:

There shall be real time clock for time stamping the data log and event records. A long life battery shall be provided to keep the clock operating in the event of the power failure. An alarm shall be generated if the battery fails. It shall also be possible to synchronize the TCS clock with GPS system provided at the substations.

k) SECURITY:

*Levels of security to limit access to authorized users shall be provided for
Viewing data and down loading data files (no access control)
Changing control mode and manual control operations (password control)
Changing settings and configuration (password control)
Software upgrade (password control)*

l) MOUNTING:

The TCS input/output modules /units shall be mounted within the auxiliary marshalling cubicle or in a separate cubicle with a similar construction located on the transformer. The cubicle shall be rated to IP56. The cubicle shall be capable of protecting the equipment contained within and keep it in operational condition at all times given the conditions described in the environmental section. The Man Machine Interface (MMI) unit will be mounted on the transformer Tap changer control panel in the control room. Cabling between the MMI unit and input / output modules / unit shall be supplied by the Purchaser. Any special cable if required, the details of the same shall be furnished. It shall be possible to have a second MMI mounted in the transformer control cubicle if required.

9.12.00 TERMINAL BLOCK:

- i) The terminal blocks 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.
- ii) All internal wiring to be connected to the external equipment shall be terminated 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 dis-connecting stud type terminals, washers, nuts and lock nuts, Terminal block design shall include a white fiber marking strip with clear plastic, slip-on / clip-on terminal cover. Markings on the terminal strips shall correspond to wire number and terminal numbers on the wiring diagrams.

- iii) Terminal blocks for current transformer secondary leads shall be provided with test links and isolating facilities. Also current transformer secondary leads shall be provided with short-circuiting and earthing facilities.
- iv) At least 20 % spare - terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
- v) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors on each side.
 - a. For all circuits except current transformer circuits minimum of two numbers of 2.5 sq. mm copper.
 - b) For all CT circuits minimum of two numbers 4 sq. mm copper.
- vi) There shall be a minimum edge to edge clearance of 250mm 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 150mm.
- vii) 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 along each side of the wiring duct to provide 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 block 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.
- viii) The number and size of the purchaser's multi-core incoming cable will be furnished to the Bidder after placement of the order.

9.13.00 PAINTING:

9.13.01 Surface Preparation for Main tank, Pipes, Conservator tank etc.

All surfaces of transformer main tank, pipes, turrets, conservator tank etc. shall be thoroughly blast cleaned with sand, shot or grit in accordance with ISO:8501 Part 1 or Swedish standard SIS:055900 to a minimum standard of Sa 2½ to make the surface free from visible oil, grease & dirt, mill, scale, rust, paint coatings and foreign matter, Machined areas and threaded components etc are to be covered during blasting to prevent damage.

The Compressed air that is used for blasting should be dry and free from oil. The flanges angles, tank curbs and other such areas shall be preferably blast cleaned prior to fabrication and paint these with one coat

of pre-fabrication primer prior to fabrication. After adequate blast cleaning of each large surface where blasting time is more than three hours an overall blast cleaning is to be done on the entire surface once more so that entire surface areas is exposed as fresh for first coat of primer paint. The First coat of primer paint should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

9.13.02 Surface Preparation for radiator:-

All internal and external surfaces of radiator shall be thoroughly cleaned either by chemical cleaning or by blast with stand, shot or grit in accordance with ISO: 8501 Part 1 or Swedish standard SIS 055900 to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Suitable chemical should be used for chemical cleaning, if required. The compressed air that is used for blasting should be dry and free from oil. After adequate surface cleaning, the first coat of primer paint /varnish should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

9.13.03 Painting –External & Internal surfaces:

Painting shall be carried out in closed and dust free area. The external surface shall be coated with suitable layers of paint and to form an impermeable layer

so that air and water cannot reach the substrate. The paint selected shall be stable in outdoor condition such as rain, sunlight, pollution etc. Paint used for primer, under coat and top or finish coat should be from the same manufacturer and compatible to each other. In case in the rare event, paint used for primer, under coat and finish coat are not from the same manufacturer the compatibility test of the paint from different source shall be carried out. Painting shall be applied as per the recommendation of the paint manufacturer. The number of coats shall be such that the minimum dry film thickness (DFT) specified is achieved. The DFT of painted surface shall be checked with a measuring gauge to ensure specified DFT. Complete painting scheme for the transformer is tabulated below.

9.13.04 **Painting –Transformer Main tank, pipes, conservator tank, radiator etc:-**

	Surface preparation	Primer coat	Intermediate Undercoat	Finish coat	Total DFT	Colour shade
Main tank, pipes, conservator tank, etc.	Blast cleaning Sa2 ½	Epoxy base Zinc Primer (30 – 40 micro m)	Epoxy HB M10 (75 um)	Aliphatic Polyurethane (PU paint) (min 50 micro m)	Min 155 micro m	Light grey,631 as per IS 5

(External surfaces)						
Main tank, pipes, (above 80 NB) conservator tank, etc. (Internal surfaces)	Blast cleaning Sa2 ½	Hot oil resistant non corrosive varnish or paint or epoxy	--	--	Min 30 Micro m	Glossy white paint/
Radiator (External surfaces)	Chemical blast cleaning (Sa 2 ½)	Epoxy base zinc primer (30-40 micro m)	Epoxy base zinc primer (30-40 micro m)	Aliphatic Polyurethane (PU Paint) (in 50 micro m)	Min 110 micro m	Matching shade of tank/different shade aesthetically matching to tank
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning if required	Hot oil proof low viscosity varnish Flushing with Trfr. Oil	--	--	--	

9.13.05

Surface preparation for control cabinets/Marshalling Boxes:- Surface preparation for all transformer Control cabinets/ Marshalling Boxes shall be carried out by Seven Tank Process confirming to following Indian standard dust free area:

- i) IS:3618 –1966: Degreasing by solvent wiping :Phosphate Treatment of Iron & steel for Protection against corrosion.
- ii) IS: 6005-1970: Code of Practice for Phosphating of Iron & Steel Sequence of tanks with required size suitable handle all transformer control cabinets/Marshalling Boxes shall be as per following:
 - i) Degreasing tank plain welded M.S. tank with suitable supports of suspending the jobs with overflow arrangement/scoop through to collect floating oils.
 - ii)Derusting tank: PVC/FRPlined mild steel tank.
 - iii) Phosphating tank: FRP lined mild steel tank
 - iv) Passivating tank: Mild steel tank.
 - v) Rinse Tanks(3 Nos. – 1 No.each after Degreasing, Derusting and phosphating) mild steel tanks with overflow arrangement.
 - vi) Driers: Suitable air blowers.

Chemical: Suitable Chemicals should be used and concentration of chemicals /weight of phosphate coating should be checked regularly as per recommendation of the chemical manufacturer and applicable IS.

Inspection: The Surface for application of paint should be dry, free from oil, dirt, acid & loose adhering powder and reasonably smooth in finish without uncovered areas, rusty surfaces and roughness.

9.13.06 Painting-Control Cabinets/Marshalling Boxes - Painting scheme is tabulated below:

Primer coat	Intermediate Undercoat	Finish Coat	Total DFT	Colour Shade
Epoxy base Zinc primer (30-40 micro m)	Epoxy HB MIO (75 micro m)	Aliphatic Polyurethane (PU Paint min 50 micro m)	Min 155 micro m	Light grey, 631 shade as per IS:5

9.14.00 BOLTS AND NUTS:

All bolts and nuts exposed to weather shall be hot dip galvanized, Bolts and nuts below M12 (half inch) size shall be electro-galvanized.

9.15.00 WIRING AND CABLING:

9.15.01 a) Cable box / sealing end shall be suitable for following types of cables:-

i) 415volts power	a) For 100 MVA and above transformer 1100 volt grade PVC insulated 1 X 4 core, 2.5 sq mm, stranded copper conductor cable b) For 31.5MVA Transformer, 1100 Volt grade PVC insulated 1 x 4 Core, 2.5Sqmm. Standard copper conductor cable.
ii) Control	a) In 100 MVA and above Transformer 1100 volt grade PVC insulated 7 x 19 core 2.5 sq mm stranded copper conductor cable. b) For 31.5 MVA Transformer

		1100 volt grade PVC insulated 4 x 19 core 2.5 sq mm stranded copper conductor cable.
iii)	Signaling cable	1Px0.5Sq.mm screened cable for 4-20mA signals

Note: All Control & Power cable shall be FRLS type.

- b) Compression type cable connector shall be provided for termination of power and control cables.
- c) All controls, alarms, indicating and relaying devices provided with the transformer shall be wired up to the terminal blocks inside the local control cabinets (both cooler and OLTC control cabinets).
- d) All devices and terminal blocks with the cooler control cabinet shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagrams.
- e) Not more than 2 wires shall be connected to one terminal. Each terminal shall be suitable for connecting two 2.5 sq. mm stranded copper conductor control cable from each side.
- f) All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks.
- g) Engraved code identification plastic Alpha numeric ferrules marked to correspond with schematic diagrams shall be fitted at both ends of wires. Alpha Numeric ferrules shall fit tightly on wires and shall not fall off when the wire is disconnected from terminal block.

9.15.02

VOID

9.16.00 **FITTINGS & ACCESSORIES ;**

9.16.01 Following fittings shall be provided with each transformer covered in this specification.

- a) Conservator for main tank, with oil filling hole and cap, isolating valves, drain valve magnetic oil level gauge with low level alarm contacts and dehydrating breather (**Maintenance Free Type Breather**), diaphragm seal type constant oil pressure system (Air cell type).
- b) Conservator for OLTC with drain valve, Buchholz relay (*oil Surge*) filling hole with cap, prismatic oil level gauge and conventional dehydrating breather.
- c) Oil preservation equipment.

- d) Pressure relief device with alarm / trip contacts.
- e) Buchholz relay double float type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm and trip contacts
- f) Air release plug.
- g) Inspection openings and covers.
- h) Bushing with metal parts and gaskets to suit the termination arrangement.
- i) Winding temperature indicators for local and remote mounting. One RWTI for each of the three windings (HV, IV&LV)
- j) Oil temperature indicators.
- k) Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
- l) Protected type mercury or Alcohol in glass thermometer.
- m) Bottom and top filter valves with threaded male adapters, top, middle and bottom sampling valves and drain valve. Sampling valves shall be provided with lap tap arrangement with nozzle,
- n) Rating and diagram plates on transformers and auxiliary apparatus.
- o) Earthing terminals.
- p) Flanged bi-directional wheels.
- q) Cooler control cabinet
- r) On load tap changing equipment and OLTC control cabinet.
- s) Drain valves / plugs shall be provided in order that each section of pipe work can be drained independently.
- t) Cooling equipment - Radiator complete with pumps, motors, fans etc.
- u) Insulating oil.
- v) Oil flow indicator
- w) Terminal marking plate.
- x) Jacking pads.
- y) Lifting bollards
- z) Haulage lugs.
- aa) Cover lifting lugs
- bb) Valve schedule plate
- cc) RTCC panel
- dd) Oil filling instruction plate of conservator
- ee) Schematic diagram plate for operation of Tap changer Motor Drive Mechanism Box.
- ff) The serial number of the transformer to be punched on the tank next to the rating plate.
- gg) Provision for fitting Nitrogen injection fire protection and extinguishing system.
- hh) Bushing CT's
- ii) *Temperature indicator compatible with SCADA.*
- jj) *Fibre Optic based temperature measuring system complete.*
- kk) *Transformer monitoring cum tap changer controller.*
- ll) *Nitrogen Injection drain & stir method type fire extinguisher.*
- mm) *On-line DGA (to be provided for 100MVA & 150MVA transformers).* ~~_____~~

nn) *Hydraulic Jacks - one set per station.*

NOTE: - a. The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of the transformer are deemed to be included.

b) The accessories required with the transformer shall be SCADA/ SAS compatible. Potential free contacts for Bucholtz relay, PRV,OSR, OTI, WTI, etc. need to provided. Further for OTI, WTI, TPI, etc. dual output of 4-20mA shall be provided.

c) ~~The On-line DGA shall be provided for transformer with rating 100MVA and above.~~

d) All the microprocessor based IEDs such as Transformer monitoring cum tap-changer controller, etc. shall be interfaced with the SAS of the sub-station in co-ordination with the SAS supplier. Necessary files such as ICD, CID and PICS, MICS and PIXIT documents shall be provided in soft copy for integration with third party HMI. In case of sub-stations without SAS, the On-line DGA is to be interfaced with numerical tap-changer controller (ITCS).

e) The required communication cables for the above is in the scope of the bidder/ supplier.

f) The auxiliary supply to all the IEDs shall be 220V, DC.

g) Warranty for the “Products and Solutions” for the IEDs as per International Standards shall be furnished. Also, guarantee for the availability of spares and solutions for all the IEDs for at least 10 years from the date of supply of products to be furnished.

9.16.02 The equipment and accessories furnished with the transformer shall be suitably mounted on the Transformer for easy operation and inspection and maintenance and the mounting details shall be subject to the approval of the purchaser. All valves shall be provided either with blind companion flanges or with pipe plugs for protection.

9.16.03 Indication, alarm and relay equipment shall have contacts, suitable for operation with 220Volts DC supply. Any other accessories or appliances recommended by the manufacturer for the satisfactory operation of the transformers together with their prices shall be given in the tender.

9.17.00 *LIMITS OF TEMPERATURE RISE :*

Refer Table No. 4 of IS-2026 (Part - II)

For purpose of standardization of limit of temperature rise of oil and winding, the following ambient temperatures shall be considered.

1 *Maximum ambient temperature*

50° C

2. *Maximum daily average ambient temperature* 40° C
3. *Maximum yearly weighted average temperature* 32° C

With the above ambient temperature, the temperature-rise shall be as follows:

1. *Winding temperature rise* - 50° C (when the
measured by *oil circulation is natural*
resistance method *or forced and non directed)*
2. *Top oil (temperature measured - 45° C*
by thermometer)

9.18.00 SPECIFICATION FOR CONTROL CABINETS:

1. Control cabinet for the tap changer driving motors shall be housed in a local kiosk mounted adjacent to or on the transformer.
2. Control cabinet of the operating mechanism shall be made out of 3mm thick sheet steel. Hinged door with handle shall be provided with padlocking arrangement. Sloping rain hood shall be provided to cover all sides 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protection of at-least IP55 as per IS : 2147. The colour of paint shall be light gray in accordance with shade No. 631 of IS-5.
3. Motors rated 1 KW and above being controlled from the control cabinet would be suitable for operation on a 415V, 3 phase, 50Hz system. Fractional KW motors would be suitable for operation on a 240 V, single phase , 50 Hz supply system,
4. Isolating switches shall be group operated units (3 pole for use on 3 phase supply system and 2 pole for single phase supply systems) quick make and break type, capable of breaking safely and without deterioration, the rated current of the associated circuit.. Switch handle shall have provision for locking, in both fully open and fully closed positions,
5. Push button shall be rated for not less than 6 Amps, 415V AC or 2 Amps 220V DC and shall be flush mounted on the cabinet door and provided with appropriate name plates. Red, Green and Amber indicating lamps shall be flush mounted.

6. For motors up to 5 KW, contactors shall be direct-on-line, air break, single throw type and shall be suitable for making and breaking the stalled current of the associated motor which shall be assumed equal to 6.5 times the full load current of the motor at 0.2 pf. For motors above 5 KW, automatic star delta type starters shall be provided. 3 Pole contactors shall be furnished for 3 phase motors and 2 pole contactors for single phase motors. Reversing contactors shall be provided with electrical interlocks between forward and reverse contactors. If possible, mechanical interlocks shall also be provided. Contactors shall be suitable for uninterrupted duty and shall be of duty category class AC4 as defined in IS : 2959. The main contacts of the contactors shall be silver plated and the insulation class for the coils shall be class E or better. The dropout voltage of the contactors shall not exceed 70% of the rated voltage.
7. Contactors shall be provided with a three element, positive acting, ambient temperature compensated time lagged, hand reset type thermal overload relay with adjustable setting. Hand reset button shall be flush with the front door of the cabinet and suitable for resetting with starter compartment door closed.
8. Single phasing preventer relay shall be provided for a 3-phase motors to provide positive protection against single phasing.
9. Mini starter shall be provided with no volt coils whenever required.
10. Purchaser's power cables will be of 1100 Volts grade stranded copper conductor. All necessary cable terminating accessories such as glands, crimp type tinned copper lugs etc., for power as well as control Cables shall be included in bidder's scope of supply. Suitable brass cable glands shall be provided for cable entry. The required quantity of cable glands suitable for cable size of 19 X 2.5 sq. mm control cable shall be provided. Dummy plates for cable glands shall be provided for purchaser's use if necessary.
11. Wiring for all control circuits shall be carried out with 1100 Volts grade PVC insulated tinned copper stranded conductors of sizes not smaller than 2.5 sq. mm. At least 20% spare terminal blocks for control wire terminations shall be provided on each panel. The terminal blocks shall be of non disconnecting stud type. All terminals shall be provided with ferrules indelibly marked or numbered and these identifications shall correspond to the designations on the relevant wiring diagrams, The terminals shall be rated for adequate capacity, which shall not be less than 10 Amps.

12. Separate terminal blocks shall be provided for terminating circuits of various voltage classes. CT loads shall be terminated on a separate block and shall have provision for short circuiting the CT secondary terminals.
13. Control cabinet shall be provided with 240V, 1-phase, 50Hz, 20W fluorescent light fixture and a suitably rated 240V, 1-phase, 5 Amps, 3 pin socket for hand lamps. The 3 pin socket shall be provided with protective electrical and mechanical cover with chain.
14. Strip heaters shall be provided inside each cabinet complete with thermostat (preferably differential type) to prevent moisture condensation. Heaters shall be controlled by suitably rated double pole miniature circuit breakers,
15. Signal lamps provided shall be of neon screw type with series resistors, enclosed in Bakelite body. Each signal lamp shall be provided with a fuse integrally mounted in the lamp body.
16. Items inside the cabinet made of organic material shall be coated with a fungus resistant varnish.

9.19.00 MOTORS:

Motors shall be 'squirrel cage' three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment. Motors shall conform to IS : 325.

10.00.00 PROTECTION:

10.01.00 The transformer shall have the following protection:

- I. Detecting or actuating devices required which form part of the transformer construction shall be provided by the transformer supplier.
 - a) Buchholz relay alarm and trip contact.
 - b) Oil temperature indicator with alarm and trip contact.
 - c) Winding temperature indicator for alarm, trip control of fans / motor contacts.
 - d) Magnetic oil gauge with low level alarm contact.
 - e) Oil surge protection for OLTC diverter tank with trip contact.
 - f) Pressure relief device with trip contact
 - g) Flow indicators and. alarms for the oil passages.
 - h) Nitrogen injection fire protection and extinguishing system
- II. Protection to be provided by purchaser.
 - a) Circuit breaker on both primary and secondary sides.

- b) High speed differential relay, restricted earth fault relay, over flux relay, and back up over current and earth fault relay on both primary and secondary side.
- c) Non directional over current relay for each phase on tertiary side.
- d) Lightning arrestors on both primary and secondary side.

10.02.00 **PROTECTION AGAINST FIRE**

Provision shall be made in the power transformers for fitting Nitrogen injection drain & stir type of fire prevention and extinguishing system.

10.03.00 **SPECIAL TOOLS AND TACKLES:**

The bidder shall include in his proposal any special erection and maintenance tools required according to the specialties of the Equipment. The list of such special tools shall be given and price of these shall be included in the proposed price.

10.04.00 **SPARE PARTS AND MAINTENANCE EQUIPMENT:**

- a) Bidder shall indicate in his proposal spares required for the trouble free operation of the equipment for (5) five years.

11.00 QUALITY ASSURANCE PLAN

The Bidder shall furnish the following information along with his offer.

- i. Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in the presence of Bidder's representative, copies of test certificates.
- ii. Information and copies of test certificates as in (i) above in respect of bought out items.
- iii. List of manufacturing facilities available.
- iv. Level of automation achieved and list of areas where manual processing exists.
- v. List of areas in manufacturing process, where stage inspection are normally carried out for quality control and details of such tests and inspection.
- vi. Special features provided in the equipment to make it maintenance free.
- vii. List of testing equipment available with the Bidder for final testing of equipment specified and test plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the

relevant standards. These limitations shall be very clearly brought out in 'Schedule of Deviations'.

11.02.00 The supplier shall within 30 days of placement of order, submit the following information to the purchaser.

- i. Name of the raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with the offer.
- ii. Type test certificates of the raw materials and bought out accessories.
- iii. Quality Assurance Plan [QAP] with hold points for purchaser's inspection. The QAP and hold points shall be discussed between the purchaser and the supplier before the QAP is finalized.

11.03.00 The supplier shall submit the routine test certificates of bought out items and raw materials at the time of routing testing of the fully assembled equipment.

12.01.00 **INSPECTION**

- i) The purchaser shall have access at all times to the works and other places of manufacture where the transformers are being manufactured and the supplier shall provide all facilities for unrestricted inspection of the suppliers works, raw materials, manufacturer of all accessories and for conducting necessary test.
- ii) The supplier shall keep the purchaser informed in advance of the time of starting and of the progress of manufacture of equipment in its various stages so that arrangements could be made for inspection.
- iii) (a) The manufacturer of transformer shall directly import CRGO either from the manufacturer or through their accredited marketing organization of repute or through authorized dealer. In support of this requirement the manufacturer of transformer should submit an undertaking in the form of an affidavit on Rs.100/- stamp paper, duly notarized, in the specified format.
(b) Suppliers, shall offer the "CORE" for inspection and get approval by the purchaser during the manufacturing stage. Suppliers call notice for the purpose should be accompanied with the following documents as applicable, as a proof towards use of Prime CORE material:
 - a) Invoice of the supplier
 - b) Mill's test Certificate
 - c) Packing List
 - d) Bill of lading
 - e) Bill of entry certificate by customs
- iv) No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested.

- v) The acceptance of any quantity of equipment shall in no way relieve the supplier of his responsibility for meeting all the requirements of this specification and shall not prevent subsequent rejection if such equipment are later found to be defective.
- vi) The supplier shall inform the purchaser at least thirty days in advance about the manufacturing programme so that arrangements can be made for inspection, if desired by the purchaser.
- vii) The purchaser reserves the right to insist on witnessing the acceptance routine testing of bought out items. The supplier shall communicate to the purchaser the details of such testing programme at least three weeks in advance. The testing shall not be postponed even if the purchaser is unable to depute his representative for witnessing the testing.

12.1.1 Tank and Conservator

12.1.1.1 Certification of chemical analysis and material tests of plates.

12.1.1.2 Check for flatness.

12.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexible.

12.1.1.4 Welder's qualification and weld procedure.

12.1.1.5 Testing of electrodes for quality of base materials and coatings.

12.1.1.6 Inspection of major weld preparation.

12.1.1.7 Crack detection of major strength weld seams by dye penetration test.

12.1.1.8 Measurement of film thickness of :

- i) Oil insoluble varnish.
- ii) Zinc chromate paint.
- iii) Finished coat.

12.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90°C and further dimensional check.

12.1.1.10 Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to NDT.

12.1.1.11 Leakage test of the conservator.

12.1.1.12 Certification of all test results.

12.1.2 Core

12.1.2.1 Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness.

12.1.2.2 Check on the quality of varnish if used on the stampings :

- i) Measurement of thickness and hardness of varnish on stampings.
- ii) Solvent resistance test to check that varnish does not react in hot oil.
- iii) Check over all quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface.

12.1.2.3 Check on the amount of burrs.

12.1.2.4 Bow check on stampings.

12.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.

12.1.2.6 Visual and dimensional check during assembly stage.

12.1.2.7 Check for interlaminar insulation between core sectors before and after pressing.

12.1.2.8 Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.

12.1.2.9 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.

12.1.2.10 High voltage test (2 kV for one minute) between core and clamps.

12.1.2.11 Certification of all test results.

12.1.3 **Insulation Material**

12.1.3.1. Sample check for physical properties of materials.

12.1.3.2 Check for dielectric strength.

12.1.3.3 Visual and dimensional checks.

12.1.3.4 Check for the reaction of hot oil on insulating materials.

12.1.3.5 Dimension stability test at high temperature for insulating material.

12.1.3.6 Tracking resistance test on insulating material

12.1.3.7 Certification of all test results.

12.1.4 **Winding**

12.1.4.1 Sample check on winding conductor for mechanical properties and electrical conductivity.

12.1.4.2 Visual and dimensional checks on conductor for scratches, dent marks etc.

12.1.4.3 Sample check on insulating paper for pH value, bursting strength and electric strength.

12.1.4.4 Check for the reaction of hot oil on insulating paper.

12.1.4.5 Check for the bonding of the insulating paper with conductor.

12.1.4.6 Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.

12.1.4.7 Check for absence of short circuit between parallel strands.

12.1.4.8 Check for brazed joints wherever applicable.

12.1.4.9 Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready.

12.1.4.10 Conductor enamel test for checking of cracks, leakage and pin holes.

12.1.4.11 Conductor flexibility test

12.1.4.12 Heat shrink test for enamelled wire.

12.1.4.13 Certification of all test results.

12.1.5 Checks Before Drying Process

12.1.5.1 Check condition of insulation on the conductor and between the windings.

12.1.5.2 Check insulation distance between high voltage connections, cables and earth and other live parts.

12.1.5.3 Check insulating distances between low voltage connections and earth and other parts.

12.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.

12.1.5.5 Check for proper cleanliness and absence of dust etc.

12.1.5.6 Certification of all test results.

12.1.6 Checks During Drying Process

12.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum

treatment.

12.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.

12.1.6.3 Certification of all test results.

12.1.7 **Assembled Transformer**

12.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.

12.1.7.2 Test to check effective shielding of the tank.

12.1.7.3 Jacking test with oil on all the assembled transformers.

12.1.7.4 Dye penetration test shall be carried out after the jacking test.

12.1.8 **Bought Out Items**

12.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.

12.1.8.2 The Contractor shall also prepare a comprehensive inspection and testing programme for

all bought out/sub-contracted items and shall submit the same to the Employer for approval. Such programme shall include the following components:

- a) Buchholz Relay.
- b) Axles and wheels.
- c) Winding temperature indicators for local and remote mounting.
- d) Oil temperature indicators.
- e) Bushings.
- f) Bushing current transformers.
- g) Cooler control cabinet.
- h) Cooling equipment.
- i) Oil pumps.
- j) Fans/Air Blowers
- k) Tap change gear.
- l) Terminal connectors.

The above list is not exhaustive and the Contractor shall also include other bought out items in his programme.

12.2 **Factory Tests**

12.2.1 **Routine Tests**

All standard routine tests in accordance with IS:2026 shall be carried out on each transformer. Operation and dielectric testing of OLTC shall also be carried out as per IS:2026 .

Following additional routine tests shall also be carried out on each transformer:

12.2.1.1 Magnetic Circuit Test

After assembly each core shall be tested for 1 minute at 2000 Volts between all bolts, side plates and structural steel work.

12.2.1.2 Oil leakage test on transformer tank as per Clause 5.2.7.1 below.

12.2.1.3 Magnetic balance test

12.2.1.4 Measurement of no-load current with 415V, 50 Hz ac supply on LV side.

12.2.1.5 Frequency response analysis (FRA)

12.2.1.6 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

12.2.2 Type Tests

12.2.2 (a) Type tested Transformer shall be offered. The type test reports shall not be older than five (5) years as on the last date of submission of bid. The type tests are to be conducted again without any extra cost to the owner in case the type test reports are older than five (5) years as on the last date of submission of bid. The type test charges are to be indicated in the schedule. The owner reserves right to insist for conducting all or a few type tests even though the type tests are less than five (5) years old as on the last date of submission of bid, the payment in such cases will be made as per the rates in the schedule.

a) For Transformers manufactured in India:

- i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

b) For Transformer manufactured Abroad:

- i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
 - ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.
- 12.2.2 (b) However, following tests shall be conducted on one Transformer of each rating, while Temp Rise Test shall be carried out on all units:

12.2.2.b. 1 Temp. Rise Test as per IS:2026 (Part-II)

Gas chromatographic analysis on oil shall also be conducted before and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 567. For the evaluation of the gas analysis in temperature rise test the procedure shall be as per IS:9434 (based on IEC:567) and results will be interpreted as per IS:10593 (based on IEC -599).

The temperature rise test shall be conducted at a tap for the worst combination of loading on the three windings of the transformer. The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

12.2.2.b.2 Tank vacuum Test as per Cl.no.12.2.6.2 (i) below.

12.2.2.b.3 Tank pressure Test as per Cl.no. 12.2.6.2 (ii) below.

12.2.2.b.4 Pressure Relief Device Test

The pressure relief device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in 'Tank tests' subsequently in this clause. The device shall seal off after the excess pressure has been released.

12.2.2.b.5 Measurement of capacitance and tan delta to determine capacitance between winding and earth. *The measurement shall be carried out before and after series of electric tests.*

12.2.2.b.6 Dielectric test as per IS: 2026 Part III:2009

- a. Full wave lightning impulse test for the line terminals (LI) [Type test (for $U_m \leq 72.5\text{kV}$), Routine test (for $72.5\text{kV} < U_m \leq 170\text{kV}$)].
- b. Chopped wave lightning impulse test for the line terminals (LIC)[Type test (for $U_m \leq 170\text{kV}$), Routine test (for $U_m > 170\text{kV}$)]
- c. Lightning impulse test for the neutral terminals (LIN)

12.2.3 Additional type tests

Following additional type tests other than type and routine tests shall also be carried out on one unit of each type :

12.2.3.1 Measurement of zero Seq. reactance (As per IS:2026, for 3-phase transformer only.)

12.2.3.2 Measurement of acoustic noise level.

12.2.3.3 Measurement of power taken by fans and oil pumps.

12.2.3.4 Measurement of harmonic level in no load current.

12.2.3.5 Deleted.

12.2.3.6 VOID

12.2.4 Dynamic Short Circuit Test Requirement And Validity

The transformer, the design of which is similar to the offered transformer, should have been successfully tested for short circuit withstand capability as per IS 2026 Part-5/IEC 60076 Part-5 in line with the requirement of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations. The validity of DSC test for transformer shall remain till the design is changed.

The criteria for similar transformer shall be as specified in IS 2026 Part-5/IEC 60076 Part-5. The relevant Test Report/certificate shall be furnished. Further, design review of offered transformer shall be carried out based on the design of reference transformer, which has already been subjected to Short circuit tests in lieu of repetition of Short circuit tests. In case, manufacturer has not conducted short circuit test earlier or there is change in design, the DSC test shall be carried out on one of the offered transformer at his cost.

Tests shall be conducted before and after short circuit test as per the relevant clauses of IEC 60076-5/ IS 2026-5

Following shall also be conducted before and after Short Circuit test

- i) Dissolved gas analysis
- ii) Frequency response analysis

12.2.5 Routine tests on bushings

The following tests shall be conducted on bushings

12.2.5.1 Test for leakage on internal fillings.

12.2.5.2 Measurement of creepage distance, dielectric dissipation factor and capacitance.

12.2.5.3 Dry power frequency test on terminal and tapping.

12.2.5.4 Partial discharge test followed by dielectric dissipation factor and capacitance measurement.

12.2.6 Type Tests on fittings:

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the clause no. 9.2 of the Section – GTR. The list of fittings and the type test requirement is:

1. Bushing (Type Test as per IS: 2099/ IEC: 137)
2. Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)
3. OLTC (Temperature Rise of contact, Short circuit current test, Mechanical test and Dielectric Test as per IEC:214 and IP-55 test on driving mechanism box)
4. Cooler Control cabinet (IP-55 test)
5. Pressure Relief device Test
The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test at Cl. No. 5.2.7.2 (ii) below. The operating pressure shall be recorded. The device shall seal off after excess pressure has been released. The terminal box / boxes of PRD should conform to degree of protection as per IP-55 of IS: 13947.
6. Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.
7. Air Cell (Flexible air separator) – Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016.
8. OTI & WTI – Switch setting & operation, Switch differential, Switch rating.
9. Oil pump – Vacuum Test at 250 torr maximum, oil pressure test at 1 kg/cm² for 24 hrs.,
Temperature rise test by resistance method, IP-55 degree of protection for terminal box.
10. Cooling fan and motor assembly – Free air delivery, Temperature rise, sound level, running at reduced voltage, IP-55 degree of protection for terminal box.

12.2.7 Tank Tests

12.2.7.1 Routine Tests

Oil Leakage Test:

All tanks and oil filled compartments shall be tested for oil tightness by being completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IS:335 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/Sq.m (5 psi) measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leak shall occur.

12.2.7.2 Type Tests

(i) Vacuum Test

One transformer tank of each size shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	Permanent deflection (in mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

(ii) Pressure Test

One transformer tank of each size, its radiator, conservator vessel and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m² whichever is lower measured at the base of the tank and maintained for one hour. the permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

12.2.8 Pre-Shipment Checks at Manufacturer's Works

12.2.8.1 Check for interchangeability of components of similar transformers for mounting dimensions.

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

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

12.2.8.4 Gas tightness test to confirm tightness.

12.2.8.5 Derivation of leakage rate and ensure the adequate reserve gas capacity.

12.3 ***Inspection and Testing at Site***

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage upto commissioning stage. An indicative programme of inspection as envisaged by the Employer is given below and in the document No.

OS/T&C/Bay/95 (Pre commissioning Procedures and Formats for substation bay equipment), which will be available in the respective sites and shall be referred by the contractor. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Testing of oil sample at site shall be carried out as per Cl.3.4 above.

12.3.1 Receipt and Storage Checks

12.3.1.1 Check and record condition of each package, visible parts of the transformer etc. for any damage.

12.3.1.2 Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

12.3.1.3 Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

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

12.3.2 Installation Checks

12.3.2.1 Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

12.3.2.2 (i) Check the direction of rotation of fans and pumps.
(ii) Check the bearing lubrication.

12.3.2.3 Check whole assembly for tightness, general appearance etc.

12.3.2.4 Oil leakage test

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

12.3.2.6 Leakage test on bushing before erection.

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

12.3.3 Commissioning Checks

12.3.3.1 Check the colour of silicagel in silicagel breather.

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

12.3.3.3 Check the bushing for conformity of connection to the lines etc,

12.3.3.4 Check for correct operation of all protection devices and alarms :

- (i) Buchholz relay.
- (ii) Excessive winding temperature.
- (iii) Excessive oil temperature.
- (iv) Low oil flow.
- (v) Low oil level indication.
- (vi) Fan and pump failure protection.

- 12.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.
- 12.3.3.6 Check resistance of all windings on all steps of the tap changer.
Insulation resistance measurement for the following:
- (i) Control wiring.
 - (ii) Cooling system motor and control.
 - (iii) Main windings.
 - (iv) Tap changer motor and control.
- 12.3.3.7 Check for cleanliness of the transformer and the surroundings.
- 12.3.3.8 Continuously observe the transformer operation at no load for 24 hours.
- 12.3.3.9 Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.
- 12.3.3.10 Phase out and vector group test.
- 12.3.3.11 Ratio test on all taps.
- 12.3.3.12 Magnetising current test.
- 12.3.3.13 Capacitance and Tan delta measurement of winding and bushing.
- 12.3.3.14 DGA of oil just before commissioning and after 24 hours energisation at site.
- 12.3.3.15 Frequency response analysis (FRA).
- 12.3.3.16 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.

12.4 SEQUENCE OF TESTS:

The sequence of type tests, special tests (whenever applicable) and routine tests required to be conducted on each transformer is as mentioned hereunder :

Sl. No.	TEST CATEGORY	DESCRIPTION
1	Type	Parameters as per drawings
2	Type	Tank pressure test with measurement of deflection
3	Type	Tank vacuum test with measurement of deflection
4	Type	Pressure relief device test
5	Type	Degree of protection IP55 for OLTC & Cooling control cabinets.
6	Type	Magnetic circuit insulation test 2kV-1 minute. Core to Yoke clamp, Core to flith plate, Core bolt to yoke.
7	Type	Oil DGA test (before & after HV & TR tests)

8	Type	No load loss & current (before & after HV & TR routine tests) at 90%, 100% & 110% of rated voltage with 3W, 3A and 3V meters method.
9	Type	Impulse test: One reduced full wave One full wave One reduced chopped wave Two full chopped wave Two full waves
10	* Type	Temperature rise test at ONAN, ONAF & OFAF ratings & quoted max. losses.
11	Type	Oil leakage test at 35 KN/m ² (0.357kg/sq.cm) over max. static head of oil measured at the base for 12hrs.
12	Type	Jacking test
13	Type	Bushing current transformer ratio & polarity tests.
14	Routine	Magnetic balance test at nay one tap.
15	Routine	IR value t 10/60/600sec (before & after HV & TR tests)
16	Routine	Winding resistance at all taps.
17	Routine	Oil BDV test (before & after HV & TR tests)
18	Routine	Voltage ratio at all taps and polarity/phase displacement at normal tap.
19	Routine	Separate source voltage withstand test.
20	Routine	Induced over voltage withstand test.
21	Routine	Load loss at extreme taps and normal tap & impedance at all taps by 3W, 3A, 3V meter method.
22	Routine	Tests on OLTC: 1). Circuit insulation test 2kV – 1Min. 2). Operations tests: 8Cy, 1Cy at 85%V, 1Cy at no load and rated V, 10Cy +/-2 steps from normal tap and rated current.
23	Routine	Cooling Control test: 1). Circuit insulation test 2kV-1Min. 2). Operating test.
24	Routine	SFRA
25	Special	Capacitance and Tan Delta (before & after HV & TR tests) at 5kV & 10kV: HV to LV + tank; HV + LV to tank under grounded and guarded specimen modes.
26	Special	Harmonic analysis of no load current at 90%, 110% of rated V
27	Special	Zero sequence impedance test at 10% / 20% / 60% / 80% / 100% of test current at extreme taps and normal tap.
28	Special	Acoustic noise level test.
29	Special	Measurement of power consumption by fans & pumps
30	Special	Dynamic short circuit test

NOTE: 1. CT, PT, Ammeter, Voltmeter, Wattmeter, frequency meter shall be of appropriate class of accuracy and shall have valid calibration certificate.

2. T.R- Temperature rise test.

* Temperature rise test shall be conducted on all units.

12.4.1 *The manufacturer shall carry out the Sweep Frequency Response Analysis (SFRA) Test at their works and also during pre-commissioning at site. The values / data shall be furnished to KP TCL for future reference. The required instruments/equipments for conducting the SFRA test at Site shall be arranged by transformer manufacturer/Contractor.*

13.00 Power transformer 31.5MVA (66/11KV class) and 100MVA and above rating shall be provided with “Nitrogen” Injection drain and stir method type fire prevention and extinguish system along with all associated fittings and control equipment. The bidder shall furnish full details of the fire extinguishing system offered. In case if the system is not being manufactured by the bidder full details of the manufacture experience and performance of the system shall be furnished with the offer.

14.00 **MINIMUM EXPERIENCE FOR QUALIFYING AS A BIDDER:**

- i. Bidders shall have a minimum experience of five years in the design, manufacture, testing and commissioning of power transformer similar of the type specified in the present enquiry. At least 50% of the quantity of similar type of transformer called for in the present enquiry shall be successful operation for a minimum period of two years. The Bidder shall furnish the performance certificate for satisfactory operation of similar equipment for a minimum period of two years . The Bidder shall furnish the type test certificate conducted on a similar equipment not later than five years as on the last date of submission of bid.
- ii) The purchaser however reserves the right to waive the minimum experience condition stipulated in clause 13.04.00 (i) in case of firm having collaboration with well experience firms. The experience of the collaborating firms in the manufacture of similar type power transformer shall be not less than ten years. The waiving of minimum experience condition will be considered by the purchaser only on furnishing the performance guarantee for the power transformer manufactured by the collaborating firms.

16.00 **REJECTION**

Apart from rejection due to failure of the transformer to meet the specified test requirements or in service during the guaranteed period, the transformer shall be liable for rejection on any of the following reasons.

- a) No load loss exceeds the guaranteed value by 2% or more.

- b) I²R / Load loss exceeds the guaranteed value by 2% or more.
- c) Impedance value exceeds the guaranteed value by tolerance as specified in IS 2026.
- d) Transformer is proved to have been manufactured not in accordance with the agreed specifications.

If the transformer is rejected after it is serviced for any of the above reasons the transformer shall be retained till the same is replaced by the supplier and commissioned successfully.

17.00.00 **DOCUMENTATION:**

17.01.00 The following tender drawings shall be submitted in triplicate for each type of transformer.

- a) A general outline and shipping dimension, net and shipping weights, height of crane hooks for lifting core and busing etc.
- b) Sectional views of bushings, heat exchangers, etc.
- c) Schematic electric control circuit diagram for OLTC control, cooler control etc.

17.02.00 The supplier shall within four weeks of placement of order submit four sets of drawings, which will describe the equipment in details for purchaser's approval. The purchaser shall communicate his comments/approval on the drawings within reasonable period.

The following drawings for each item are to be supplied as part of the contract.

- a) Outline dimensional drawings of transformers and accessories.
- b) Assembly drawings and weight of main component parts.
- c) Shipping drawings showing dimensions and weights of each package.
- d) Foundation: The weight of the individual parts which require separate foundations and the position of separate bolts and nuts required shall be advised by the supplier. Foundation design and drawings giving full particulars shall be supplied to the purchaser in time to enable the foundation to be erected by the time the transformers arrive at site. The position of ducts, trenches, oil piping etc., shall clearly be indicated on the same. The safe bearing pressure of the soil may be assumed as 0.5 tonne per sq.ft.
- e) Tap changing and name plate diagrams.
- e) Schematic control and wiring diagram for all auxiliary equipments.
- f) Schematic diagram showing the flow of oil in the cooling system as well as each limb and winding. Longitudinal and cross sectional views showing the ducts sizes, cooling pipes, etc., for the transformer heat exchanger drawing to scale shall be furnished.
- g) Bushing drawing with sectional views and specification.

- h) Test reports.
- i) Diagram and rating plates.
- j) Electrical connections of windings, number of taps, tapping switchgear terminal vector group polarity etc.
- k) Control circuits and wiring diagrams, schematic circuit diagrams for cooler control, paralleling interlock, wiring diagrams of control cabinets, signaling and indicating devices, block diagram showing inter connecting control cable schedule to enable the purchaser to prepare the schedule of control cables etc.
- l) Assembly of core and coils: Details of winding connection, insulation spacers, barriers clearances, core bolt insulation, etc., which will help the purchaser to replace a set of winding in any future eventuality. The component parts shall be suitably numbered and parts shipped shall have similarly numbered tags.
- m) Drilling details and internal wiring of devices supplied loose for mounting on the purchaser's control board.
- n) Assembly of OLTC gear mechanism: Full details of the mechanism parts, limits and fits contours wearing parts, timing gear adjustments.
- o) Detailed assembly drawing to enable the purchaser to do the core and coil assembly. Parts shall be identified by separate numbers.
- p) Dimensional drawings showing cooling passage on transformers and windings.
- q) The supplier shall, if necessary, modify the drawings and resubmit four copies of the modified drawings for purchaser's approval within two weeks from the date of comments.

17.03.00 After the approval of drawings the Bidder should supply the drawings and manuals as detailed below:

- i. 12 sets of blue print copies and one set of reproducible originals of all the approved drawings and 12 sets instructions, erection, commissioning and maintenance manuals to the officer designated in purchase order .
- ii. Three sets blue print copies of all approved drawings and three sets instruction, erection, commissioning and maintenance manual to the consignee in respect of each transformer.
- iii. Marked erection drawings shall identify the component parts of the equipment as shipped to enable purchaser to carryout erection with his own personnel. Each manual shall also contain one set of all the approved drawings, type test reports as well as acceptance reports of the corresponding consignment dispatched.

17.04.00 The manufacturing of the equipment shall be strictly in accordance with approved drawings and no deviation shall be permitted without the written approval of the purchaser. All manufacturing and fabrication

work in connection with equipment prior to the approval of the drawing shall be at the supplier's risk.

17.05.00 The firm should supply the contract drawings and manuals detailed in clause 14.02.00 well before the supply of transformer. Further the firm should give a specific confirmation to this effect.

17.06.00 **TEST REPORTS**

- i. Four copies of type test reports shall be furnished to purchaser within three weeks of conducting the tests. One copy will be returned duly certified by purchaser to the supplier within two weeks thereafter and on receipt of the same Bidder shall commence with the commercial production of the concerned material.
- ii. Four copies of acceptance test reports shall be furnished to the purchaser. One copy will be returned duly certified by the purchaser and only thereafter shall the materials be dispatched.
- iii. All records of routine test reports shall be maintained by the supplier at his works for periodic inspection by the purchaser.
- iv. All test reports for tests conducted during manufacture shall be maintained by the supplier. These shall be produced for verification as and when requested for by the purchaser

18.00.00 **PACKING AND TRANSPORTATION**

18.01.00 The equipment shall be packed in crates suitable for vertical/horizontal transport as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for any damage to the equipment during transit, due to improper and inadequate packing. The easily damageable material shall be carefully packed and marked with the appropriate caution symbol. Wherever necessary, proper arrangement for lifting, such as lifting hook etc. shall be provided. Any material found short inside the packing cases shall be supplied by supplier without any extra cost.

18.02.00 The transformer shall be transported, thoroughly dried under vacuum and sealed under positive pressure with inert gas (Nitrogen). Nitrogen gas pressure gauge shall be provided.

18.03.00 All brass fitting should be dismantled after test at the factory and should be transported separately to avoid loss during transit. The opening should be suitably plugged except inert gas inlet and outlet which should be fitted with iron fittings.

18.04.00 All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contract number and shall have detailed packing list containing the following information.

- a) Name of the consignee.
- b) Details of consignment
- c) Destination
- d) Total weight of consignment.
- e) Sign showing upper/Lower side of the crate.
- f) Handling and unpacking instructions.
- g) Bill of material indicating contents of each packing.

18.05.00 The supplier shall ensure that the packing and bill of materials are approved by the purchaser before dispatch.

18.06.00 The Bidder shall supply the factory assembled transformer and the accessories will be assembled at site. However, if the Bidder choose to supply the transformer in knocked down condition, Bidder should make his own arrangement for assembly and delivery of transformer at site.

18.07.00 **LIMITING DIMENSION**

The manufacturer has to note the limitations of transporting, package dimensions and weights for transportation over the railways/public transport as notified in the tender and should take the responsibility of transporting the units to site.

19.00.00 **TRAINING:**

19.01.00 The successful Bidder shall be required to provide facilities for in plant training, at no extra cost to the purchaser, to at least 4 engineers to be nominated by the purchaser for a period of three weeks (i.e., 12 man weeks) at his works, where the equipments offered shall be manufactured. The scope of the training shall cover assembly, factory testing, site testing, periodical maintenance operation and possible trouble shooting of the transformers & Nitrogen Fire Prevention / Extinguishing System.

19.02.00 **TESTS**

Type test certificates not later than 5 years as per relevant standards for Nitrogen injection fire protection system as a whole unit shall be furnished.

- iv. Furnish Guarantee for performance for a period of 5 years.

20.00.00 **TESTING AND COMMISSIONING:**

- i. **COMMISSIONING**

The Bidder shall note that their commissioning Engineers have to be deputed at no extra cost for testing and commissioning of transformer, in case orders are finalized on them.

21.00.00 **GENERAL**

21.01.00 i. ***INFORMATION TO BE FILLED INVARIABLE BY THE BIDDER***

For ready reference of the tenderer, the information required to be invariably furnished by the tenderer in his offer, are listed below:

Following information is to be submitted physically along with offer (Techno commercial bid).

- i) GTP*
 - ii) List of type test conducted*
 - iii) Certificate of accreditation of the testing laboratory where the type test are conducted.*
 - iv) Drawings, test certificate & documents as per Qualifying requirement clause of this specification.*
 - v) Performance certificates*
 - vi) Type Test reports*
 - vii) Undertaking in the form of affidavit regarding CRGO as per clause nos: 9.01.01 and 12.01.00 (iii)*
- ii. The scope of supply shall include supply of 2.5% extra quantity of bolts , nuts, washers, split pins, cotter pins and such other small loose items free of cost.
- iii. The transformer is required to be delivered at our 220KV receiving station.

21.02.00 The chargers, if any, for delivery at site inclusive of transit risk insurance, loading and unloading charges, etc., are to be clearly indicated. Please note that there should be definite commitment by you for delivery of the transformer at site. Any statement like the probable estimated transportation charges etc., will be considered as non-responsive and such offers will be overlooked without any further correspondence.

22.03.00 **NITROGEN INJECTION FIRE PROTECTION.**

22.03.01 The transformers shall be supplied along with the Nitrogen injection fire protection system. However, the price towards the same shall be quoted separately.

22.03.02 Nitrogen injection fire prevention and extinguishing system should be provided for transformers (using Drain and stir method). This system should prevent tank explosion and fire in case of internal failure and also protect the transformers from external fire. Dedicated system shall be provided for individual transformer. It should be fully automatic and shall require minimum maintenance and practically no running cost.

24.00 **DEVIATION FROM TECHNICAL SPECIFICATION**

The Bidder shall furnish the details of deviation modification proposed by him to improve overall performance of the system. The deviation if any shall be brought in the tender clause by clause.

ANNEXURE-A

TYPE, RATING AND TECHNICAL REQUIREMENTS OF 220KV CLASS POWER TRANSFORMER

Sl. No.	PARTICULARS	3	20/66kV/11kV 100MVA 4	20/66/11kV Transformer 150MVA 5	220/110/11kV Transformer 100MVA 6	220/110/11kV Transformer 160MVA 7	220/110/11kV Transformer 200MVA 8	Remarks 9
1	2	3	4	5	6	7	8	9
1	Name of the Manufacturer and country of origin							
2	Reference standard	IS-2026						
3	Service [Indoor/outdoor]		Out door	Out door	Out door	Out door	Out door	
4	Duty	Continuous						
5	Continuous rating under conditions specified in IS-2026 Part-I, 1977 Clause No.3	: HV	100MVA	150MVA	100MVA	160 MVA	200 MVA	
5		: IV	100MVA	150MVA	100MVA	160MVA	200MVA	
5		: LV	Unloaded tertiary (*)	Unloaded tertiary (*)	Unloaded tertiary (*)	Unloaded tertiary (*)	Unloaded tertiary (*)	
6	Ratings :							Refer Annexure A – Principal parameter of specification.
	a.)1. With ONAN cooling - MVA		60	90	60	96	120	
	2. With ONAF cooling - MVA		80	120	80	128	160	
	3. With OFAF cooling - MVA		100	150	100	160	200	
	b. Rated no load voltage							
	HV – kV		220	220	220	220	220	
	IV - kV		66	66	110	110	110	
	LV – kV		11	11	11	11	11	
7	a. Rated Frequency : (Hz)		50±5%	50±5%	50±5%	50±5%	50±5%	
	b. Number of phases		3	3	3	3	3	
8	Current at rated voltage and on principal tap-Amp	:HV	262.44	393.66	262.44	419.9	524.8	
		: IV	874.8	1312.98	524.88	839.8	1049.8	
		:LV	Unloaded (*)					

	PARTICULARS		220/66kV/11kV 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	Remarks	
1	2	3	4	5	6	7	8	9	
9	Type of cooling	a). ONAN/ONAF/OFAF b). Separate 2x50% cooler bank c). 2x100% cooling pumps out of which one is connected stand by d). 2 Fans as stand by, one for each stand by						Refer Cl. No. 9.11 of Specification	
10	Flux density at rated voltage and rated frequency in tesla	1.6 Tesla (Max.)						Refer Cl. No. 7.0.8 of specification	
11	Material of core lamination	High grade non aging low loss cold rolled supergrain orientated Silicon steel – conventional grain oriented (CGO) core of grade M4 or better						Refer Cl. No. 9.01.01 of specification	
12	Maximum temperature rise over Ambient temperature of 50 °C								
	a. Winding	50 °C						Refer Principal parameters Annexure A	
	b. Oil	45 °C							
	c. Winding hot spot rise over yearly weighted temperature of 32 °C	61 °C						Refer Cl. No. 7.09 of Specification	
	d. Tank hot spot temperature	110 °C							
	e. Period of operation of transformer at full load without calculated winding hot spot temperature exceeding 140°C with								
	50% coolers fail	20min.							
	100% coolers fail	10min.							
13	Type of winding connection								
		HV	Star						Refer Principal parameters Annexure A
		IV	Star						
		LV	Delta						
		Neutral	Effectively earthed						

Sl. No.	PARTICULARS	3	220/66kV/11kV 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	8	Remarks
1	2	3	4	5	6	7	8	9	
14	Vector group		YNyn0d11	YNyn0d11	YNa0d11	YNa0d11	YNa0d11		Refer Principal parameters Annexure A
15	Tap changing gear :								
	a. Type of tap changer	On load suitable for bidirectional flow <i>In tank Hi speed Transient Resister Type on load</i>							
	b. Step Voltage %	1.25% of 220kV							
	c. Total tap range (+) percent to (-) percent	+5% to -15%							Refer Principal parameters Annexure A
	d. Tappings provided at	Neutral end of HV winding							
	e. Tap Control	Full capacity OLTC suitable for group /independent, remote / local electrical & local manual operation							
16	Type of mounting	On wheel mounted on rails							Refer Principal parameters Annexure A
17	No. of windings	Three windings with tertiary							
18	Maximum Permissible Losses of Transformers								
	a. Max. No Load Loss in KW at rated voltage & frequency	50	60	25	30	35			
	b. Max. Load loss in kW at rated current and at 75°C (at principal tap position)	250	320	180	200	260			
	c. Max. I ² R loss at rated current and at 75°C (at principal tap position)	207	265	140	145	190			
	d. Max. Auxiliary Loss at rated voltage & frequency	6	8	6	6	8			
18A	Percentage impedance Voltage on normal tap & at line MVA with tolerance as per IS2026,latest version								
	a. HV – IV	10% at line MVA	15% at line MVA	10% at line MVA	12.5% at line MVA	12.5% at line MVA			
B	Minimum percentage impedance voltage at normal tap at line MVA								Refer Principal parameters Annexure A

	a). HV – LV	15% (Minimum) at line MVA	25% (Minimum) at line MVA	26% (Minimum) at line MVA	26% (Minimum) at line MVA	26% (Minimum) at line MVA		
	b). IV – LV	15% (Minimum) at line MVA	30% (Minimum) at line MVA	15% (Minimum) at line MVA	15% (Minimum) at line MVA	15% (Minimum) at line MVA		
Sl. No.	PARTICULARS	220/66kV/11kV 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	Remarks	
1	2	4	5	6	7	8	9	
		<p>NOTE:</p> <p>1) The above impedance values shall be achieved with the winding arrangement at the discretion of the manufacturer without using reactor for 220/66/11kV, 100MVA & 150MVA Transformers.</p> <p>2) The above impedance values shall be achieved with the winding arrangement for 100MVA, 160MVA & 200MVA, 220/110/11kV Auto Transformer as follows: CORE – LV – IV – Regulating – HV without using reactor.</p> <p>3) The tolerance for the above impedance values shall be as per IS 2026- Part I (2011) or latest version</p>						
19	Minimum air core reactance of HV winding	20%						
20	Short time thermal withstand capacity & duration in Sec.	100/z times the rated primary current of transformer for 3 secs. Where z is the Percentage impedance of the transformer. Calculation to be furnished					Refer Cl. No. 9.02.09 of Specification	
21	Permissible overloading – HV	As per IS 6600					Refer Cl. No. 7.04 of Specification	
	- IV							
	- LV							
22	Insulation level for winding & OLTC							
	a. Lightning impulse withstand kV (peak)	HV IV LV & Neutral	950 325 170	950 325 170	950 550 170	950 550 170	950 550 170	Refer Principal parameters Annexure A
	b. Chopped wave lightning Impulse withstand voltage (kVp)	HV IV	1045 358	1045 358	1045 605	1045 605	1045 605	
	c. Switching Impulse withstand voltage (kVp)	HV	750	750	750	750	750	
	d. Power frequency voltage withstand kV (rms)	HV IV LV & Neutral	395 140 70	395 140 70	395 230 70	395 230 70	395 230 70	
23	Tan delta of winding %	≤ 0.5%						

24	RI V at 1.1 times minimum phase to ground voltage	5000 micro volts						Refer Principal parameters Annexure A
25	Maximum Noise level at rated voltage, at principal tap & No load and all cooling active(dB)	75 dB						
26	System short circuit level & duration for which the transformer shall be capable to with stand thermal & dynamic stress at its terminals(kA rms/ sec)	50kA for 3 Sec.						Refer Principal parameters Annexure A
Sl. No.	PARTICULARS		220/66kV/11kV V 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	Remarks
1	2	3	4	5	6	7	8	9
27	Insulating and cooling medium	EHV grade Transformer Oil confirming to IEC: 60296						Refer Cl. No. 9.05 of Specification
28	Oil preservation							
	a). Main conservator	Air Cell Type conservator with Dehydrating breathers (Maintenance Free Type Breather)						
	b). OLTC Conservator	Conventional type conservator with 2 numbers Silica gel breathers with oil seal						
29	Approximate weights							
	a. Core (Kg)							
	b. Windings (Kg)							
	c. Tank & Fittings (Kg)							
	d. Oil (Kg)							
	e. Untanking weight (Kg)							
	f. Total weight (Kg)							
30	Minimum clearance in air(mm)							
	a) HV							
	i. phase to phase	2000			2000			
	ii. phase to ground	1820			1820			
	b) IV							
	i. phase to phase	700			1430			
	ii. phase to ground	660			1270			
	c) LV							
	i. phase to phase	350			350			
	ii. phase to ground	320			320			
31	Terminals:							

	a) HV winding line end	245 KV class RIP/RIS bushing						Refer Principal parameters Annexure A
	b) IV winding line end	72.5 KV class RIP/RIS bushing			145kV class RIP/RIS Bushing			
Sl. No.	PARTICULARS		220/66kV/11kV 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	Remarks
1	2	3	4	5	6	7	8	8
	c) HV/IV winding neutral end(for solid grounding)	36 KV porcelain bushing						
	d) LV winding	36 KV porcelain bushing						
	NOTE : The supplier should provide higher rating of neutral bushing if design so warrants							
32	Bushing current rating (Amps)							Refer Principal parameters Annexure A
	a)HV		1250	1250	1250	1250	1250	
	b)IV		1250	2000	1250	1250	1250	
	c)LV		2000	2000	2000	2000	3150	
	d)HV/IV winding neutral		2000	2000	2000	2000	3150	
33	Insulation level of bushings:							
	a) Lightning impulse withstand (KVP)	HV IV LV & Neutral	1050 325 170	1050 650 170				
	b) Switching impulse withstand(KVP)	HV IV LV & Neutral	850 - -					
	c) One minute power frequency. withstand voltage (KV rms)	HV IV LV & Neutral	505 155 77	505 305 77				
	d) Creepage distance(mm)	31mm/kV of highest system voltage						
	e) Tank delta of bushing at ambient temperature	%	≤0.5					

	f) Max. partial discharge level at U_m	pC	10						
34	Anticipated continuous loading of windings						Refer Principal parameters Annexure A		
	1.HV and IV	Not to exceed 110% of its rated capacity							
Sl. No.	PARTICULARS		220/66kV/11kV Transformer 100MVA	220/66/11kV Transformer 150MVA	220/110/11kV Transformer 100MVA	220/110/11kV Transformer 160MVA	220/110/11kV Transformer 200MVA	Remarks	
1	2	3	4	5	6	7	8	9	
	2.Tertiary	Unloaded but should be designed for one third the rated MVA of transformer as given below:							
			33.33MVA	50MVA	33.33MVA	53.33MVA			
		All the terminals of tertiary delta connections including a corner delta open connection shall be brought out (4 terminals) externally through porcelain bushing for testing purpose. The corner delta open connection shall be provided with a tinned copper link of adequate cross-section and shall be earthed. Any suggestion for convenient/foolproof testing of tertiary winding of the Transformer. shall be furnished in the tender.							
35	Over voltage operating capability & duration	1. 110% of rated voltage- continuously 2. 125% of rated voltage for 60 secs 3. 140% of rated voltage for 5 secs						Refer Principal parameters Annexure A & 7.08 of specification	
36	<u>Windings:</u>								
	a. Material of winding conductor	Electrolytic grade Copper						Refer Cl. No. 9.02.02	
	b. Max. current density of winding	3Amps / Sq.mm.						Refer Cl. No. 9.02.11	
	c. <i>Type of winding insulation</i>								
	i). <i>HV/IV winding</i>	Graded							
	ii). <i>LV winding</i>	Uniformly Fully insulated							
37	<u>Details of Tank :</u>								
	a. Material for Transformer Tank	Tested grade low Carbon steel						Refer Cl. No. 9.03 of specification	
	b. Type of the tank	Bell type							
	c. Minimum thickness of sheet								
	i. Sides (mm)	Not less than 10mm						Refer Cl. No. 9.03.01 of specification	
	ii. Bottom (mm)	Not less than 20mm							
	iii. Cover (mm)	Not less than 20mm							

38	iv. Cooling tubes/Radiators mm)	1.2mm	
	Max. Partial discharge level at $1.58 * U_r / \sqrt{3}$ (pC)	100	

NOTE:

1. HV: High Voltage.
IV : Intermediate voltage
LV : Low voltage
2. Regulation of Transformers: Each tap shall be designed for the full rated MVA without exceeding the temperature and shall withstand continuously 15% voltage above the rated voltage of the tap.
3. Insulation for 100MVA & above Transformer: The HV & IV winding of the transformer shall have graded insulation. The insulation class of the neutral end of the winding shall be graded to 170 KVP (impulse) and 70KV (power frequency withstand). The 11 KV tertiary winding and terminals shall be capable of withstanding the surge voltage of 170 KV
4. Frequency:- the transformer shall be Suitable for continuous operation with a frequency variation of $\pm 5\%$ from normal of 50Hz without exceeding the specified temperature rise.
5. Impedance: Supplier shall indicate the guaranteed impedance and tolerance. Impedance shall include positive and zero sequence and shall be expressed in terms of the branches of the star connected equivalent diagram, all on the same MVA basis and the range shall be given for each branch of the equivalent circuit in turn.
6. * Tertiary shall be designed for $1/3^{\text{rd}}$ of rated MVA and shall be suitable for withstanding mechanical & thermal stresses due to dead short circuit on its terminals

TEST REPORTS

- a) Six (6) sets of certified test reports and oscillograms shall be submitted for approval prior to dispatch of the equipment. The equipment shall be dispatched only when all the required type and routine tests have been carried out and test reports have been approved by the purchaser.

Each report shall supply the following information:

- i. Complete identification data including serial number of transformer.
- ii. Method of application, where applied, duration and interpretation of results for each test.
- iii. Temperature data corrected to 75° C including ambient temperature.

- b) Four (4) copies of the test reports for the tests carried out on the auxiliary apparatus shall be furnished to the purchaser for approval prior to dispatch.
- c) All auxiliary equipment shall be tested as per the relevant standard. Test certification shall be submitted for bought out items.