

TECHNICAL SPECIFICATION

SECTION – 3(A)

TRANSFORMERS

Karnataka Power Transmission Corporation Limited

TECHNICAL SPECIFICATIONS FOR 110KV & 66KV CLASS POWER TRANSFORMER OF 20MVA & BELOW CAPACITY

SECTION-1

1.0 SCOPE :

1.01 This specification covers design, manufacture, shop testing, supply, delivery, supervision of erection, testing and commissioning of 110KV& 66KV CLASS two winding Transformer with all fittings and accessories, OLTC, RTCC, FCC, parallel operating equipments, first filling of oil and 10% spare oil in non-returnable drums at 110kV or 66KV Sub-stations in KPTCL grid. 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 Transformers and its accessories 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 judgement, 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 judgement, 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, 1993	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-60185
IS-3202	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 <i>connectors</i>	
IS-5578 IS-11353	Guide for marking of Insulated Conductors	
IS-6272	Industrial cooling fans	
IS-6600	Guide for loading of oil immersed transformers	IEC-60076-7
IS-8468	On load tap changer	IEC-60214-1, 2003
IS-8478	Application guide for OLTC	IEC-60214-2
IS-9434	Guide for sampling and analysis of dissolved gas in oil filled equipments.	IEC-60567
IS-12676	Oil impregnated paper-insulated condenser Bushing Dimension and requirements.	
IS-3716	Application Guide For Insulation Co-Ordination	IEC-60071
IS-2071	High Voltage Test Techniques	IEC-60060-3
IS-13947	Low voltage switchgear & controlgear	
	CEA-(Technical Standards For Construction Of Electrical Plants And Electric Lines)Regulations-2010	
	IEEMA Standard Publication- Transformer-I	
	CBIP manual on Transformers Publication No. 317 (April 2013 edition) the Central Board of Irrigation & Power, Malcha Marg, Chanakyapuri, New Delhi	

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, bureau central de la Commission Electro Technique Internationale, 1, Rue de Verembe, 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(as per IS)
- 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 110kV Switchyard with bay width of 10400mm, boom height at 8500mm, the phase to phase & phase to earth clearance of 110kV Bay is 2700mm and 2500mm. However, the overall width of transformer is limited to 7000 mm.
- b) In 66KV Switchyard with bay width of 7600mm boom height of 8500mm, the phase to phase and phase to earth clearance of 66KV Bay is 2000 mm and 1800 mm. However, the overall width of transformer is to be limited to 6500 mm.

5.0 SERVICE CONDITIONS:

As per IS 2026 (Part-1) – 2011, Clauses 1.1, 1.1.1 and 1.1.2.

RAIL GAUGE:

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

- a) In the direction parallel to the line of 110kV/66KV bushing - 1676mm.
- b) In the direction perpendicular to the line of 110kV/66KV bushing -1676mm.

SECTION – II

GENERAL TECHNICAL REQUIREMENTS

1.1 GENERAL DESIGN OF APPARATUS:

The Transformers and accessories shall be designed and manufactured in accordance with IS 2026 and all applicable section of CBIP manual on Transformer, in regard to design, standardization, galvanizing, lables, bolts and nuts, cleaning and painting, oil and prevention of acidity.

1.2 ELECTRICAL CHARACTERISTICS AND PERFORMANCE:

1.2.01 All transformers, unless otherwise specified shall be oil immersed and core type and shall be suitable for outdoor installation.

Transformers designed for mixed cooling shall be capable of operating under the natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts in WTI and the transformer will operate as a forced cooled unit.

Transformers shall be capable of remaining in operation at full load for 10 minutes after failure of blowers with the calculated winding hot-spot temperature *not* exceeding 140⁰C. Transformer fitted with two coolers each capable of dissipating 50 percent of the heat at C.M.R. shall be capable of remaining in operation for 20 minutes in the event of failure of blowers associated with one cooler with the estimated winding hot-spot temperature *not* exceeding 140⁰C.

1.2.02 CONTINUOUS MAXIMUM RATING AND OVER LOAD:

Transformers provided with ONAN/ONAF cooling shall in regard to rating, temperature and overloads comply with Clause 4.0 of IS 2026, Part-I with latest amendments thereof.

1.2.03 VOLTAGE RATIO:

The voltage between phases on the higher and lower voltage windings of each transformer measured at no load and corresponding to the normal ratio of transformation shall be those stated in the ordering schedule, and shall be capable of giving rated volts from the secondary when rated primary voltage is applied at the normal tap and at the rated frequency.

1.2.04 ELECTRICAL CONNECTIONS:

Transformers shall be connected in accordance with the IS Vector symbol specified in ordering schedule of the requirements. The primary shall be connected in Delta and the secondary in Star following the Vector Group Dyn11.

1.2.05 DUTY UNDER FAULT CONDITIONS:

Except where modified below, it is to be assumed that the amount of generating plant simultaneously connected is such that normal voltage will be maintained on one side of any transformer when there is a short circuit between phases or to earth on the other side. Any transformer may be directly connected to an underground or

overhead transmission line and switched into and out of service together with its associated transmission line.

The rated short time rating shall be $100/Z$ times the rated primary current for 3 seconds where 'Z' is % impedance of Transformer.

The supplier would furnish the detailed calculation to prove the short circuit strength of the Power Transformer.

1.2.06 REQUIREMENTS WITH REGARD TO ABILITY TO WITHSTAND SHORT CIRCUIT.

As per IS 2026 (Part-5):2011, Clause 3 and Sub-Clauses thereof.

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 110kV, 66kV, 33kV & 11kV windings shall be furnished before drawing approval.**

1.2.07 DEMONSTRATION OF ABILITY TO WITHSTAND SHORT CIRCUIT:

As per IS 2026 (Part-5):2011, Clause 4 and Sub-Clauses thereof.

1.2.08 LOSSES:

1.2.08.01 MEASUREMENT:

As per Clause 10.4 and 10.5 of IS 2026 (Part-I) 2011.

1.2.08.02 TOLERANCE

As per Clause 9 of IS 2026 (Part-1) 2011.

1.2.08.03 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) I^2R 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.		

1.2.09 **REGULATION AND IMPEDANCE:**

The impedance voltage at principal tap and Rated KVA shall be stated in the order and tolerance shall be in accordance with IS:2026.

1.2.10 **FLUX DENSITY:**

The maximum flux density in any part of the core and yoke, at rated MVA, voltage and frequency at any tap shall not exceed 1.6 Tesla (16,000 Lines per sq.cm.)

1.2.11 **SUPPRESSION AND HARMONICS:**

All the transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave form distortion and from any possibility of high frequency disturbances, inductive effects or of circulating currents between the neutral points at different transforming stations reaching such a magnitude as to cause interference with communication circuits.

2.0 **CORES:**

2.01 **CONSTRUCTION:**

The cores shall be constructed from high grade cold rolled non-aging 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.

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.

2.02 MAGNETIC CIRCUIT:

- a) 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 the production of flux components at right angles to the plane of the laminations which may cause local heating.
- b) Every care shall be exercised in the selection, treatment and handling of core steel to ensure that as far as is practicable, the laminations are flat and the finally assembled core is free from distortion.
- c) The oxide/silicate coating given on the core steel is adequate, however, laminations can be insulated by the manufacturers if considered necessary.
- d) Oil ducts shall be provided where necessary to ensure adequate cooling. The winding structure and major insulation shall not obstruct the free flow of oil through such ducts. Where the magnetic circuit is divided into pockets by cooling ducts parallel to the planes of the laminations or by insulating material above 0.25 mm thick, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between pockets.
- e) The frame work and clamping arrangements shall be earthed in accordance with Clause 4.01.
- f) The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000V AC for one minute.
- g) Transformers shall withstand, without injurious heating, combined voltage & frequency fluctuations, which produce the following over fluxing condition:
 - i) 110% - continuous
 - ii) 125% - for one minute.
 - iii) 140%- for five seconds.

2.03 MECHANICAL CONSTRUCTION OF CORES:

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

All steel sections used for supporting the core shall be thoroughly sand blasted or shot blasted after cutting, drilling and welding. Any non-magnetic or high resistance alloy shall be of established quality.

Adequate-lifting lugs shall be provided to enable the core and windings to be lifted.

Adequate provision shall be made to prevent movements of the core and winding relative to the tank during transport and installation or while in service.

The supporting frame work of cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve, or cause trapping of air during filling.

2.04 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

3.0 WINDINGS:

- 3.01 All delta connected windings of 110kV/66KV and above shall be uniformly insulated through out the length of the winding. All windings for system voltages lower than 66KV shall be fully insulated. All neutral points shall be insulated for the voltages specified in IS: 2026. All winding conductors shall be of electrolytic grade copper only.**
- 3.02** Power transformers shall be designed to withstand the impulse and power frequency test voltages as specified in IS: 2026.
- 3.03 The windings shall be designed to reduce to a minimum, the out-of-balance forces in the transformer at all voltage ratios.
- 3.04 The insulation of transformer windings and connection shall be free from insulating composition liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.
- 3.05 The stacks of windings shall receive adequate shrinkage treatment before final assembly. Adjustable devices shall be provided for taking up any possible shrinkage of coils in service.
- 3.06 The coil clamping arrangement and the finished dimensions of any oil ducts shall be such as will not impede the free circulation of oil through the ducts.
- 3.07 No strip conductor wound on edge shall have a width exceeding six times its thickness.
- 3.08 The conductors shall be transposed at sufficient intervals in order to minimise eddy currents and equalise the distribution of currents and temperatures along the windings.
- 3.09 Further, windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and that field repairs to the windings can be made readily without any special equipment. The coils shall be supported between adjacent sections by insulating spacers and barriers.
- 3.10 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. Guides shall be used wherever practicable.
- 3.11 The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits.
- 3.12 For transformers with HV delta winding, separate tap winding shall be provided instead of tapping from the mid of the HV winding. The tap winding shall be inserted over the HV winding throughout the length.
- 3.13 The maximum current density in any winding shall not exceed 2.3A/sq.mm .
- 3.14 BRACING OF WINDINGS:**
- The windings and connections of all transformers shall be braced to withstand shocks which may occur during transport, or due to switching short circuit and other transient conditions during service.

4.00 **INTERNAL EARTHING ARRANGEMENT:**

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.

4.01 **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.

4.02 **EARTHING OF MAGNETIC CIRCUIT:**

- a) The magnetic circuit shall be earthed to the clamping structures 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.
- b) Magnetic circuits 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 in accordance with Clause 2.02(d) and the magnetic circuit shall not be regarded as being of sectional construction.

4.03 **EARTHING OF COIL CLAMPING RINGS :**

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

4.04 **SIZE OF EARTHING CONNECTION:**

All earthing connections with the exception of those from the individual coil clamping rings shall have a cross sectional area of not less than 0.8sq.cm. Connections inserted between laminations of different sections of core as per Clause 4.02 (b) shall have cross sectional area of not less than 0.2 sq.cm.

5.00 **TANKS:**

5.01 **CONSTRUCTION:**

Conventional type of tank construction could be used.

The transformer tank and cover shall be fabricated from good commercial grade low carbon steel suitable for welding and of adequate thickness. The tanks of all transformers shall be complete with all accessories and shall be designed so as to allow the complete transformer in the tank filled with oil, to be lifted by crane or

jacks, transported by road, rail without over straining any joints and without causing subsequent leakage of oil.

The main tank body excluding tap changing compartments, radiators and coolers shall be capable of withstanding vacuum:

Highest system voltage KV	MVA rating	Vacuum gauge pressure KN/sq.m.	(mm of Hg)
Upto 72KV	Up to 1.6 above 1.6 & up to 20	34.7 68.0	250 500
Above 72KV	For all MVA ratings	100.64	760

The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

Normally a detachable under base will be used, but in case transport facilities permit, a fixed under base can be used.

Where the base, is of a channel construction, it shall be designed to prevent retention of water.

Tank stiffeners shall be designed to prevent retention of water.

Where possible the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 15mm except for short branch pipes which may be 6mm minimum inside diameter.

All joints other than those which may have to be broken shall be welded when required they shall be double welded. All bolted joints to the tank shall be fitted with suitable oil-tight gaskets which shall give a satisfactory service under the operating conditions and guaranteed temperature rise conditions. Special attention shall be given to the methods of making hot oil tight joints between the tank and the cover as also between the cover and the bushing and all other outlets to ensure that the joints can be remade satisfactorily at site and with ease with the help of semi-skilled labour.

However the minimum thickness of the plates used for Transformer Tanks shall not be less than 8mm for the sides and not less than 10mm for the bottom plate and top cover. Thickness of radiator sheet shall be 1.25mm.

5.02 LIFTING AND HAULAGE FACILITIES:

Each tank shall be provided with:

- Lifting lugs suitable for lifting the transformer complete with oil.
- A minimum of four jacking lugs, in accessible positions to enable the transformer complete with oil, to be raised or lowered using hydraulic or screw jacks. The minimum height of the lugs above the base shall be

- (i) Transformers upto and including 40 tonnes weight-300mm (approx.) so as to accommodate suitable jacks beneath the jacking parts.
- (ii) Transformers above 40 tonnes weight-500mm (approx.) so as to accommodate suitable jacks beneath the jacking parts.
- (c) Suitable haulage holes shall be provided.

In addition the Transformers shall be provided with bollards on the Transformer Tank sides at the top for lifting the Transformer by a crane.

5.03 TANK COVER:

Each tank cover shall be of adequate strength, and shall not distort when lifted. Inspection openings shall be provided as necessary to give easy access to bushing or changing ratio or testing the earth connection. Each inspection opening shall be of ample size for the purpose for which it is provided and atleast two openings one at each end of the tank, shall be provided.

A ladder (with anti-climbing lock arrangement) shall be provided for tank above 3m height. The tank shall be designed so as to avoid collection of rain water at the tank top.

The tank cover and inspection covers shall be provided with suitable lifting arrangements. Unless otherwise approved inspection covers shall not weigh more than 25kg. each.

The tank cover shall be fitted with pockets for thermometer and for the bulbs of oil and winding temperature indicators. Protection shall be provided where necessary, for each capillary tube.

The Thermometer pocket shall be fitted with a captive screwed top to prevent the ingress of water.

The pockets shall be located in the position of maximum oil temperature at C.M.R. and it shall be possible to remove the instrument bulbs without lowering the oil in the tank.

5.04 AXLES AND WHEELS:

All wheels should be detachable and shall be made cast iron or steel as required.

Wherever specified, flanged wheels shall be provided suitable for use on gauge track as specified in the detailed specification and shall be so placed that pinchbar can be used to move the transformer.

The direction of motion shall be specified in case of unidirectional movement.

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

The wheels shall be suitable for movement on a rail track, the gauge of which shall be 1676mm standard broad gauge track.

5.05 CONSERVATOR VESSELS, OIL GAUGES AND BREATHERS:

- 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.
- h) The oil connection from the transformer tank to the conservator vessel shall be arranged at a rising angle of 3 to 9 degrees to the horizontal upto the Buchholz Relay and shall consist of:
 - i. For transformers up to and including 1000KVA, 25mm inside diameter pipes as per IS:3639.
 - ii. For transformers from 1001 to 10,000 KVA, 50mm inside diameter pipes as per IS:3639.
 - iii. For transformers of over 10,000KVA, 80mm inside diameter pipes as per IS: 3639.
- i) A valve shall be provided at the conservator to cut-off the oil supply to the transformer, after providing a straight run of pipe for at least a length of five times the internal diameter of the pipe on the tank side of the gas and oil actuated relay and atleast three times the internal diameter of the pipe on the conservator side of the gas and oil actuated relay.
- j) **Condition Controlled Maintenance Free Type Breather**
 - i. The main Transformer tank & OLTC 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.
 - ii **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.

iii. Technical Features:

- a. 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.
- b. Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:
 - Led for Power of control unit – ON
 - LED for Filter heater – ON
 - LED for Anti-condensation heater (of control unit) – ON
 - LED & relay contact for “Device Error”
 - LED & relay contact for Regeneration active (De-humidification in process)
 - Analogue output signal (4-20mA) for the Temperature of air (in filter unit/pipe).
- c. 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.
- d. 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.
- e. 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.
- f. 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.

- g. 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.
- h. The control unit shall be equipped with suitable heater to prevent moisture condensation.
- i. The size of condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.
- j. 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.
- k. Condition Controlled Maintenance Free Type Breather of alternate proven technology shall also be acceptable.
- l. 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.

5.06 FILTER AND DRAIN PLUGS, SAMPLING DEVICES AND AIR RELEASE PLUGS:

Each transformer shall be fitted with the following:

- (a) The filter and drain valves as specified.
- (b) A drain valve as specified below shall be fitted to each conservator.

For diameter upto 650mm:	Size of the valve 15mm
For diameter above 650mm:	Size of the valve 25mm
- (c) A robust oil sampling device shall be provided at the top and bottom of the main tank. The sampling device shall not be fitted on the filter valves specified under (a) above. However top, middle and bottom oil sampling valves shall be mounted at the tank base through suitable internally located pipe headers.
- (d) One 15mm air release plug.

All other valves opening to atmosphere shall fitted with blank flanges.

5.07 COOLER AND RADIATOR CONNECTIONS:

Valves and valve mountings shall be provided as specified under "Cooling Plant" Cl. 7.0, Section-A of CBIP Manual.

All valves shall be of gun-metal or cast steel or may have cast iron bodies with gun-metal fittings. They shall be of full way type with internal screw and shall be opened by turning counter clock-wise when facing the hand wheel.

Means shall be provided for padlocking the bottom valves in the open and closed positions. This required for the valves where opening device like hand-wheel, keys, etc., are the integral part.

Every valve shall be provided with an indicator to show clearly the position of the valve. All valves shall be provided with flanges having mechanical faces.

The drilling of valve flanges shall comply with the requirements of IS: 3939.

5.08 PRESSURE RELIEF DEVICE:

The pressure relief device shall be provided of sufficient sizes of rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tank. Means shall be provided to prevent the ingress of rain.

Unless otherwise approved the relief device shall be mounted on the main tank, and if on the cover shall be fitted with skirt projecting 25mm inside the tank and of such a design to prevent gas accumulation.

If a diaphragm is used it shall be of suitable design and material and situated above maximum oil level.

If a diaphragm is put at the base of pipe, an oil gauge is required on the standpipe for indicating fracture of diaphragm.

One of the following methods shall be used for relieving or equalizing the pressure in the pressure relief device.

- (a) An equalizer pipe connecting the pressure relief device to the conservator, or
- (b) The fitting of a silicagel breather to the pressure relief device the breather being mounted in a suitable position for access at ground level.

5.09 EARTHING TERMINAL:

Two earthing terminals capable of carrying for 4 seconds the full lower voltage, short circuit current of the transformer. Provision shall be made at positions close to each of the bottom two corners of the tank for bolting the earthing terminals to the tank structure to suit local conditions.

5.10 RATING AND DIAGRAM AND PROPERTY PLATES:

The following plates shall be fixed to the transformer tank at an average height of about 1750mm above ground level:

- (a) A rating plate bearing the data specified in the appropriate clauses of IS:2026.
- (b) A diagram plate showing the internal connection and also the voltage vector relationship of the several windings in accordance with IS:2026 and in addition a plan view of the transformer giving the correct physical relationship of the terminals. When links are provided in accordance with Clause 2.3 section A, of CBIP manual for changing the transformer ratio, then approved means shall be provided for clearly indicating ratio for which the transformer is connected. No load voltage shall be indicated for each tap.
- (c) Where specified a plate showing the location and function of all valves and air release cocks or plugs. This plate shall also warn operators to refer to the maintenance instructions before applying the vacuum treatment for drying.

The above plates shall be of material capable to withstanding continuous outdoor service.

5.11 JOINTS AND GASKETS:

All gaskets used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber or synthetic rubber gaskets as per IS 4253.

5.12 COOLING PLANT:

The transformer shall be supplied with the requisite number of radiators and coolers.

General:

Radiators and coolers shall be so designed as to avoid pockets in which moisture may collect and shall withstand the pressure tests.

Unless the pipe work is shielded by adequate earthed metal the clearance between all pipe work and live parts shall be more than the clearance for live parts to earth.

Radiators mounted directly to the tank/banked.

Detachable radiators as per section JJ of CBIP manual.

Valves shall be provided in the tank at each point of connection to the tank.

Where separate radiator banks are provided, the conservator vessels specified in Clause 6.5, Section-A of CBIP Manual can be mounted thereon.

All coolers shall be suitable for mounting on a flat concrete base.

The oil circuit of all coolers shall be provided with the following:

- (a) A valve at each point of connection to the transformer tank.
- (b) Removable blanking plates to permit the blanking off the main oil connection of each cooler.
- (c) A drain valve 25mm at the lowest point of each bank of cooler.

- (d) A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each separately mounted cooler bank.
- (e) A filter valve as specified in Clause 6.6, Section-A of CBIP Manual at the top and bottom of each cooler bank of cooler.
- (f) Air release plugs of 15mm.

In addition the following are to be provided only with water cooled oil coolers which shall be as per IS:6088.

- (a) A suitable differential pressure gauge or equivalent suitable device fitted with electrical contacts to give an alarm when differential pressure between cooler oil outlet and water inlet pressure drops below a preset value.
- (b) Oil and water flow switches, fitted with electrical contacts, in the pipe work adjacent to the coolers.

Water cooled oil coolers shall be designed to facilitate cleaning without any risk of water mixing with the oil. The material of the tube plates and tubes shall be such that corrosion shall not take place due to galvanic action. A report on water analysis shall be furnished, in time, to enable supplier to ensure a suitable material for tube and tube plates.

Any leakage which may take place in the oil cooler shall be of the oil into the water and the reverses, and means shall be provided to ensure that the pressure of the oil in the cooler is always greater than the pressure of the water. The water pressure in the cooler will be kept as low as possible. Further, the cooling water discharge should be free to the atmosphere to reduce the pressure in the cooler.

The necessary oil piping shall be provided for connecting each transformer to the coolers and oil pumps. The oil piping shall be with flanged gasketed joints. Cast iron shall not be used.

The drilling of all water and oil pipe flanges shall comply with IS:3639 (Section-1, Specification For Valves Of Transformer).

A suitable expansion piece shall be provided in each oil pipe connection between the transformer and the separately mounted oil coolers.

Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently.

5.13 PAINTING:

The internal and external surfaces including oil filled chamber and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale or foreign

adhering matter or grease. All steel surfaces in contact with insulating oil shall be painted with two coats of heat resistant, oil insoluble insulating varnish.

All steel surfaces exposed to weather shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a colour distinct from primary and final two coats of glossy oil and weather resisting light grey paint in accordance with shade No. 631 of IS-5.

All paints shall be carefully selected to withstand extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

The minimum thickness of outside painting of tank shall be 20 microns and the total thickness of painting shall be minimum 80 microns.

6.00 **VOLTAGE CONTROL (ON-LOAD TYPE): (should be SCADA compatible)**

6.01 a) The transformers shall be fitted with an onload tap changer mechanism.

Each transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on-load and without producing phase displacement.

Equipment for local and remote electrical and local manual operation shall be provided and shall comply with the following conditions. Local remote selector Switch may be housed in remote control panel or in tap changer driving unit.

It shall not be possible to operate the electric drive when the manual operating gear is in use. It shall not be possible for any two electric controls to be in operation at the same time.

Operation from the local or remote control switch shall cause one tap movement only until the control switch is returned to the off position between successive operations.

All electrical control switches and the local operating gear shall be clearly labeled in a suitable manner to indicate the direction of tap changing.

The local control switches shall be mounted in the marshalling box, or driving gear housing.

The equipment shall be so arranged as to ensure that when a tap change has been commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply during a tap change or any other contingency such as tap changer getting stuck would result in that movement not being completed adequate means shall be provided to safeguard the transformer and its auxiliary equipment.

Suitable apparatus shall be provided for each transformer to give indications as follows.

To give an indication, mechanically at the transformer and electrically at the remote control point, of the number of tapping in use on the transformer.

To give an indication at the remote control point that a tap change is in progress, by means of an illuminated lamp.

All relays and operating devices shall operate correctly, at any voltage between the limits specified in the relevant Indian Standard.

Any enclosed compartment not oil filled and shall be adequately ventilated, metal clad thermostatically controlled heaters shall be provided in the driving mechanism chamber and in the marshalling box, all contactors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.

The tap changer contacts which are not used for making or breaking current like separate selector switch contacts can be located inside main transformer tank where tap changer construction permits such an arrangement. On load tap changers having separate compartment for selector contacts, the oil in such compartment shall be maintained under conservator head by means of pipe connection from the highest point of the chamber to the conservator. Such connection shall be controlled by suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate Buchholz relay/diverter switch may be provided for this compartment.

It shall not be possible for the oil in these compartments of the tap change equipment, which contain contacts used for making or breaking current, to mix with the oil in the compartments containing contacts not used for making or breaking current.

Each compartment in which the oil is not maintained under conservator head shall be provided with a suitable direct reading oil gauge.

The alternating supply for electrical operation of the control and indicating gear shall be standard 415 volts, three phase, 3 wire, 50Hz, along with 240 volts, single phase, 2 wire, 50 Hz, subject to a variation of +10 to -30% so that the equipment offered can withstand variation in A.C.

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 or other approved device 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 mechanical declutching mechanism incorporated.

Thermal devices or other means like motor circuit breakers with shunt trip coil shall be provided to protect the motor and control circuits. All relays, switches, fuses, etc., shall be mounted in the marshalling box or driving gear housing and shall be clearly marked for purposes of identification. They shall withstand the vibration associated with tap changer gear operation.

The control circuits shall operate at 110V single phase to be supplied from a transformer having a ratio of 415V/55-0-55V with the center point earthed through a removable link mounted in the marshalling box or tap changer drive.

The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.

A five digit counter shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.

A permanently legible lubrication chart shall be fitted within the driving mechanism chamber, where applicable.

On-load tap changer driving gear Motor shall be of squirrel cage totally enclosed type and shall comply with Indian Standard IS:325. It shall be suitable for direct starting and continuous running from 415 volts, 3 phase supply. Motor shall be capable of continuous operation at any frequency between 48 and 51 Hz. together with any voltage within 10 percent of nominal value. Motor shall have ball or roller bearing and vertical spindle motor shall have bearing capable of withstanding of thrust to the weight of the moving parts. The stator winding shall be adequately brazed and suitably impregnated to render them non-hygroscopic.

The overload protection relay shall be of robust adjustable triple-pole construction. It should provide accurate and reliable protection against overload, single phasing, over heating and short circuit. The relay should be provided with temperature compensating device to offset the effect of ambient temperature variation.

Contactors/Relays shall be of robust and compact construction and shall comply with Indian Standard IS:2959.

The contactors shall be suitable for operation at 110 volts A.C. –15 percent to +10 percent 50Hz. Main and auxiliary contacts of contactors shall be suitably rated. For sufficient long life these contacts shall be of double break type and shall make contacts practically bounce-free.

The control supply transformer shall be single phase having ratio 415V/55-0-55V. Its insulation shall be suitable impregnated to render it non-hygroscopic.

All the control selector switches shall be robust and compact construction and shall comply with Indian Standard IS:4064 and 4047.

Remote tap position indicator mounted on remote control cabinet shall show accurately same tap position as indicated by local tap position indicator on on-load tap changer. "The remote indication can be by means of an analogue indicator, or digital indicator or by means of lamp indications. The remote indicator mounted on control cabinet shall not be affected by normal auxiliary voltages supply variation.

Necessary indicating lamps provided shall be of low watt consumption of LED type.

Space heater of adequate capacity and robust construction shall be provided inside each control cabinet to prevent moisture condensation. Space heaters shall be rated for 240V, 1 phase, 50Hz, supply. Heater shall be complete with miniature circuit breaker or “ON-OFF” switch.

All the wiring shall be carried out for motor circuit with 1100 volts grade PVC insulated stranded copper conductors of size 2.5 sq.mm. and for control circuit with 650 volts grade PVC insulated copper conductor of size 1.5 sq.mm. suitable for tropical atmosphere. All wiring shall be in accordance with relevant IS. Engraved/Printed core identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is removed. All wiring shall be terminated on terminal blocks through suitable lugs. Insulated sleeves shall be provided at all the wire terminations. All wiring shall be neatly bunched and cleated without affecting access to equipment mounted within the cabinet.

Terminal board rows should be spaced adequately apart to permit convenient access to wires and terminations.

Terminal boards shall be so placed with respect to the cable gland plate (at a minimum distances of 200 mm) as to permit satisfactory arrangement of multicore cable tails without undue stress or bends opening of door should not disturb or stress the wire termination.

- b) **Separate tap winding shall be provided on the HV winding running all along the length. Suitable OLTC with higher insulation shall be provided at the line end of HV delta winding of transformer. The tap change variation shall be in the range of +5% to -15% on HV in steps of 1.25 % i.e. 16 equals steps (Number of position 17)**
- c) Regarding 110KV and 66KV class transformers : On-load tap changer shall be of double compartment design, in which diverter switch and tap selector switch are separate. It shall have
 - i) A separate selector to select a tap and shall carry current but not make or break current.
 - ii) A diverter switch to carry, make and break currents in circuits as per IS 8468 –1973, clause 2.12 & 2.13.

The transitional resistance shall be capable of with standing full load current of transformer for 1 sec.

OLTC shall be of bi-directional type and housed inside the transformer tank.

- d) **The OLTCs shall be suitable for Delta Configuration of Transformers. The OLTCs shall have been type tested as per IEC 60214. Copies of Type Test Report shall be furnished.**

- e) The OLTC shall be suitable for supervisory control an indication on multi- way switch, make before break having one fixed contact for each tap position shall be provided and when specified, wired to the tap changer drive gear. This switch shall be provided in addition to any, which may be required for remote tap changer indication purposes. Supervisory indication shall also be provided when specified in the form of contacts to close on” tap change incomplete”.

The make of OLTCs shall be from any of the KPTCL approved vendor.

6.02 OLTC Routine Tests

OLTC manufacturer shall conduct the following routine tests fully in compliance with IEC 60214-1 and its subsequent amendments on every unit as given below before dispatch to assure the quality of the product.

Sl. No.	IEC Reference	Test description	Acceptance level
1	60214-1 CI No. 5.3.1	Mechanical Endurance Test	Minimum 1000 operations
2	60214-1 CI No. 5.3.2	Sequence Test	Switching operation with timing less than 50m sec.
3	60214-1 CI No. 5.3.4	Pressure Test	10 PSI (0.7kg per Sq.cm.) for 8 hrs. at room temp.
4	60214-1 CI No. 5.3.4	Vacuum (Helium) Test	Vacuum level of 6×10^{-5}
5	60214-1 CI 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 mili ohms
8	Special Test	Physical & Dimensional Checks	As per approved drawing

All the relevant test reports shall be submitted along with the test report of Transformer for KPTCL approval.

6.03 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 control cubicle to be supplied by the supplier shall be 610 mm depth and 2312 mm height. The width of the cubicle to be as per suppliers practice. The colour of the finishing paint shall be opaline green corresponding to shade No. 275 of IS : 5 (for 110kV & 66kV Sub-stations) and shall be Siemens grey corresponding to Shade no. RAL 7032 (for 220kV Sub-stations), for panel exterior.

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

1. Local - Remote 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. Remote Winding Temperature Indicator and Oil 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. Separate hooter along with indicating lamp shall be provided for annunciation of tap change in progress.
11. I. Annunciator (facia type) scheme complete with accessories for the following:
 - i) Tap changer incomplete.
 - ii). Tap changer out of step
 - iii) Tap changer motor trip.
 - iv) Failure of 415V AC supply to the OLTC local control Kiosk.

- v) a) Running Fan failure of each group.
b) Standby fan failure of each group.
- vi) 415V cooler control supply failure.
- vii) 415V OLTC Supply failure.
- viii) OLTC control supply fail.

12. Signal lamps for:

- i) Fan 'ON' for each fan.
- ii) Cooling system on Local manual / local auto
- iii) Cooling system on Remote manual/ Remote auto
- iv) 415 Volts cooler Supply 'ON',
- v) 415V OLTC supply Healthy.
- vi) OLTC control supply ' ON '.
- vii) OLTC upper limit reached.
- viii) OLTC lower limit reached.
- ix) a) OLTC in Remote RTCC Mode.
b) OLTC in Remote SCADA Mode.
- x) OLTC in Local Mode.

6.04 **Microprocessor based Numerical RTCC Unit for Tap changer Control & Transformer Monitoring**

VOID

7.00 **PARALLEL OPERATION OF TRANSFORMERS WITH ONLOAD TAP CHANGERS :**

Besides the local and remote electrical control specified on – load tap changers, when specified, should be suitable for remote electrical parallel control also.

In addition to the methods of control as in Clause 9, Section – A of CBIP Manual, the following additional provision shall be made.

Suitable selector switch be provided, so that any one transformer of the group can at a time be selected as “Master”, “Follower” or “Independent.

Necessary interlock blocking independent control when the units are in parallel shall be provided.

The scheme will be such that only one transformer of a group can be selected as “Master”.

An out-of-step device shall be provided for each transformer which shall be arranged to prevent further tap changing when transformers in a group operating in “Parallel Control” are one tap out-of-step.

8.00 BUSHING:

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

Voltage Rating	Bushing Type
145kV & 72.5 kV bushings	RIP/RIS
Bushings of 36 kV and below	Solid porcelain (oilcommunicating 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)	

8.00.02 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.

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

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

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

8.00.05 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.

8.00.06 Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

8.00.07 Bushings of **identical rating of different makes shall be interchangeable** to optimise the requirement of spares.

8.00.08 **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.**

- 8.00.09 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.
- 8.00.10 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).
- 8.00.11 Clamps and fittings shall be of hot dip galvanised/stainless steel.
- 8.00.12 Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.
- 8.00.13 **No arcing horns** shall be provided on the bushings.
- 8.00.14 **Corona shield, wherever required, shall be provided** at bushing terminal (air end) to minimize corona.
- 8.00.15 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.
- 8.00.16 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.
- 8.00.17 The terminal marking and their physical position shall be as per IS 2026.
- 8.00.18 **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.
- 8.00.19 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.

8.01.00 TERMINAL CONNECTORS:

8.01.01

- a) The 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 110KV and 66KV side. The connector shall be designed to prevent corrosion due to bimetallic action.

The LV & neutral bushings shall be provided with suitable connectors for connection to strip type copper bus bars for ground connections.

- b) 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.

8.01.02 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.

9.00 **TEMPERATURE CONTROLLERS:**

- 9.01 The transformer shall be provided with a 150 mm dial type top oil temperature indicator, fitted with maximum reading pointer, resetting device and two sets of electrical contacts. The contacts shall be with mercury switches, electrically independent ungrounded. The accuracy class shall be +1.0%. Remote oil Temperature Indicator with 4-20 mA DC dual output shall be provided for the purpose of SCADA.
- 9.02 The transformer shall be provided with two 150 mm dial type Winding Temperature Indicator (HV & LV), fitted with maximum reading pointer, resetting device and three sets of electrical contacts. The contacts shall be with mercury switches, electrically independent ungrounded. The accuracy class shall be +1.0%.
- 9.03 The temperature indicators shall be of dial type, (not less than 150 mm dia) and robust pattern.
- 9.04 The temperature indicator shall be fitted in a tank mounted, weather proof, marshalling box.
- 9.05 The tripping contacts of winding-temperature indicators shall be adjustable to close between 60⁰C and 120⁰C and alarm contacts to close between 50⁰C and 100⁰C and both shall re-open when the temperature has fallen by about 5⁰C.
- 9.06 All contacts shall be adjustable on a scale & shall be accessible for removal of the cover.
- 9.07 It shall be possible to check the operation of the contacts and associated equipment.
- 9.08 Connections shall be brought from the device to terminals placed inside the marshalling box.
- 9.09 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.
- 9.10. 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. Only one R WTI with a point selector switch shall be provided for all the three windings (HV, IV and LV). Auxiliary supply for R WTI, if required, will be 110V-220V DC, 4-20mA DC dual output only. Drawing showing dimensional details of R WTI shall be submitted to the owner within 2 months from the date of award of contract.

10.0 GAS AND OIL ACTUATED RELAYS:

Each transformer shall be fitted with gas and oil actuated relay equipment conforming to IS: 3637 having contacts which close following oil surge or low oil level conditions.

Each gas and oil actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Where specified to allow gas to be collected at ground level, a pipe approximately 5 mm inside diameter shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1.25Mtr above ground level, where it shall be terminated by a cock.

A machined surface shall be provided on the top of each relay to facilitate the setting of the relays and to check the mounting angle in the pipe and the cross level of the relay.

The design of the relay mounting arrangements, the associated pipe work and the cooling plant shall be such that mal-operation of the relays shall not take place under normal service conditions.

The pipe work shall be so arranged that all gas arising from the transformer shall pass into the gas and oil-actuated relay. The oil circuit through the relay shall not form a delivery path in parallel with any circulating oil pipe, nor shall it be tied into or connected through the pressure relief vent. Sharp bends in the pipe work shall be avoided.

When a transformer is provided with two conservators the gas and oil actuated relays shall be arranged as follows:

If the two conservators are connected to the transformer by a common oil pipe one relay shall be installed in the common pipe.

If the two conservators are piped separately to the transformer two relays shall be installed, one in each pipe connection.

Adequate clearance between oil pipe work and live metal shall be provided.

11.0 TEMPERATURE RISE:

As per Clauses 3.1 of IS: 2026 (Part-II) – 2010.

12.0 INSULATION LEVELS:

As per IS: 2026 (Part-III) – 2009, Clauses 3.0, 5.0, 7.0 and sub-clauses thereof.

13.0 TERMINAL MARKINGS, TAPPINGS AND CONNECTIONS:

As per IS: 2026 (Part-IV) – 1977. However the transformer shall be designed for constant flux voltage as per Clause 3.2 of the said IS.

14.0 INSULATING LIQUIDS:

Uninhibited Mineral insulating oil shall be used and 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 laboratories. The oil shall be got tested by R&D

section, KPTCL after filling into the transformer before energising as per relevant standards.

Loose oil to be supplied shall be in sealed oil drums with 10% extra quantity over and above that required for the first filling.

15.0 MARSHALLING BOX:

A sheet steel vermin proof, well-ventilated and weatherproof marshalling box of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have domed or sloping roofs and the interior and exterior painting shall be in accordance with Clause 1.6 of CBIP manual.

The marshalling box, wherever provided shall accommodate the following equipments alternatively weatherproof instruments can be mounted outdoor:

- (a) 2 Nos. of WTI, one each for HV & LV to be provided and 1 No. of OTI.
- (b) Control and protection equipment for the local electrical control of tap changer, if the same cannot be accommodated in the motor driving gear housing.
- (c) Control and protection equipment for the cooling plant, and
- (d) Terminal boards and gland plates for incoming and outgoing cables (terminal shall be of Nut & stud type of M4 size (CAT m4))

All the above equipments except (d) shall be mounted on the panels and back of panel wiring shall be used for interconnection.

The temperature indicators shall be so mounted that the dials are not more than 1600 mm from ground level and the door(s) of adequate size.

To prevent internal condensation an approved type of metal-clad heater shall be provided controlled by a suitable switch. Ventilation louvers shall be provided.

All incoming cables shall enter the kiosk from the bottom and the gland plate shall be not less than 450 mm from the base of box. The gland plate and associated compartment shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

Un-drilled gland plate shall be provided for accommodating glands for incoming and outgoing cables.

Note: 1) All cable connections shall be taken from bottom only.

2) 1100 V grade, 2.5mm multistranded PVC copper cable shall be used for

Wiring of control cable and 1100V grade, 4.0 Sq.mm multistranded PVC copper cable shall be used for wiring of power circuit. The following colors code shall be used.

Power Circuit	-	RYB
Earth	-	Green
Control circuit	-	Black
DC Circuit	-	Grey

SECTION -III

COMPONENTS OF THE TRANSFORMER

The transformer shall generally comprise of the following components/parts.

- 1) HV line bushing.
- 2) LV line bushing.
- 3) LV neutral bushing.
- 4) Bi-metallic terminal connectors for HV.
- 5) Bi-metallic Terminal Connectors for LV.
- 6) Terminal connector for neutral suitable for connecting Copper/G.I. flats.
- 7) Monogram Plate.
- 8) Main Conservator with compartment of OLTC as per design with Sump, Drain Valve lifts. Separate conservator for OLTC optional as per design.
- 9) Oil filling hole with bolted cover for main conservator.
- 10) 150 mm Dial Magnetic oil level gauge with low level alarm contact.
- 11) 150 mm Dial winding temperature indicator with alarm trip contacts and maximum reading pointer.
- 12) 150 mm Dial oil temperature indicator with alarm and trip contacts and maximum reading pointer.
- 13) Surge Protection Relay with one set of contact and one isolating valve on conservator side for OLTC.
- 14) Pressure relief device with one set of contact for 110KV and 66KV Transformers. Explosion Vent for 33KV class Transformers with equalizer pipe.
- 15) Buchholz Relay with alarm and trip contacts and two wheel type isolating valves (50 mm size) with directions of mounting marked on Buchholz relay.
- 16) De-hydrating Silicagel with oil seal and glass inspection window.
- 17) Prismatic oil level gauge.
- 18) Thermometer pocket.
- 19) Air release plugs on main tank and Bushing turrets.
- 20) Inspection cover lifting lug.

- 21) Inspection covers on main tank and side manholes for OLTC conservator.
- 22) WTI CT Test link box with access window for Transformer of above 5 MVA capacity.
- 23) Bath for oil temperature indicator with probe for capillary tubing.
- 24) Bath for winding temperature indicator with probe for capillary tubing.
- 25) Marshalling box with PVC copper cable wiring 660/1100 grade (Tank mounted weather proof) along with required control cables for connection to Buchholz relay, temperature indicator etc.,
- 26) ON-LOAD Tap changer with operation counter and Single Phase Preventer if OLTC is of 3-phase 440 V design.
- 27) Radiator with top and bottom Shut off valve, Lifting lug, Air release and Drain plug.
- 28) Combined Rating and Diagram Plate and valve schedule line diagram. The rating plate shall be minimum 1 mm thick anodised cadmium steel plate and it should contain wiring diagram of OLTAC also. The additional particulars to be engraved on the Rating plate apart from that specified in IS will be intimated at the time of approval of drawings.
- 29) Lifting Bollards.
- 30) Jacking pads 500 mm above the base with adequate pad area.
- 31) Haulage eyes.
- 32) Earthing pads suitable to receive plate with M12 tapped holes to suit 4 bolted connections.
- 33) Earth connection between tank and cover.
- 34) Drain valve with locking arrangement and blanking plate.
- 35) Top filter valve (size 50 mm) with blanking plate with 38 mm adopter with locking arrangement.
- 36) Bottom filter valve (size 50 mm) with blanking plate with 38 mm adopter with locking arrangement.
- 37) Middle sampling valve (size 15mm) with plugs.
- 38) Bottom sampling valve (size 15mm) with plugs.
- 39) Piping arrangement from top and middle valve to the level of the bottom filter valve.

- 40) Under base – skid type.
- 41) Bi-directional rollers to suit 1676 mm track with locking arrangements.
- 42) Top stay bracket for supporting the conservator.
- 43) Main & Stand By Fans for cooling with fan control cubicle (for 20MVA & above).
- 44) Provision for connecting Nitrogen Injection Fire Protection System (for 10MVA & Above).
- 45) Remote OLTC control panel with 2312 height and 610 mm depth with single phase preventor protection for driving mechanism motor and AC voltmeter of adequate rating (for 110KV & 66KV Transformers)
- 46) G.I./Copper Bar (2 nos. of Flats) of adequate rating from neutral bushing mounted on insulators to a convenient point near base plate for neutral earth connection with terminal connection.
- 47) Pressure relief device for external mounted OLTC in case of 33KV class Transformers.
- 48) Details of bushing:

Sl. No.	MVA	Voltage Category	Rated voltage (KV)/Current (Amps)	
			HV side	LV side
1	8	66/11KV	72.5/400	17.5/630
2	12.5	66/11KV	72.5/400	17.5/2000
3	16/20	66/11KV	72.5/400	17.5/2000
4	10	110/33-11KV	145/400	36/2000*
5	16/20	110/33-11KV	145/400	36/2000(33KV)
*(Since common bushings are used for 33KV as well as 11KV				
Note: Creepage distance of all the bushings shall be 31mm/kV				

- 49) Detachable ladder/climbing device.
- 50) RTCC unit for Tap Changer Control.
Note: The accessories required with the transformer shall be SCADA compatible. Potential free contacts for Bucholtz relay, PRV, OSR, OTI, WTI, etc. need to be provided. Further for OTI, WTI, TPI, etc. dual output of 4-20mA shall be provided.
- 51) *Nitrogen Injection drain & stir method type fire extinguisher for 10MVA and above rating.*

SECTION – IV

Technical particulars of Power Transformers covered in this specification are as under:

Sl. No.	Particulars	110KV Class	
		16-20MVA	10MVA
1.	Type	Outdoor three phase	
2.	System frequency	50Hz.	
3.	Voltage rating	110/33-11KV	
4.	Standard rating HV (in MVA) LV (in MVA)	16-20MVA 16-20MVA	10MVA 10MVA
5.	Percentage impedance at normal Tap%	10%	10%
6.	Type of Cooling	ONAN/ ONAF	ONAN
7.	Winding connection a) HV b) LV	Delta Star	
8.	Vector group	Dyn11	
9.	On Load Taps a) Plus b) Minus	5 onHV 15 on HV	
10.	Type of insulation: a) H V b) L V	Fully insulated	
11.	Maximum permissible Losses of transformers (in kW)		
	i. Max. No Load loss at rated voltage & frequency	15	8
	ii. Max. Load loss at rated current and frequency and at 75 ⁰ C at principal tap position.	54	42
	iii. Max. I ² R loss at rated current and frequency and at 75 ⁰ C, at principal tap position.	46	35.5
	iv. Max. Auxiliary loss at rated voltage and frequency.	2	-
12.	Maximum temperature rise over Ambient temperature of 50 °C		
	a. Winding	50° C	
	b. Oil	45° C	
	c. Winding hot spot rise over yearly weighted temperature of	61° C	
	d. Tank hot spot temperature	110° C	

13.	Insulation level in KV Nominal system voltage (NSV) Highest system voltage (HSV) Power frequency withstand voltage Lightning Impulse withstand voltage	110KV 33KV 11KV 123KV 36KV 12KV 230KV 70KV 28KV 550KVp 170KVp 75KV(Peak)
14.	Temperature rise	As per IS 2026 Part II 2010

Technical particulars of Power Transformers covered in the specification are as under:

Sl. No.	Particulars	66KV Class		
		16-20MVA	12.5MVA	8MVA
1.	Type	Outdoor three phase		
2.	System frequency	50Hz.		
3.	Voltage rating	66/11KV		
4.	Standard rating HV (in MVA)	16-20MVA	12.5MVA	8MVA
		16-20MVA	12.5MVA	8MVA
5.	Percentage impedance at normal Tap%	10%	10%	8.35%
6.	Type of Cooling	ONAN/ONAF	ONAN	ONAN
7.	Winding connection			
	a) HV	Delta		
	b) LV	Star		
8.	Vector group	Dyn11		
9.	On Load Taps			
	a) Plus	5 onHV		
	b) Minus	15 on HV		
10.	Type of insulation:			
	a) HV	Fully insulated		
	b) LV			
11.	a) Maximum permissible Losses of transformers (in kW)			
	Max. No Load loss at rated voltage & frequency	11	9	8
	Max. Load loss at rated current and frequency and t 75 ⁰ C at principal tap position.	54	50	43
	Max. I ² R loss at rated current and frequency and at 75 ⁰ C, at principal tap position.	46	42	36.5
	Max. Auxiliary loss at rated voltage and frequency.	2	-	-
12.	Maximum temperature rise over Ambient temperature of 50 °C			
	a. Winding	50° C		
	b. Oil	45° C		
	c. Winding hot spot rise over yearly weighted temperature of 32°C	61° C		
	d. Tank hot spot temperature	110° C		

13.	Insulation level in KV Nominal system voltage (NSV) Highest system voltage (HSV) Power frequency withstand voltage Lightning Impulse withstand voltage	66KV 72.5KV 140KV 325KVp	11 KV 12 KV 28 KV 75 (KV Peak)
14.	Temperature rise	As per IS 2026 Part II 2010	

NOTE – 1:

- I. HV: High 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. 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.
4. Impedance : Supplier shall indicate the guaranteed impedance and tolerance and also the upper and lower limit of impedance which can be offered without any increase in the quoted price. 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.
5. Separate tap winding to be provided on the HV delta winding running all along the length. Suitable OLTC with higher insulation shall be provided at the line end of HV delta winding of transformer.

SECTION - V

OTHER TERMS AND CONDITIONS

1.0 SPARES:

A complete set of spares required for 5 years trouble free maintenance shall be quoted by the supplier.

2.0 TENDER DRAWINGS AND LITERATURES:

Duplicate copies of following drawings and literatures shall be submitted along with tender:

- a) GA drawing showing dimensional details.
- b) Front and rear views of transformer with instrument and device position marked.
- c) Photographs of similar transformer supplied by the manufacturer.
- d) Illustrative descriptive literature and General Technical Data.

3.0 CONTRACT DRAWINGS:

Supplier within four weeks of placement of order shall submit drawings in quadruplicate for the approval of the purchaser prior to manufacture in A3/A4 size only. After the drawings are approved SIX copies of drawings shall be supplied for immediate use.

The supplier shall forward the drawings and literature as follows:

- a) ONE set of reproducible originals and 12 sets of copies of all approved drawings along with 12 sets of literature, commissioning and maintenance manuals to the office of the Chief Engineer, Elecy. (Tendering & Procurement), KPTCL, Bangalore.
- b) Four sets of copies of all approved drawings along with four sets of literature and manual to consignees in respect of each of the Stations.
- c) The following drawings are to be submitted for approval.
 - i). Foundation drawings indicating the details of foundation plan cross-section suitable for Normal Dry Soil taking SBC as 10 Tons/sq.mt.
 - ii). Outline dimensional drawings of transformers and accessories.
 - iii). Assembly drawings and weight of main component parts.
 - iv). Shipping drawings showing dimensions and weights of each package.
 - v). Schematic control and wiring diagram for all auxiliary equipments.
 - vi). Bushing assembly, plan, elevation, sectional view and details of joints, seals etc.,
 - vii). Radiator assembly: Sectional View of radiator.
 - viii). Interconnection diagram between Marshalling box and OLTC, Power Transformer and other associated equipments.
 - ix). Dimensional drawings showing cooling passage in transformer core and windings.
 - x). Individual internal wiring diagram of all devices and elementary wiring diagram of relays for internal wiring.

- xi). Electrical connections of windings, number of taps, tapping switchgear terminal vector group polarity etc.
- xii). 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 connection control cable schedule to enable the purchaser to prepare the schedule of control cables etc.
- xiii). Assembly of core and coils: Details of winding connection, insulation spacers, barriers clearances, core bolt insulation, etc., which will help the purchaser to replace as set of winding in any future eventuality. The component parts shall be suitably numbered and parts shipped shall have similarly numbered tags.
- xiv). Construction details of the switches, terminal blocks and test blocks etc.,
- xv). Diagram and rating plates as per details in the specification, temperature rise oil and winding high voltage test figures, etc.,
- xvi). Assembly of OLTC gear mechanism: Full details of the main parts, limits and fits wearing parts, timing gear adjustments, etc.
- xvii). Detailed assembly drawing to enable the purchaser to do the core and coil assembly. Parts shall be identified by separate numbers.
- xviii). Schematic drawings showing the details of interconnection and other details of OLTC, DM, MB and RTCC.

Along with the drawings, followings documents are also to be submitted for approval.

- i). Guaranteed Technical Particulars.
- ii). Type Test Certificates

It may be noted that non-supply of part supply of drawings literature and manuals will be deemed as incomplete supply of Transformer.

4.0 **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'.

- 5.0 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.

- 6.0 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.

7.0 **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) Supplies, 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 requirement 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 arrangement can be made for inspection, if desired by the purchaser.
- vii) The purchaser reserves the right to insist for 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.

7.1.1 **Tank and Conservator**

- 7.1.1.1 Certification of chemical analysis and material tests of plates.
- 7.1.1.2 Check for flatness.
- 7.1.1.3 Electrical interconnection of top and bottom by braided tinned copper flexible.
- 7.1.1.4 Welder's qualification and weld procedure.
- 7.1.1.5 Testing of electrodes for quality of base materials and coatings.
- 7.1.1.6 Inspection of major weld preparation.
- 7.1.1.7 Crack detection of major strength weld seams by dye penetration test.
- 7.1.1.8 Measurement of film thickness of :
 - i) Oil insoluble varnish.
 - ii) Zinc chromate paint.
 - iii) Finished coat.
- 7.1.1.9 Check correct dimensions between wheels, demonstrate turning of wheels through 90° and further dimensional check.
- 7.1.1.10 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.
- 7.1.1.11 Leakage test of the conservator.
- 7.1.1.12 Certification of all test results.

7.1.2 **Core**

- 7.1.2.1 Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness.
- 7.1.2.2 Check on the quality of varnish if used on the stampings :

Measurement of thickness and hardness of varnish on stampings.
Solvent resistance test to check that varnish does not react in hot oil.
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.
- 7.1.2.3 Check on the amount of burrs.
- 7.1.2.4 Bow check on stampings.
- 7.1.2.5 Check for the overlapping of stampings. Corners of the sheet are to be part.
- 7.1.2.6 Visual and dimensional check during assembly stage.
- 7.1.2.7 Check for interlaminar insulation between core sectors before and after pressing.
- 7.1.2.8 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.
- 7.1.2.9 Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
- 7.1.2.10 High voltage test (2 kV for one minute) between core and clamps.
- 7.1.2.11 Certification of all test results.
- 7.1.3 **Insulation Material**
- 7.1.3.1 Sample check for physical properties of materials.
- 7.1.3.2 Check for dielectric strength.
- 7.1.3.3 Visual and dimensional checks.
- 7.1.3.4 Check for the reaction of hot oil on insulating materials.
- 7.1.3.5 Dimension stability test at high temperature for insulating material.
- 7.1.3.6 Tracking resistance test on insulating material

7.1.3.7 Certification of all test results.

7.1.4 **Winding**

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

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

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

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

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

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

7.1.4.7 Check for absence of short circuit between parallel strands.

7.1.4.8 Check for brazed joints wherever applicable.

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

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

7.1.4.11 Conductor flexibility test

7.1.4.12 Heat shrink test for enamelled wire.

7.1.4.13 Certification of all test results.

7.1.5 **Checks Before Drying Process**

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

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

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

- 7.1.5.4 Insulation of core shall be tested at 2 kV/minute between core to bolts and core to clamp plates.
- 7.1.5.5 Check for proper cleanliness and absence of dust etc.
- 7.1.5.6 Certification of all test results.
- 7.1.6 **Checks During Drying Process**
- 7.1.6.1 Measurement and recording of temperature, vacuum and drying time during vacuum treatment.
- 7.1.6.2 Check for completeness of drying by periodic monitoring of IR and Tan delta.
- 7.1.6.3 Certification of all test results.
- 7.1.7 **Assembled Transformer**
- 7.1.7.1 Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
- 7.1.7.2 Test to check effective shielding of the tank.
- 7.1.7.3 Jacking test with oil on all the assembled transformers.
- 7.1.7.4 Dye penetration test shall be carried out after the jacking test.
- 7.1.8 **Bought Out Items**
- 7.1.8.1 The makes of all major bought out items shall be subject to Employer's approval.
- 7.1.8.2 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.

7.2 **Factory Tests**

7.2.1.1 **Routine Tests**

All standard routine tests in accordance with IS: 2026 Part I: 2011 shall be carried out on each transformer.

- a) Measurement of winding resistance.
- b) Measurement of voltage ratio and check of phase displacement.
- c) Measurement of Short-circuit impedance and load loss.
- d) Measurement of no-load loss and current.
- e) Dielectric routine tests IS 2026 (Part 3): and
- f) Tests on on-load tap-changers, where appropriate.
- g) Measurement of insulation resistance to earth of windings, and/or measurement of dissipation factor ($\tan \delta$) of the insulation system capacitances.

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

- a) **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.
- b) Oil leakage test on transformer tank as per Clause 7.2.7.1 below.
- c) Magnetic balance test
- d) Measurement of no-load current with 415V, 50 Hz ac supply on LV side.
- e) Frequency response analysis (FRA)
- f) High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

7.2.2 **Type Tests**

7.2.2 (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**.

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.

7.2.2.b. However, following type tests shall be conducted on one Transformer of each rating:

7.2.2.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.

7.2.2.b.2 Tank vacuum Test as per Cl.no.7.2.7.2(i) below.

7.2.2.b.3 Tank pressure Test as per Cl.no.7.2.7.2(ii) below.

7.2.2.b.4 Deleted

7.2.2.b.5 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)
- c. Lightning impulse test for the neutral terminals (LIN)

7.2.3 Additional type tests

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

7.2.3.1 Determination of Capacitances windings-to-earth, and between windings.

7.2.3.2 Measurement of zero Seq. Impedance(s) on 3-phase transformer.

7.2.3.3 Determination of sound level.

7.2.3.4 Measurement of power taken by fans and oil pump motors.

7.2.3.5 Measurement of harmonics of the no load current.

7.2.3.6 Deleted.

7.2.3.7 VOID.

7.2.4 Dynamic Short Circuit Test Requirement And Validity

7.2.4.1 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

7.2.5 **Routine tests on bushings**

The following tests shall be conducted on bushings

7.2.5.1 Test for leakage on internal fillings.

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

7.2.5.3 Dry power frequency test on terminal and tapping.

7.2.5.4 Partial discharge test followed by dielectric dissipation factor and capacitance

measurement.

7.2.6 **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: 60137)
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: 214-1 2003 and IP-55 test on drive 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.7.2.7.2 (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. VOID
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.

7.2.7 Tank Tests

7.2.7.1 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.

7.2.7.2 **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 eight hours. The ~~permanent deflection of flat plates after the excess pressure has been~~ released shall not exceed the figure specified above for vacuum test.

7.2.8 Pre-Shipment Checks at Manufacturer's Works

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

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

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

7.2.8.4 Gas tightness test to confirm tightness.

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

7.3 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.

7.3.1 Receipt and Storage Checks

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

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

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

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

7.3.2 Installation Checks

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

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

7.3.2.3 Check whole assembly for tightness, general appearance etc.

7.3.2.4 Oil leakage test

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

7.3.2.6 Leakage test on bushing before erection.

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

7.3.3 Commissioning Checks

7.3.3.1 Check the colour of silicagel in silicagel breather.

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

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

7.3.3.4 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.

- 7.3.3.5 Check for the adequate protection on the electric circuit supplying the accessories.
- 7.3.3.6 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.
- 7.3.3.7 Check for cleanliness of the transformer and the surroundings.
- 7.3.3.8 Continuously observe the transformer operation at no load for 24 hours.
- 7.3.3.9 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.
- 7.3.3.10 Phase out and vector group test.
- 7.3.3.11 Ratio test on all taps.
- 7.3.3.12 Magnetising current test.
- 7.3.3.13 Capacitance and Tan delta measurement of winding and bushing.
- 7.3.3.14 DGA of oil just before commissioning and after 24 hours energisation at site.
- 7.3.3.15 Frequency response analysis (FRA).
- 7.3.3.16 Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Employer for future record.
Technical Parameters

8.0 **PACKING :**

The supplier shall provide such packing of goods as is required to prevent damage or deterioration during transport to their final destination. The packing shall be sufficient to withstand, without limitation, rough handling during transport and exposure to extreme temperature and open storage. The packing case, size, weights shall be taken into consideration, where appropriate the remoteness of goods final

destination and the absence of mechanized heavy handling facilities at all points in transport. Any material found short inside the packing cases shall be supplied by supplier without any extra cost

9.0 **DEVIATION FROM TECHNICAL SPECIFICATION :**

The tenderer shall furnish the details of deviations / modifications proposed by him to improve overall performance of the system. The deviations shall be brought in the tender clause by clause as per Annexure.

10.0 **UNLOADING :**

The tenderer shall quote separate rates for transportation to site and unloading at site. The purchaser however reserves the right to order any one or both. However unloading of transformer is optional item in bid.

11.0 **ERECTION & COMMISSIONING:**

The tenderer shall note that their commissioning Engineers have to be deputed for erection and commissioning of transformers in case orders are finalized on them. This has to be taken note of while furnishing the offers.

12.0 **GUARANTEED TECHNICAL PARTICULARS:**

The tenderer shall furnish the relevant Guaranteed technical particulars as per Annexure-I.

13.0 **Power transformer of 10MVA 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.**

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.

ANNEXURE-I
GUARANTEED TECHNICAL PARTICULARS FOR POWER TRANSFORMER

Sl No.	Description			
1	Name of the Manufacturer and country of origin			
2	Reference standard			
3	Service [Indoor/outdoor]			
4	Continuous rating under service conditions specified in IS-2026 Part-I, 2011 Clause No.1.1	: HV		
		: LV		
5	Ratings :			
	a. 1. With ONAN cooling - MVA			
	2. With ONAF cooling - MVA			
	b. Rated no load voltage			
	HV - kV			
	LV - kV			
6	a. Rated Frequency : (Hz)			
	b. Number of phases			
7	Current at rated voltage and on principal tap-Amp	:HV		
		:LV		
8	Maximum hot spot temperature rise calculated by formula °C over the maximum yearly weighted average ambient temperature			
9	Flux density at rated voltage and rated frequency in tesla			
10	Temperature rise of top oil, °C by the thermometer (above Max. Ambient Temperature).			

11	Temperature rise of winding measured by resistance (above Max. Ambient Temperature).			
	i. With ONAN cooling °C			
	ii. With ONAF cooling °C			
	iii. Period of operation of transformer at full load without calculated winding hot spot temperature exceeding 140°C and when			
	50% coolers fail			
	100% coolers [Refer Cl. No. 1.2.0.1] fail			
12	No. of windings			
13	Connections	HV		
		HV Tap wdg		
		LV		
		Neutral LV		
14	Connection Symbol and vector group			
15	Tappings :			
	i. Type of tap changer			
	ii. Tap step (percent)			
	iii. Total tap range (+) percent to (-) percent			
	iv. Tappings provided at			
	v. Type of regulation :			
	Constant flux regulation			
	Variable flux regulation			

	Combined regulation vi) Insulation level of tap changer			
16(A)	Magnetization data at no load, at rated frequency			
	i. Current in Amps			
	ii. Power factor			
	iii. Loss in KW (core loss + dielectric loss)			
	iv. Max. flux density in lines/sq.cm.			
a	At 90% rated no load voltage			
b	At 100% rated no load voltage			
c	At 110% rated no load voltage			
d	At maximum rated primary voltage (i.e. 105% rated no load voltage)			
16(B)	i) No-load loss at rated frequency at Principal Tap (KW)			
	ii) No-Load loss at voltage corresponding to the Highest Tap (KW)			
17	Load loss including cooler loss, at <i>rated output</i> , at rated frequency, at rated current at 75 °C winding temperature.	At Lowest Tap	At Principal Tap	At Highest Tap
	i. For ONAN rating CuL in KW			
	ii. For ONAF rating CuL in KW+CL in KW			
	NOTE : 1. CuL : Copper loss			
	2. CL : Cooler loss			

	Note for Sl. No. 16 & 17: Guaranteed values of the losses shall be indicated which shall be firm & without indicating the tolerance limit.			
18	Impedance at rated current and frequency at 75°C winding temperature on rated MVA base.		HV to LV	
	i. At normal tap in %			
	ii. At max. voltage tap in %			
	iii. At min. voltage tap in %			
19	Reactance at rated current and frequency and normal tap on rated MVA base:			
	HV to LV - %			
20	Zero sequence impedance at reference temperature of 75°C at principal tap %			
21	Resistance at 75 °C			
	HV winding in Ohms in %			
	LV winding in Ohms in %			
22	Efficiency at 75°C winding temperature as derived from guaranteed. loss figures	At Unity	At 0.8 p.f	
	a. At 125% full load			
	b. At 100% full load			
	c. At 75% full load			
	d. At 50% full load			
23	a. Maximum efficiency.....%			

	b. Load at which maximum efficiency occurs (% of full load)			
24	Regulation at full load and at 75°C			
	a. At unity p.f. in %			
	b. At 0.8 p.f. (lag) in %			
25	a. Short time thermal rating of LV winding in KA & duration in seconds.			
	b. Short time thermal rating of HV winding in KA & duration in seconds.			
26	Permissible overloading - HV			
	- LV			
27	Test voltages	HV	LV	
	i. Lighting impulse withstand kV (peak)			
	ii. Power frequency voltage withstand kV (ms)			
	iii. Switching impulse withstand kV (peak)			
28	Partial discharge level at $1.5U_m / \sqrt{3}$ kV _{rms} (pC)			
29	RIV at 1.1 times minimum phase to ground voltage			
30	VOID			
31	Noise level when energized at normal voltage and normal frequency at no load (db)			

32	External short circuit withstand capacity (MVA) & duration (seconds)			
33	Over flux withstand capability of the transformer :			
34	Insulating and cooling medium			
35	Approximate weights			
	a. Core with clamping (Kg)			
	b. Winding with insulation (Kg)			
	c. Core & Winding (Kg)			
	d. Tank & Fittings with accessories (Kg)			
	e. Oil required for first filling (Kg)			
	f. Untanking weight (Kg)			
	g. Total weight with oil weight & fitting (Kg)			
	h. Weight of total insulation (Kg)			
36	Required quantity of oil in litres			
37	Terminal arrangement			
	HV			
	LV			
	Neutral LV			

ADDITIONAL TECHNICAL PARTICULARS:				
1	Details of Core (along with Tolerance if any):			
	a. Type of core configuration			
	b. Type of core joints			
	c. Flux density at 90% of rated voltage and frequency at Principal Tap	Tesla :		
	d. Flux density at 110% of rated voltage and frequency at Principal Tap	Tesla :		
	e. (i) Material of core lamination			
	(ii) Thickness of core lamination (mm)			
	f. Approximate core weight (please indicate core weight only)			
	g. Type of Joints used between core limb and yoke			
2	Details of Windings:			
	a. Conductor area in <u>sq.cm</u> and current density in Amps/Sq.cm (at rated current).	Current density A/ <u>sq. cm</u>	Conductor area <u>sq.cm</u>	
	HV			
	HV TAP WINDING			
	LV			
	Regulating			
	b. Material of winding conductor			
	c. Approximate weight of winding (along with tolerance if any)in kgs			

d. Type of windings			
HV			
HV TAP WINDING			
LV			
e. Winding insulation	Type and class	Graded or ungraded	
HV			
HV TAP WINDING			
LV			
f. i. Insulating material used for :			
1. Regulating winding			
2. HV winding			
3. HV TAP WINDING			
4. LV winding			
ii. Between HV and TAP WDG and LV as applicable			
iii. Between core & LV side.			
iv. For core bolts, washers and end plates			
v. Regulating winding & earth.			
g. i. Type of axial coil support			
HV winding			
HV TAP WDG			
LV winding			
ii. Type of Radial coil support :			
HV winding			
HV TAP wdg			
LV winding			
h. Core bolt insulation voltage			

	i. Details of special arrangement provided to improve surge voltage distribution in the windings			
	j. Approximate weight of winding (Kgs) (Tolerance if any on the above)			
	k. Minimum clearance (mm)	In oil		
		Between Phases	Phase to ground	Between Phases
	HV			
	LV			
3	Details of Tank :			
	a. Material for Transformer Tank			
	b. Type of the tank			
	c. Minimum thickness of sheet			
	i. Sides (mm)			
	ii. Bottom (mm)			
	iii. Cover (mm)			
	iv. Cooling tubes/Radiators (mm)			
	d. Vacuum recommended for hot oil circulation (torr)			
	e. Vacuum to be maintained during oil filling in transformer tank (torr)			
	f. Vacuum to which the tank can be subjected without distortion (torr)			
		Transverse Axis	Longitudinal Axis	
	g. No. & size of bi-directional wheels provided.			

	h. (i) Track gauge required for the wheels-longitudinal axis & transverse axis			
	(ii) Size of rail recommended for the track			
4	Details of painting at works and site			
5	(a) Minimum clear height for lifting tank cover and for lifting core & windings from tank (mm) (untanking height).			
	(b) Minimum clear height for lifting (mm)			
	i. OLTC			
	II. Bushings - HV			
	- LV			
6	Shipping details :			
	i. Parts detached for transport			
	ii. Weight of heaviest package in Kgs			
	iii. Weight of other heavy packages in Kgs			
	iv. Dimensions of largest package			
	a. Length in mm			
	b. Breadth in mm			
	c. Height in mm			
	v. Dimensions of other heavy packages:			
	a. Length in mm			
	b. Breadth in mm			
	c. Height in mm			

	vi. Transformer will be transported with oil / gas			
7	Details of Bushings	HV	LV	
	a. Make & Type			
	b. Rated voltage class - KV			
	c. Rated current - Amps			
	d. One minute dry withstand power frequency voltage - kV (ms)			
	e. One minute wet withstand power frequency voltage - kV (ms)			
	f. (i) 1.2 / 50 micro sec. Lighting impulse withstand voltage - kV (Peak)			
	(ii) Switching surge withstand test voltage kV _(peak)			
	g. (a) Creepage Distance in air			
	(b) Creepage Distance (protected)			
	h. Quantity of oil in bushing and specification of oil used (Kgs)			
	i. Whether test tap is provided			
	j. Weight of assembled bushing			
	k. Phase to earth clearance in air of live parts at the top of bushing.			
	l. Minimum clearance (mm)	In Air		
		Between phases	Phase to ground	
	(i) H V			
	(i i) L V			
	m. Partial discharge level			
8	Cooling system			
	a. Grade of oil			

	b. Total weight of oil in radiator in Kgs/litres			
	c. Total weight of radiator without oil in Kgs.			
	d. Total radiating surface in square meters			
	e. Method of drying out transformer at site			
	f. Type and make of material used for the radiators with size.			
	g. Type of radiator			
	h. Total number of Radiators/Banks for transformer and over all dimensions (LxBxH)			
	i. Rating of Transformer with one radiator bank out of service.			
	j. Total weight of radiators in Kgs			
	k. Type of mounting			
	l. Vacuum withstand capability			
9	Cooling equipment	Fan Motor	Pump Motor	
	a. Make and Type (Details)			
	b. Number of connected units (nos.)			
	c. Number of standby units (nos.)			
	d. Rated Power (KW)			
	e. BHP of driven equipment			
	f. Capacity (cu m/min) or (Litres/Minute)			
	g. Rated voltage (Volts)			
	h. Locked rotor current (Amps)			

	i. Temperature range for which control is adjustable			
	j. Efficiency of motor at full load (percent)			
	k. Temp. rise of motor at full load (°C)			
	l. Whether the fan and/or pumps suitable for continuous operation at 85% of their rated voltage			
	m. Estimated time constant in hours for			
	i. Natural cooling			
	ii. Forced air cooling			
10	On Load Tap Changing gear (should be SCADA <i>Compatible</i>)			
	a. Make			
	b. Type			
	c. Power flow (uni-directional or bi-directional or restricted bi-directional)			
	d. Rated voltage to Earth kV			
	e. Rated maximum current Amps			
	f. Step voltage V.			
	g. Number of steps			
	h. Control : Manual / Auto / Local/Remote/Independent / Parallel.			
	i. Auxiliary supply details			
	j. Voltage control (whether automatic or manual)			
	k. Line drop compensation Provided / Not provided.			
	l. Protective devices			

	m. Time for complete tap change (one step) sec.			
	n. Divertor selector switch Transient time - Cycles.			
	o. Value of maximum short circuit current Amps.			
	p. Maximum impulse withstand test voltage with 1.2/50 micro seconds full wave between switch assembly and earth (kV peak)			
	q. Maximum power frequency test voltage between switch assembly and earth - kV rms.			
	r. Maximum impulse withstand test voltage with 1.2/50 micro seconds across the tapping range (kV peak).			
	s. Approximate over all dimensions of Tap changer mm			
	t. Approximate over all weight Kgs.			
	u. Approximate over all quantity of oil-ltrs/Kgs.			
	v. Particulars of the OLTC control panel for installation in the control room.			
	w. OLTC Routine test shall be conducted on each Transformers. i) Mechanical Endurance Test (Min. 1000 operations)			
	ii) Sequence Test			
	iii) Pressure Test			
	iv) Vacuum (Helium) Test			
	v) Auxiliary Circuit Insulation test			
	x. OLTC Drive Mechanism Box: Make & Type			

11	Over all dimensions of transformer including cooling gear, tap changing gear etc.			
	a. Length -mm			
	b. Breadth -mm			
	c. Height -mm			
	d. Reference drawing No.			
12	Whether oil temperature indicator provided (Yes/No).			
13	Type of oil level indicator and whether supervisory alarm contact for low oil level provided (Yes/No)			
14	Type and size of Gas operated relay and whether supervisory alarm and trip contacts provided and their size and Nos.			
15	Temperature indicators	Oil Temp. indicator	Winding temp. indicator	
	a. Make and Type			
	b. Permissible setting ranges for alarm & trip.			
	c. No. of contact			
	d. Current rating of each contact			
	e. Whether remote indicator provided, if so, whether equipment required at purchaser's control room is included.			
	f. Size and No.			
16	Ratio and Type of CT used for winding temperature			
	a. Ratio			
	b. Type			

17	Type and size of Thermostat used			
18	No. of Breathers provided (No.)	For Tr.	OLTC	
19	Type of dehydrating agent used for breathers			
20	a. Capacity of conservator vessel litres			
	b. Volume between the highest and lowest visible oil level (litres)			
21	Valve sizes and number required/ fitted			
	i. Drain valves - mm - No.			
	ii. Filter valves - mm - No.			
	iii. Sampling valves - mm - No.			
22	a. Type and make of pressure relief device			
	b. No. of each type of devices per transformer unit (Nos.)			
	c. Minimum pressure at which the device operates (Kpa)			
23	Lifting jacks			
	a. Governing standard			
	b. No. of jacks in one set			
	c. Type & make			
	d. Capacity (tonnes)			
	e. Pitch (mm)			
	f. Lift (mm)			
	g. Height in closed position (mm)			
	h. Mean diameter of thread (mm)			
24	Characteristics of Insulating oil to be used			
	1 - Function			
	Viscosity at 40 °C in mm ² /s			

Viscosity at -30 °C in mm ² /s			
Pour point in °C			
Water content in mg/kg			
Breakdown voltage in kV			
Density at 20 °C in g/ml			
DDF at 90 °C			
Particle content			
2 – Refining/stability			
Appearance			
Acidity in mg KOH/g			
Interfacial tension in mN/m			
Total sulphur content			
Corrosive sulphur			
Potentially corrosive sulphur			
DBDS in mg/kg			
Inhibitors of IEC 60666 in %			
Metal passivator additives of IEC 60666 in mg/kg			
Other additives			
2- Furfural and related compounds content in mg/kg			
Stray gassing			
3 - Performance			
Oxidation stability for uninhibited oil – 164 hrs			
-Total acidity in mg KOH/g			
-Sludge in %			
-DDF at 90 °C			
Gassing tendency			

	ECT			
	4 – Health, safety and environment (HSE)			
	Flash point in °C			
	PCA content in %			
	PCB content in mg/kg			
	5 – N-dm Analysis CA %			
	CM %			
	CP %			
	6. Details of oil preserving equipment offered.			

